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Using Collective Argumentation to Engage Students in a Primary Mathematics Classroom

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Abstract

This article focuses on using sociocultural theory to support student engagement with mathematics. The sociocultural approach used, Collective Argumentation (CA), is based on interactive principles necessary for coordinating student engagement in the discourse of the classroom. A goal of the research was to explore the affordances and constraints of using CA to enrich student engagement with mathematics. The design of the research was based on a teaching experiment that sought to capture the influence of social and cultural processes on learning and development. Participants included primary and secondary school teachers and their mathematics classes. This article focuses on the practice of one female primary school teacher. Data sources included interview transcripts, report writings, journal entries and observational records. Data were analysed using a participation framework. Findings suggest that aspects of CA such as students explaining and justifying ideas and presenting ideas to the whole class can be used by teachers to promote student engagement with mathematics.

Key Words: Engagement, Sociocultural, Collective Argumentation, Teacher Perceptions, Primary Classroom Mathematics

Introduction

Level of engagement with mathematics has a significant impact on student performance in the short term and the quality of their learning in the long term (Thomson, De Bortoli, & Buckley, 2013). According to the OECD Programme for International Student Assessment (PISA, 2012), Australian students demonstrated a higher level of motivation to learn mathematics than the OECD average and higher than average agreement that learning mathematics would enhance future career and study prospects. However, research has shown that Australian students are disengaging with the learning of mathematics due to, amongst other things, inappropriate learning and teaching processes (Sullivan, 2011).

The problem of engaging students with learning is not recent nor is it confined to Australia. For example, in 1989 Finn noted that a disproportionate number of students from minority groups and homes of low socio-economic status were disengaging from the American schooling system. Newmann (1991) proclaimed that student disengagement in academic work was especially acute for children from the middle years of schooling onwards. In mathematics education Oakes (1990) raised the concern of student disengagement with mathematics, particularly for low-income and minority students. A major review of the curriculum in Queensland, Australia noted that mathematics was viewed by students as being the least preferred lesson of the school day (Wiltshire, McMeniman, & Tolhurst, 1994). Recently, authors such as Fredericks note the increasing necessity for researchers, educators and policymakers to address the problem of student disengagement at both the elementary and middle years of schooling level (Fredericks, Blumenfeld, & Paris, 2004; Fredericks & McCloskey, 2012). Referring to the Australian context, Martin, Anderson, Bobis, Way and Vellar (2012) refer to the problem of student disengagement in mathematics and its predictors such as anxiety, ethnicity and socioeconomic status. As such, student lack of engagement with mathematics is one of the most critical issues that educators face in the 21st century.

The term engagement has a number of interpretations. For example, Newman (1991) refers to a broad definition of engagement relating to the general desire of students to succeed in school. Fredericks et al., (2004) refer to engagement as being multifaceted incorporating behavioural, emotional and cognitive dimensions. Bobis, Anderson, Martin and Way (2011) link engagement to factors such as valuing school, self-efficacy, persistence and task management. A report from the Office of the Australian Chief Scientist (2012), *Mathematics, Engineering and Science in the National Interest*, emphasised that an important aspect of "inspiring students to engage with Mathematics" was the need for teachers to "have the knowledge and confidence to present the curriculum imaginatively" (Chubb, & Chubb, 2012, p. 25). Presenting the curriculum imaginatively requires from teachers a broad interpretation of engagement that includes the use of pedagogical strategies that go beyond traditional approaches to teaching mathematics to include "inquiry-based teaching skills" (Chubb, & Chubb, 2012, p. 21).

There is no paucity of literature about teacher strategies that facilitate student engagement with mathematics. For example, Paul Cobb and colleagues have researched the teaching of classroom mathematics to clarify the characteristics of classroom mathematics traditions (Cobb, Wood, Yackel, & McNeal, 1992), the emergence of mathematical meaning (Cobb, & Bauersfeld, 1995), the role of discourse, argumentation, reflection and autonomy

(Yackel, & Cobb, 1996), and, norms of participation facilitative of student engagement with mathematics (Cobb, Yackel, & Wood, 1989).

This century, Cobb and colleagues have progressed research in the field to include student reasoning as a form of participation in the inquiry classroom (Cobb, Stephan, McClain, & Gravemeijer, 2001) and as being an essential component of mathematical practice (Cobb, Stephan, & Bowers, 2011). This line of thinking is extended by research such as that of Jo Boaler (2008) and her development of the concept 'relational equity' into the teaching and learning of mathematics, that is, teachers and students working together in contexts that value a diversity of ideas and that encourage active listening and respect. Franke and colleagues position classroom discourse, norms and relationships as being central to classroom practices that support mathematical learning (Franke, Kazemi, & Battey, 2007). In Australasia research is being enacted that situates mathematical learning within culturally sensitive contexts that build relationships through the development of identity (Civil, & Hunter, 2015), that scaffold the development of argumentation-based norms (Makar, Bakker, & Ben-Zvi, 2015) and that conceptualise the learning of mathematics within sociocultural frameworks of participation (Goos, Galbraith, & Renshaw, 2002; Goos, 2014). However, even though teachers may profess beliefs associated with the findings of such research, the enactment of these beliefs in the classroom can appear wanting (Leatham, 2006). As such, supporting teachers to implement inquiry-type approaches to learning in the classroom is a key challenge for mathematics education. The research reported in this article concerns itself with exploring the affordances and constraints of using a sociocultural approach to teach mathematics in an upper-primary school classroom.

Theoretical perspective

This article employs a sociocultural understanding of engagement to explore the affordances and constraints of using a sociocultural approach to teach mathematics in a primary classroom. Sociocultural theory maintains that children learn in relationship with others through the use of cultural tools such as the signs and symbols (including language) of mathematics (Vygotsky, 1978). From this perspective engagement with learning may be viewed as being socially constructed in each teaching and learning encounter, based on what has gone before and what beliefs and attitudes teachers and students bring to these encounters.

In enacting such a view of engagement in the mathematics classroom it becomes necessary to expand the role of classroom communication beyond the intra-psychological

function of promoting understanding through the transmission of knowledge, to include the inter-psychological function of transforming personal understanding through the processes of inter-subjectivity and collective thinking. The theory of Vygotsky provides a framework for such an expansion.

According to Vygotsky (1978), learning is a mediated process of appropriation brought about by students co-constructing meaning as they participate in the social activity of the classroom. Learning occurs in collaboration with others and is an interpretive activity embedded in engagement with critical inquiry. This claim requires that the role of communication in the classroom be reformulated to take into account the role of semiotic tools, that is the signs and symbols (including language) of mathematics, in interweaving students everyday ways of knowing and doing with the sophisticated ways conventionalised by mathematics. One model of collaboration that provides students with access to a range of semiotic tools that may be used to facilitate engagement in the classroom is 'Collective Argumentation' (Brown & Renshaw, 2000).

Collective Argumentation (CA)

CA is based partially on the pioneering work of Miller (1987). Miller defined three interactive principles essential for coordinating student engagement with learning. First, the *'generalisability'* principle requires students to attempt to communicate their individual thinking about a task. Students may do this through representing a diagram, doing a sum, or re-writing the task, et. cetera. Second, the *'objectivity'* principle maintains that ideas relevant to a task can only be rejected through reference to experience or logical argument. Students may do this by comparing the similarities and differences between ideas and through explaining their ideas. Third, ideas about a task which are contradictory to each other or that belong to mutually exclusive points of view must be determined through argument - the *'consistency'* principle. Students achieve this by justifying their ideas about a task and through providing reasons as to why certain ideas should be accepted or rejected. Brown and Renshaw (2000) extended Miller's principles from the small group to the whole class context by including a principle of *'consensus'* and a principle of *'recontextualisation'*. Consensus requires that all students in a group understand an agreed approach to completing the task and that they can explain elements of the approach to others. The 'recontextualisation' principle requires students to present the group's ideas about the task to the class for discussion and validation. Presenting to class members, challenges students to rephrase and defend ideas and to assess the validity of their thinking. CA, therefore, has the potential to create

communicative spaces in the classroom where students have regular opportunities to ‘represent’, ‘compare’, ‘explain’, ‘justify’, ‘agree’ about and ‘validate’ their ideas.

Finn's (1989) participant-identification model and Newman's (1991) model of engagement are consistent with the principles of CA. The participation-identification model attempts to explain student disengagement with school as being a process of de-identificaton that takes place over time (Finn, 1989). CA, through highlighting the mediating role that identifying with the classroom community has on student engagement, speaks to this model and extends its focus to the mathematics classroom. In turn, Newman’s (1991) model of engagement emphasises that long term learning develops largely through the persistence of students to engage with continuous cycles of studying, producing, correcting mistakes and starting over again (Newman, 1991). CA scaffolds students’ persistence with learning mathematics through establishing a classroom culture of learning based on a teacher-student negotiated charter of values (Renshaw & Brown, 1997). The values negotiated reflect social virtues of engagement such as courage, humility, honesty, restraint, persistence and affirmation, and together with the key word format guide activity in the mathematics classroom. In terms of teacher education specific sociocultual practices related to CA such as representing mathematical ideas and using language to compare, explain, justify and validate ideas have been at the core of in-service professional development and pre-service mathematics education undergraduate and postgraduate courses.

The research history associated with the design and development of CA extends back to 1992. From 1992 to 1994 the research was concerned with the design of the model of CA (see Brown, 1994). From 1994 to 2001 the research was concerned with designing and researching the implementation of CA in a mathematics classroom (see Renshaw & Brown, 1997; Brown, 2001). From 2001 to 2005, the research concerned itself with disseminating the findings of the earlier research to teachers, principals, pre-service teachers and system authorities (see Brown, 2005b). It was at this stage of the research that Jackie, the teacher who is the focus of this article, approached the researchers and requested to be a part of the CA project. From 2005 to 2008 the research was synthesised through the implementation of a nationally funded research scheme. This larger research project aimed to explore if CA (a) could be appropriated by teachers and students in the mathematics classroom, (b) improves the overall quality of teaching and learning in the mathematics classroom, and if the use of CA (c) promotes productive classroom talk and higher-order thinking skills. In terms of the above aims, the research found that CA (a) can be appropriated by teachers and students in the mathematics classroom (Brown, 2005a; Hirst & Brown, 2008; Brown & Hirst, 2010;

Brown, 2011; Brown, Heck, Pendergast, & Kanasa, 2014), (b) improves the overall quality of teaching and learning in the mathematics classroom, (Brown & Renshaw, 2006; Brown, 2007; Brown 2009a; Brown 2009b Brown, 2010; Marshman, & Brown, 2014), and (c) promotes productive classroom talk and associated higher-order thinking skills (Brown & Hirst, 2005; Brown & Hirst, 2007; Renshaw & Brown, 2007; Redmond, Brown, & Sheehey, 2013; Brown, Redmond, Sheehey, & Lang, 2015). This article is concerned with exploring the affordances and constraints of using CA to facilitate student engagement with mathematics in a Year 7 school classroom.

Method

The design of the larger research project was based on a 'teaching experiment' (Cobb, 2000). The 'teaching experiment' is an extension of Vygotsky's (1987) experimental-developmental method designed to capture the determining influence of social and cultural processes on learning and development. The initial stage of this study was about learning about collective argumentation and involved participants in three whole-day professional development sessions where participants were coached in a problem solving approach to teaching mathematics that required students to represent a solution to a problem individually, to compare this representation with other representations generated in their group, explain and justify their solution to the group and then come together with the group to agree on a solution to the problem that could be presented to the whole group for discussion and validation. After the initial cycle of the study, six participants were involved in the design, implementation, analysis and dissemination of the remaining cycles of the study, namely, learning with CA and learning from CA as co-researchers.

The role of teacher as co-researcher is consistent with a sociocultural approach to research and required all those associated with the research (researchers, assistants and teachers) to be integrally involved in collecting and analysing data, incorporating results into classroom practice and disseminating findings through presentations, workshops and writing. As such, each co-researcher had decision making authority and a commitment to continual professional development and to using a systematic approach to reflect on practice. No participant in this research received any incentive, including credit for any course of study, for participating in the research.

Participant

The research reported in this article reports on one Year 7 teacher (Jackie) and her perceptions of the affordances and constraints of using Collective Argumentation (CA) to facilitate student engagement with mathematics. Jackie was chosen as the focus for this article for her commitment to developing her role as a co-researcher. This commitment involved Jackie in exploring and reporting the affordances and constraints of using CA in an everyday primary classroom, a classroom where the teacher has to demonstrate achievement and consistency to students, parents, other teachers, principals and system authorities over an extended period of time (9+ years). Over this extensive period, Jackie taught in metropolitan, co-educational primary schools.

Data sources

The study required each class of students and their teachers to be video/audio taped twice during the year when using CA in their mathematics lessons. Observational records relating to teacher-student and student-student interactions were made on a regular basis and the teachers and those students who were able were asked to keep a reflective journal. Teachers were also asked to provide an oral or written report about their experiences of using CA at professional development sessions and conferences.

Interview protocol

Towards the end of the study each teacher was interviewed about their perceptions of doing CA in their mathematics lessons. These interviews employed stimulated recall (see Meade, & McMeniman, 1992) as a tool for collecting data. Teachers individually responded to a set of questions whilst watching a video of their class doing CA in a mathematics lesson. Stimulated recall was used in the interview as a mediating process (O'Brien, 1993) to capture the reflections-in-action of teachers in the classroom (Stough, 2001), and the questions posed by researchers were general in nature to assist teachers to reflect on issues related to using CA to teach mathematics.

In terms of this article, Jackie's responses to questions about the good points and difficult points of using CA are the focus. In particular Jackie was asked, "What are the good points of CA for your own teaching?" To balance this question, Jackie was also asked, "What are the difficult points of CA for your own teaching?"

Journal Writing Framework

To inform teaching practice and to provide a record of day to day observations each teacher was provided with a 'journal writing reflection sheet' and asked to record their perceptions of doing CA for each lesson. This reflection sheet provided opportunities for the teacher to record his/her perceived level of (a) influence over the direction of the lesson's proceedings, (b) assessment and monitoring of student activity, (c) affect associated with participating in the lesson, and (d) personal learning and difficulties associated with implementing the lesson. Opportunities to reflect on the quality of learning were provided in the sections of the reflection sheet devoted to the assessment and monitoring of student activity. For the purpose of providing insights into the affordances and constraints of using CA to facilitate student engagement with mathematics, Jackie's journal reflections about implementing a mathematics unit on Area (6 lessons) were chosen for analysis.

Written report context

Reports by teachers on their classroom activity were written for and delivered at professional sessions and conferences of mathematics teachers and educators. Each report was a reflection on their own teacher practice and covered the following topics: (a) Why did you consider using CA in your mathematics lessons, (b) What effect did this consideration have on your students, (c) What were the good points and difficult points of using CA to teach mathematics, and (d) How did using CA fit or not fit with current curriculum expectations and classroom planning?

Analytic Framework

Jackie's interview was transcribed and, along with her written reflections and report, subjected to a form of analysis derived from methods associated with the sociocultural family of theories related to the work of authors such Lave & Wenger (1991), Wenger (1998), and James Wertsch (1991) and framed around Vadeboncoeur's (2006) participation framework. This framework centres on the broad categories of *location* - how the classroom is organised, *relationships* - the roles and responsibilities visible in the classroom, *content* - type of knowledge privileged in the classroom, *pedagogy* - what the teacher and students do in the classroom, and *assessment* - what is valued in the classroom (Vadeboncoeur, 2006).

The Vadeboncoeur framework was developed to be used in informal contexts of learning. However, the elements of the framework: location, relationships, content, pedagogy, and assessment relate to all learning contexts both formal and informal and can be used in any context that has goals and expected outcomes (Vadeboncoeur, 2006). This framework

was chosen to frame the analysis of data as some of the teachers involved in the study were from alternative education sites (see Singh, Brown & Märtsin 2012; Brown & Redmond, 2015). Also, the sociocultural research that surrounds the development of the framework speaks to Finn's (1989) 'participation-identification model' that emphasises the importance of locating learning within the context of schooling and Newman's (1991) focus on students who do not succeed in school. As such, the participation framework provides a useful tool for identifying patterns of relationships and interactions constituted in social and discursive practices, practices such as representing, comparing, explaining, justifying, agreeing and validating, and for exploring the affordances and constraints of using CA to teach mathematics.

Analytic Process

In terms of the analytic method of this study, issues central to the quality and credibility of qualitative research as referred to by Patton (1999) were addressed. First, the procedure for gathering data was rigorous in that the interviews, classroom observations and report/journal writing were conducted, recorded, scaffolded and transcribed by a Research Assistant. Second, participants' interview and report/journal writing data were analysed by two researchers who cross-referenced participant responses with classroom observations. Third, researchers engaged in ongoing conversations about particular data interpretations where there was disagreement until agreement was reached. Fourth, initial analyses of interview and report/journal data were presented to the participants to check for reasonableness. Fifth, in order to minimise researcher bias, initial analyses of data along with examples of student work were presented to teachers, principals and academics at professional development sessions and conferences that encouraged peer review. Unfounded assumptions or biases that emerged during these presentations were set aside and alternative interpretations of data sought.

Analysis

Location: classroom versus school

For Jackie, the mathematics classroom emerges as a 'busy', 'co-operative' place where students can feel safe to make and 'recognise mistakes'. In her Journal Entries Jackie writes:

I loved watching the co-operation, the ability to realise mistakes and correct or even the ability to recognise mistakes even though they (the students) did not know what to do. All children were involved and all children were busy (Journal entry, 26/05).

In response to the interview question, "What are the good points of CA for your own teaching?" Jackie focused on student presentations of work as being the 'selling point' of CA.

I have done group work previously, I've done cooperative learning, I've done all those other things and, yeah, I've got good results sometimes, other times I haven't. What sold this (CA) and the change I saw in their (the students) work was when they had to get up in front of their peers and had to really and truly own it and understand it.

Nevertheless, the time taken for students to do these presentations can be a 'worry'. In response to the question, "What are the difficult points of CA for your own teaching? Jackie responded:

With CA, by the time they (the students) have finished giving all their presentations it takes me roughly an hour and a half sometimes longer. I worry that teachers are going to dismiss it (CA) because it takes too long.

As such, it appears that 'school' emerges or has the potential to emerge for Jackie as a place where making students' thinking public and spending one and a half hours on a lesson can be anxiety provoking.

I did not enjoy the time it took to complete the lesson (Journal entry 13/07).

However, this anxiety seemed to be compensated for by the learning relationships established in the classroom.

Relationships: student versus teacher centred

For Jackie, building relationships with students is about giving students opportunities to engage in talk about mathematics tasks and to tackle difficult problems.

I see lots of mathematical talk from everybody. I am so pleased with how many children are willing to tackle difficult problems. They really want to challenge themselves (Journal entry, 13/07).

Building relationships in her classroom is about providing support for students to pursue 'creative' solutions to tasks and about getting students to develop autonomy in the process.

I enjoyed the creative way Group A and myself were able to come up with a fairly accurate solution. I also enjoyed the fact that Group A were able to represent and explain their solution without my help (Journal entry 10/06).

Engaging in mathematics is now a social responsibility of all in the classroom, the 'bossy', the 'shy', and the 'knowledgeable'.

The greatest thing that I think comes out of it (doing CA) is the social relationships stuff. The importance of negotiating with other people, working with different personalities, you know, the bossy person, the knowledgeable person, the shy person.

How much this is possible depends, for Jackie, on dealing with 'dominant' students in a manner that encourages all students, especially the 'hesitant', to have input into the workings of a group in ways that conform to the values of the classroom.

At the beginning of the year one or two children dominated each group, but now everyone is having input. Next lesson I would like to target the one or two children who still 'sit back' or are hesitant – discuss this as a class. I need to revisit the values chart (Journal entry 1/06).

In noting the difficult aspects of CA, Jackie, in her interview added:

The ability to get every child involved in the group and having one or two children that no one wants to work with, that's a difficulty. Yes it is a negative but it is a healthy negative because at least we are exposing it, we are working with it.

These aspects of classroom relationships are echoed in Jackie's written report where she states:

At times the social demands have been too difficult for a student and I have taken the opportunity to co-present with this student; thus modelling the skills required and at the same time giving the student autonomy; rather than operating from an autocratic approach (Report entry p.4).

Nonetheless, the tension existing between aspects of past teacher centred relationships and the present student centred relationships in Jackie's mathematics classroom is evident as exemplified in the following interview extract:

I still have teacher talk lessons occasionally and the discipline comes straight back in. As soon as I am out the front having to teach a lesson, suddenly I would be asking someone to be quiet because they are not listening to me. And if someone wants to ask something they put up their hand to ask a question. But now it is just not part of my teaching anymore. All of the behaviour that was there before that I felt was important, it's just not there. A lot of my energy now goes into checking around the kids and talking to them rather than me getting out the front and worrying about who is listening to me.

However, at times, the nature of the content dictates the teacher-student relationship.

Content: understanding versus memorising

Teaching curriculum emerges, for Jackie, in partnership with engaging 'kids' with mathematics content on 'a level that suits them', where they can feel safe to 'express trouble' with concepts and where they can 're-clarify' their understanding through discussion.

I love the fact that the children can operate on a level that suits them. One or two children had trouble expressing 'What is length?' This is a revelation for me as these children have covered length every year for 7 years. This led to a small discussion on length and next lesson will hopefully re-clarify length, width vs columns, rows vs area (Journal entry, 1/06).

For Jackie, teaching is about scaffolding student understanding through engaging them with the task as reflected in the following interview extract.

Whenever I come to a group I'll be asking, "What have they done?" If they're stuck I'll be asking them, "Why are they stuck? Where are they stuck?" Um, and constantly asking them to retell it (their understanding) back to me.

The aim, for Jackie, is not only to engage students' with the knowledge and skills of mathematics, but also to include their learning style in the mathematics of the classroom.

One girl in particular is communicating mathematical ideas beautifully in the oral situation. I have not seen this ability to grasp concepts in any of her 'normal' maths lessons. I believe we have really tapped into her learning style (Journal entry, 1/06).

These aspects of privileging understanding and engagement are further highlighted where Jackie writes:

When planning I will read what is required by the syllabus and then spend time reading the syllabus materials, and other educational materials, to design what I believe are rich tasks, (inquiry type tasks). Sometimes the students will make an enquiry during class and this will form its own lesson, for example, "Is a decimal fraction the same as a remainder? (Report entry p. 5)

However, Jackie's confidence in using CA to scaffold student understanding does not extend to 'new syllabus' content as illustrated in the following interview script:

But we have had some new syllabus stuff come out this year. And I guess I'm not as confident now to have Collective Argumentation on new content. I want to know that content well before I turn it into CA.

Talking about the difficult points of CA for her teaching, Jackie again refers to teaching the syllabus.

Getting your head around that idea of covering the maths syllabus by giving them (the students) one question (task) but knowing that in that question they are going to explore everything that they needed to know. I worry that teachers will not accept that you are going to be covering a great deal of work with one question (mathematics task).

Nevertheless, Jackie's pedagogy goes beyond simply managing the knowledge requirements of the syllabus.

Pedagogy: extending versus limiting

Teaching emerges from Jackie's journal reflections as having to do with extending the knowing and doing of mathematics into those practices necessary for engaging with mathematics. That is, teaching, for Jackie, has come to mean assisting students to show 'persistence' and 'determination'.

The persistence of the children impressed me. I enjoyed the determination of two groups to get as exact as possible (Journal entry 26/05).

Teaching is about convincing students to 'remain on task', to 'attempt difficult problems' and to 'challenge' the ideas of others.

I enjoyed that an ADHD (Attention Deficit Hyper-Activity Disorder) child remained on task, that three girls who normally are disinterested in maths persisted for one and a half hours to solve a problem, that three 'average' girls attempted the most difficult problem, and the determination of two boys to challenge the teacher's presentation. Their reasons were clear and enlightening (Journal entry 14/06).

This approach to extending students' engagement with mathematics is revisited in Jackie's writing where she emphasises that teaching is about encouraging students' 'understanding' through ways that make 'sense to them' and through extending an individual's understanding to those of others through the 'diagnosis of error patterns' and through the provision of 'constructive feedback'.

The students are encouraged to present work in a way that makes 'sense to them' and this provides students with a variety of ways to come to an understanding. The more capable students are challenged to diagnose errors and/or error patterns thus extending their thinking. All students know their work and efforts are valued as we take the time to discuss and explain these errors thus providing constructive feedback and meeting the needs of the individual (Report entry p. 3).

For Jackie an important aspect of her pedagogy is the use of the key word format. As previously mentioned, Collective Argumentation is founded on interactive principles designed to coordinate student engagement with learning – generalisation, objectivity, consistency, consensus and recontextualisation. These principles are presented to students at the classroom level in the form of a key word format – represent, compare, explain, justify, agree, and validate. This key word format guides student activity as they are encouraged to represent a task or problem alone, compare representations within a small group of peers, explain and justify the various representations to each other in the small group, reach agreement within the group, and finally present the group's ideas and representations to the class to test their acceptance by the wider community of peers and the teacher.

When talking about the key word format in her interview, Jackie referred to 'individual representation' as being important to *"getting students started"*, to 'comparing' as involving students in *"talking to each other and seeing what one person has done"*, to 'explaining' and 'justifying' as helping students to *"see the problem that they are missing"*, and to 'validating' as motivating students to *"suddenly care that someone else is going to*

comment on their work". Yet, implementing the key word format has its challenges for Jackie, especially when dealing with *"the child who is struggling"*, the group that has members who need a solution *"explained to them so many times"* and when dealing with students who find it difficult to have *"negative comments"* made about their work.

As implied in the above, using the key word format has, for Jackie, its affordances and constraints. However, the importance of using CA is reflected in Jackie's approach to assessing student engagement in her classroom.

Assessment: doing versus knowing

For Jackie, assessment seems to be concerned not only with what students can and cannot achieve, but also with 'creativity' and 'variety' mediated through the 'embarrassment' free process of 'making errors' and providing 'explanations'.

The creativity and variety of solutions was interesting and revealing as to the cognitive level of the child (Journal entry 26/05).

When the two groups who made errors with (r^2) presented their work they realized their mistakes after questioning from myself and other classmates and were able to explain the errors also. The children are no longer embarrassed about making a mistake (Journal entry 14/06).

The use of 'errors' by Jackie as a form of assessment is reinforced in her report writing where 'errors' are referred to as providing the teacher with a 'diagnostic tool' and as a strength of doing mathematics. Within Jackie's classroom assessment is conducted in a context where 'fear of failure' is 'diminished', thus providing students with the potential to develop competencies related to the 'doing' of mathematics.

A further strength of using CA is that feedback is immediate, not a day or a week later, which is often the case with work handed in for marking, and errors are seen as a way of learning; they are used as a diagnostic tool for everybody and the fear of failure or looking foolish is diminished (Report entry p. 2).

Assessment, for Jackie, is no longer simply about 'knowing' mathematics, but also about engaging in the 'doing' of mathematics. Yet, helping children see that there are multiple ways of doing mathematics can be a difficulty, for Jackie, associated with implementing CA as illustrated in the following interview response.

Their (the students) ability to learn in certain areas (is a difficulty), we will openly discuss that someone might be struggling in this area and how can we help that particular person. They (the students) will openly admit "I can't get this"; "I can't do this", so we (the teacher and the students) discuss how we can work with them (the struggling student) and how they can be involved (in the mathematics of the classroom).

Discussion

This article set out to describe the affordances and constraints, as reflected in the interview script and writings of one teacher, of using a sociocultural approach to engage students with mathematics in a Year 7 classroom. As can be seen in the above analysis, Jackie's classroom is organised around the sociocultural principles of Collective Argumentation (CA).

According to Jackie, CA is providing her with the necessary tools to engage her students in productive teaching learning relationships in the mathematics classroom. It is well known that student engagement with mathematics declines over the middle years of schooling, years 6 to 9 (Sullivan, 2011). Jackie's perceived improvement in student engagement implies, therefore, a change in her own practice from being a teacher to being an expert participant in the mathematics of the classroom. This change requires from Jackie a shift in the way authority is distributed across the classroom, a shift requiring more symmetrical, engaging and collaborative forms of interaction between teacher and students. Such a shift is necessary for the development of teacher student relationships productive of engagement with mathematics (Cobb, Stephan, McClain, & Gravemeijer, 2001).

This transformation in Jackie's classroom is further evidenced in the type of knowledge that is privileged. Not only is the academic knowledge of mathematics privileged, but also the ways of knowing and doing mathematics. These ways are encapsulated in such virtues as persistence, determination, and challenge and are necessary for managing student affect in the mathematics classroom (Cobb, Yackel, & Wood, 1989). What the teacher and students are doing in Jackie's classroom, therefore, is moving beyond a conventional approach to teaching and learning mathematics to construct a creative and critical classroom context for engaging with mathematics, a classroom context advocated by national documents such as *Mathematics, Engineering and Science in the National Interest (2012).*

The development of this classroom context is further evidenced in Jackie's perceptions of the constraints of CA. As suggested in the above analysis these constraints are expressed in the form of tensions that exist for Jackie in each of the analytic categories. In terms of location, Jackie alludes to the tension between her classroom and the school in which it operates. References to feeling uncomfortable about the time devoted to lessons expresses a concern raised by many teachers interested in implementing an inquiry type approach to teaching mathematics in a school context that privileges a traditional school timetable (Leatham, 2006). Relationships in Jackie's classroom require the teacher to support students to engage with classroom talk, to assume autonomy in the learning process, to actively participate in their own learning and, where reasonable, challenge students' and the teacher's

ideas. Constructing such student centred relationships in a mathematics classroom can be uncomfortable for teachers who are used to the division of labour that exists in many conventional classrooms (Sullivan, 2011).

In terms of content, it is clear that Jackie is concerned with teaching mathematics to students in a manner that facilitates understanding through engaging in meaningful tasks. This can be somewhat difficult at times for teachers operating in school systems that are rated by their students' performances on standardised, external testing regimes (Leatham, 2006). Pedagogy, for Jackie, appears to be framed by the values/norms of mathematical practice, such as determination and persistence. Such norms are necessary to implementing the type of teaching appropriate for the development of inquiry type approaches to teaching mathematics (Makar, Bakker, Ben-Zvi, 2015). However, such pedagogy is often represented by teachers as being unsuitable for dealing with disengaged students (Sullivan, 2011). It is not surprising then to see that what is valued in Jackie's classroom goes beyond the 'knowing', that is, the conceptual and procedural knowledge of mathematics, to embrace competencies related to the 'agency' and 'accountability' of 'doing' mathematics, competencies necessary for engaging with mathematics. As such competencies are intimately related to the structure of the tasks presented to students (Goos, Galbraith, & Renshaw, 2002), it is not surprising that competencies of this nature are not privileged in many conventional classrooms, another potential source of tension for Jackie when, for example, moderating assessment practices with other teachers. For Jackie, assessment seems concerned not only with what students should achieve, but also with what students could achieve when working with others if provided the opportunity, a view of assessment in line with the sociocultural principles that underpin CA.

Conclusion

This article has explored a primary school teacher's interview script and writings relating to implementing a sociocultural approach to engaging students with the learning of mathematics. As used by Jackie, Collective Argumentation (CA) has the potential to focus the teacher on collaborating with students to come to know and do mathematics.

In terms of the larger study referred to in this article, findings suggest that teachers can employ the pedagogical strategies of CA in the domain of mathematics if they are supported within their school communities and provided with on-going assistance. Nevertheless, the level of efficacy of such appropriation for bringing about lasting change in student engagement with mathematics varies. Transforming teacher practice in the mathematics

classroom requires the teacher to learn how to balance the complex interactions between relationships, content, pedagogy, and assessment with the institutional location of schooling. How teachers may be assisted to address this balance is a focus of future research.

Findings also suggest that aspects of CA such as students comparing their ideas with others, explaining and justifying their ideas to others and presenting ideas to the whole class for discussion and validation can be used by teachers to promote behavioural, emotional, and cognitive engagement with mathematics. These findings are in line with the work of researchers such as Finn (1989) and Newman (1991). However, before the use of such practices can spread beyond Jackie's classroom, issues related to the constraints of implementing approaches such as CA in the mathematics classroom need to be dealt with at the national, state and local levels of schooling. These constraints relate to and reinforce the belief of many students (especially low-achieving students) that they cannot learn mathematics (Sullivan, 2011).

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