Reconceptualising Agency Through Teachers Talking About a Sociocultural Approach to Teaching Mathematics in the Classroom

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This paper explores teachers' "agency" as they talk about using a Sociocultural approach to teaching and learning (Collective Argumentation) to mediate activity in the mathematics classroom. The paper examines a re-conceptualisation of teacher agency as evidence in a report by one middle school teacher of a classroom mathematics activity. Employing discourse analysis to examine aspects of teacher activity in the report, the paper relates the development of teacher agency to the appropriation of pedagogical practices and to teacher talk about those practices.

Classrooms operate within institutions and suffer constraints common to institutions, constraints that specify the roles, status and degree of autonomy that teachers and students are accorded. However, due to the diverse ways of living that teachers and students bring to teaching and learning, classrooms are also embedded in contexts in which learning is mediated by the social and cultural identities of participants (Bruner, 1996). A question that confronts teachers of mathematics, therefore, is how best to establish in their institutional spaces (primary, middle-school, senior-secondary) classroom communities where they may participate more fully with their students in the discourse of the mathematics curriculum, that is, in the ways of thinking, saying, writing, and doing deemed essential by a society's culture for a worthwhile way of life. It is a purpose of this paper to explore the affordances that one particular Sociocultural approach to teaching and learning (Collective Argumentation) provides teachers when engaging in what Pickering refers to as the "dance of agency".

In accounting for historical advances in mathematics and science, Pickering (1995) labelled the tension between the agency of the person knowing and doing the mathematics and the agency of the discipline that accredits and conventionalises ways of knowing and doing mathematics as the "dance of agency". According to Pickering (1995) when teachers follow the established patterns of the discipline, they privilege disciplinary agency and when they take initiative through engaging students in open-ended tasks and cross–discipline conversation they privilege human agency. It is in negotiating the forwards, backwards and sideways movements from the human to the discipline, from the "everyday" to the "scientific", that the "dance of agency" can be conceptualised as taking place.

Mediating Agency in the Classroom

From a sociocultural point of view, simply theorising "agency", that is, the capacity to plan, implement and evaluate the attainment of a goal, as originating in the individual or in a collective (see Hernandez & Iyengar, 2001) is insufficient for understanding the mediating role of "agency" in the learning of mathematics. From a sociocultural perspective, agency needs to be understood as being synonymous with a person's way of being, seeing and responding in the world and as being embedded in contexts of activity and interpretive practices (Edwards, 2000). This understanding is commensurate with research findings that suggest that situating teaching and learning within particular activity contexts influences mathematical development. For example, in articulating the role of discourse in the learning of mathematics Cobb and Hodge (2002) note that student participation in the discourse practices of their classrooms (e.g., engaging in an Initiation-Response-Evaluation format of classroom talk or engaging in reflective discourse) influences the identity development of students when learning mathematics. Van Dijk, van Oers, and Terwel (2003) provide evidence that teacher demonstrated and student co-constructed mathematical models lead to different ways of problem solving in students. What these studies highlight is the tension in mathematics teaching and learning that exists between conventional mathematics and novel ways of knowing and doing mathematics – the "dance of agency".

The notion of "mediated agency" recognises the "dance of agency" as it may play out in the classroom by focusing attention on the "irreducible tension" manifested between agent/s (e.g., teachers, students) on the one hand and the mediational means (e.g., ways of knowing and doing) that they employ or have access to on the other (Wertsch & Rupert, 1993, p. 230). Through interpreting the relationship between agent/s and mediational means in terms of "mediated agency", Wertsch and Rupert (1993) promote a view of human agency which positions mental functioning within systems of collective action that are culturally and historically situated.

From this point of view, issues which affect the organisation of mental functioning on the intermental plane (such as authority, membership, and norms which privilege certain ways of thinking and acting) are seen as essential aspects of functioning on the intramental plane.

According to Smith (1996) approaches to teaching mathematics that extend beyond transmission approaches to teaching and learning and that recognise the tension between teachers' and students' ways of knowing and doing often fail to help teachers reconceptualise their sense of agency and thus fail to convince teachers to change their classroom practice. What is needed if teachers are to move their pedagogy beyond transmission are, according to Smith (1996), opportunities for reconceptualising agency in the teaching of mathematics – opportunities that assist teachers to:

- design tasks that support the development of student thinking/understanding;
- predict student reasoning and the language they may use to express it;
- create safe contexts where students can express and justify their own ideas; and
- value students' activity whilst introducing conventional mathematics.

This paper explores teachers' "agency" as they talk about using a Sociocultural approach to teaching and learning mathematics (Collective Argumentation) to mediate teacher and student activity in their classrooms. Specifically, it examines a reconceptualisation of teacher agency as evidenced through a report by one teacher (Sam) of a classroom mathematics activity to a group of peers.

Method

Sam's report on his classroom activity took place during a professional development session that was part of a larger study into teachers' appropriation of the practices of Collective Argumentation into their everyday teaching of mathematics and/or science. The larger study, conducted over a three-year time frame, involves university educators working with 20 elementary and middle school teachers of mathematics and/or science from 6 schools located in South-East Queensland to bring about and reflect upon change in the way they teach mathematics and/or science.

Collective Argumentation (Brown & Renshaw, 2000) is an approach to teaching and learning that is based on five interactive principles necessary for coordinating competing knowledge claims. First, the "generalisability" principle requires that students attempt to communicate their ideas, so that fellow students can participate in sifting relevant from irrelevant ideas. Second, the "objectivity" principle requires that relevant ideas can be rejected only if they can be denied by reference to past experiences or logical reasoning. If ideas cannot be denied then they must remain part of the discussion. Third, the "consistency" principle requires that ideas which are contradictory to each other or that belong to mutually exclusive points of view must be resolved through discussion. Fourth, a principle of "consensus" requires that all members of the group understand the agreed approach to solving the problem. If a member of the group does not understand, there is an obligation on that student to seek clarification, and a reciprocal obligation on the other group members to assist. Finally, the "recontextualisation" principle involves students re-presenting the group response to the other members of the class for discussion and validation. Communicating to class members outside the group, challenges students to rephrase their ideas, to defend their thinking, and to reassess the validity of their thinking.

Research Design

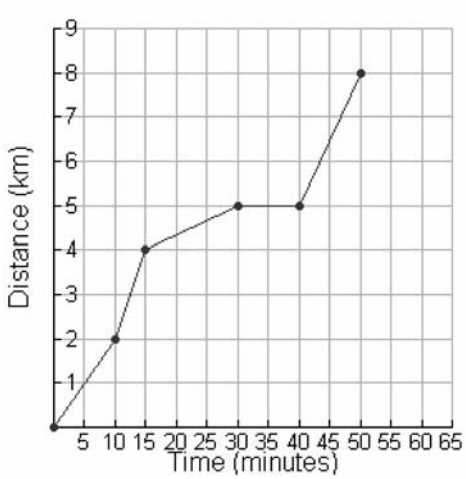
The study employs a sociocultural methodology, based on a "design-experiment" (see Schoenfeld, 2006). The "design-experiment" involves prolonged systematic inquiry into change through engagement in collaborative cycles of analysis, design, implementation, assessment and reflection. The professional development session referred to in this paper was one mechanism used to assist teachers to reflect upon and assess the nature of the activity of their students, their activity as teachers of mathematics and/or science, and the co-constructed activity of their classrooms.

Research context. During a professional development session, involving seven teachers and two mathematics educators, teachers were invited to report on the teaching and learning of mathematics and/or science in their classroom. Each report was video-taped, transcribed and subjected to a form of discourse analysis. Discourse analysis has been used by researchers to, among other things, situate teachers' instructional practices in institutional settings (Cobb, McClain, de Silva Lamberg, & Dean, 2003), and to study the development of students' critical awareness in the mathematics classroom (Wagner, 2007). Informed written consent was provided by teachers for their reports to be used for research purposes.

Research participant. The teacher who is the focus of this paper, Sam, had been using the practices of Collective Argumentation to inform his teaching of mathematics for one school year. Sam taught at a P-12 school located in a middle-class suburb of a major city. Sam started his career, now in its 20th year, by framing his teaching of mathematics within pedagogical practices that reflected a transmission approach to teaching and learning. As such, Sam's agency as a teacher of mathematics, that is, his knowing what to say, when to say it, and how to assess and report student performance, was supported by working in a traditional classroom using tools such as textbooks. However, after a decade of wondering why students performed inadequately when it came to the application of mathematics to novel situations, Sam set out on a journey of professional development which led him to view student learning within a framework that anchored teacher agency to pedagogical strategies that afforded him a focus on student understanding. The following sharing of a classroom lesson with peers provides insights in to the nature of these affordances. The class referred to in Sam's report is a Year 6 class of high-achievers who were being accelerated in their study of mathematics.

The task being reported. The task that was the focus of Sam's report is represented in Figure 1. In the analysis that follows, italics have been used to identify Sam's actual words.

Collective Argumentation Task



a. You are to write a plausible story for this graph. You need to provide a full explanation.

b. You are to develop a suitable title for this graph.

c. Suppose there is need to return back to the starting position by 65 minutes, how can this be shown on the graph? What speed would need to be travelled to allow this to occur? Do you think it is likely that it will be possible to achieve this goal?

Figure 1. Task sheet as presented to a Year 6 class.

Analysis of Sam's Report of a Classroom Lesson

Choosing problems that privilege understanding. *In describing the lesson to peers, Sam commenced by situating the activity of the class within a problem solving context that allowed students to* "give me some information about how they are going in developing … understanding". *Adapting a textbook activity so that it* "allowed them to use collective argumentation" *and so that the students could go* "away and have a bit of a play"*, Sam's purpose was about eliciting* "a variety of responses" *from students. Explaining that this* "play" *was structured by* "focus questions" *(see Figure 1), Sam admitted that he had inadvertently limited student thinking,* "I made a mistake"*, by verbally introducing the problem to the class within the context of* "a runner" *and by referring to* "how fast the runner would need to run". *This contextualising of the problem was interpreted as a mistake by Sam because it was seen as directing student thinking toward a response that* "was very straight forward" *a response that simply required students to* "draw a line from that point *[see Figure 1 coordinates (50,08)]* down to that point *[see Figure 1 coordinates (65,0)]*".

This introduction by Sam to the teaching of a mathematics lesson provides an important insight into how Sam interprets knowing and doing mathematics in this classroom. Teaching mathematics is seen by Sam as being a creative endeavour where the teacher and students are fully engaged in coordinating their interpretations of a task and in establishing co-operative patterns of interaction whilst at the same time having their creativity structured by convention, for example, the use of "focus questions". This view of mathematics evidences a sociocultural approach to teaching and learning mathematics where a balance may be achieved between students' individual ways of thinking and the collective endeavour of the class to learn mathematics. It is in achieving this balance in the classroom that mathematics conventions may be connected with students' inventions (Lampert, 1990). In the process, students may encounter multiple and varied ways in which to participate in mathematics, ways facilitative of the development of understanding and the "higher mental" processes – ways in which Sam's admission that *"I made a mistake"* is interpreted in a developmental rather than self-effacing sense. Sam then goes on to provide his peers with an enthusiastic account of how one group of students responded to the task (see Figure 2).

A Student Group Response

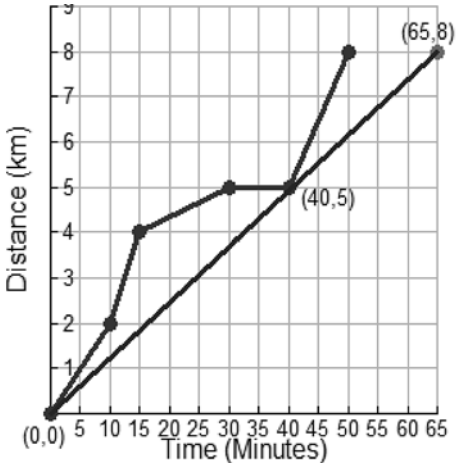


Figure 2. A novel response to a "straightforward" task.

Moving beyond the expected to consider the novel. Sam narrated a "plausible story" provided by one group of students that he considered to be a novel response to the task. The story concerned a bicyclist going for a morning ride travelling at 0.2 kilometres per minute for the first 10 minutes, 0.4 kilometres per minute for the next 5 minutes, 0.07 kilometres per minute for the next 15 minutes, resting for 10 minutes and then travelling 0.3 kilometres per minute for the last 10 minutes. So this group of students had translated the problem in terms of the concept of *"speed",* a translation that Sam considered to be *"pretty cool".* However, what was *"really cool"* was the return journey where the students *"found the average speed. So they said I want to get home in sixty-five minutes, so this is where home is* [see Figure 2 (0,0)]*, so what they found was they drew a point from here* [see Figure 2 (65,8)] *to here* [see Figure 2 (0,0)]*, because this* [points to the coordinates (65,8)] *is how far out they are, so they are eight kilometres away and they want to get back home in sixty-five minutes… So that's the speed he's got to travel to get back home, and they* (the group) *found the equation to that particular line." Sam then went on to say that he had "never actually thought about it* (the task) *like that" and that "for them* (the group) *to interpret it* (the task) *that way, it's really cool".*

This account by Sam of a student group response to the task highlights an important element of the nature of the teacher's agency in this classroom. Sam's knowing what to say, when to say it and how to evaluate a response is anchored to "thinking mathematically", that is, to applying formal mathematical knowledge flexibly and meaningfully to appropriate situations. This is reflected in Sam's utterance that he *"never actually thought about it* (the task) *like that"* and that *"for them* (the group) *to interpret it* (the task) *that way, it's really cool"*. As such, Sam's agency within this mathematics lesson may be said to reside not in his authority as the "teacher" nor in his use of a textbook task, but in his capacity as an expert who is willing to participate in the struggle to understand the novel and to link it to the knowledge of the discipline – to engage in a "dance of agency" with his students. As such, it may be said that Sam's report of a class activity to a group of peers is just as much about how he values thinking about and understanding mathematics as it is about finding equations to particular lines – an essential element of mathematics teaching and learning (Schoenfeld, 1988). This valuing is reflected by Sam's peers as they engage him in discussion about the activity of his class. For ease of presentation only those turns of the 5 minute discussion that are representative of teachers' contributions are recorded in Table 1. Please note that all turns are in chronological order.

Table 1

Teachers thinking about student thinking

Turn	Speaker	Dialogue
01	Julie	The fact that they (the group) sort of interpreted it (the task), the fact that they wanted to get home in sixty-five minutes and so that (7.35km per hr) is the average speed that they needed to travel to get through, I thought that was pretty clever.
02	Jay	It's a realistic way as you said.
03	Sam	I mean they probably could have intersected it (the X-axis) further down, but then you've got the same sort of problem of the speed scenario. Yeah, so they have done their calculations and they have come up with a speed of, the slope of that line is what, 7.35km / hr to reach home. So in terms of the speeds they were travelling all the way through, that is a reasonable type of speed.
04	Julie	What made them (the group) go backwards (work from right to left), I mean every juncture of the journey, they've (the group) always moved from left to right, why are they going that way (right to left)?
05	Sam	Well I think they were just trying to represent the fact that they were going to travel eight kilometres in sixty-five minutes, you know that's what they were trying to do, trying to represent the fact that they were travelling eight kilometres in sixty-five minutes. And of course that's right they couldn't of dropped it down here [to the point (65,0)] because then they wouldn't of travelled it in sixty-five minutes they would of only travelled it in fifteen minutes, so they actually had to go back to that point (0,0) to actually satisfy the condition of travelling the eight kilometres in sixty-five minutes.
06	Jay	Maybe it's my not understanding, but wouldn't that (the question) be, 'Complete the whole thing (journey) in sixty-five minutes?' But they (the group) have done to take sixty-five minutes to get back home, just different interpretation.
07	Sam	That's right they've (the group), it was to return home, well they've sort of read it as (getting home) by sixty-five minutes.
08	Sam	So in terms of what I expected and what I got I thought that (the group response) was pretty cool.
09	Julie	Yeah because scientifically and mathematically we always do it (read graphs) left to right, so um, but it (the group response) is right. I think what they have done is they have reinterpreted to idea of time. Total time as opposed to …
10	Sam	It took me a long time to understand what their interpretation was and why they did it, but when I finally did (understand) it (the group response) was fine.

It is clear from the above excerpts of teacher discussion that this group of teachers privileges thinking about and understanding the mathematics generated by students over replacing students' ways of knowing and doing with disciplinary conventions. This privileging is represented in statements that, although accepting the response as being *"pretty clever"* (turn 01), provide some sense of the "dance of agency" that these teachers are participating in on a regular basis as they struggle to understand a novel student response within an institutional curriculum that privileges the conventions of the discipline. Statements that peppered the whole discussion such as *"what made them* (the group) *go backwards* (work from right to left)*..."* (turn 04), *"maybe it's my not understanding, but wouldn't that* (the question) *be, 'Complete the whole thing* (journey)

in sixty-five minutes?'" (turn 06), *"…because scientifically and mathematically we always do it* (read graphs*) left to right…"* (turn 09), and *"it took me a long time to understand what their interpretation was…"* (turn 10) provide evidence that these teachers have moved beyond simply managing the tensions between students' goals and the goals of the school classroom. The verbal interactions between Julie, Jay and Sam evidence a desire by these teachers to use students' representations of solutions to tasks as "cultural tools", that is, as thinking devices that may explain and generate understanding. This is evidenced in Jay's statement at turn 02 that the student solution *"is a realistic way"* of addressing the task, by Julie's statement that *"…we always do it* (read graphs) *left to right, so um, but it* (the group response) *is right"* (turn 09), and Sam's statement at turn 08 that *"…in terms of what I expected and what I got I thought that* (the group response) *was pretty cool"*. In so doing, these teachers are struggling to interpret the novel within the conventional, at the same time gaining insights into their own practices as mathematicians and/or scientists.

Conclusion

This paper explores the nature of "agency" as evidenced in a teacher report of a student solution to a task provided to teachers who employ a Sociocultural approach to mediate the teaching and learning of mathematics. As Sam talked to and with the teachers during the presentation a number of characteristics of Sam's "agency" in the mathematics classroom became evident. Firstly, Sam's way of being, seeing and responding in the mathematics classroom is embedded in contexts of activity, contexts that will allow students to go *"away and have a bit of a play"* and that will elicit *"a variety of responses"* from students. Secondly, Sam's capacity to plan, implement and evaluate the attainment of a goal in the mathematics classroom is embedded in interpretive practices that give Sam *"some information about how they* (the students) *are going in developing ... understanding"*. These characteristics of agency are reflected in statements made by Sam's peers as they partner Sam in a "dance" of linking a novel student response to their own understandings and to ways of knowing and doing privileged by the discipline. In so doing, Sam, Julie, and Jay are provided with opportunities to gain further insights into the efficacy of what they are doing in their classrooms and to further conceptualise a sense of teacher agency that validates their efforts to provide opportunities for students to bring their understandings to bear on tasks and to see the effects that these understandings have on making sense of mathematics.

The development of a sense of agency that utilises the tension between teachers' and students' ways of knowing and doing, a sense of agency as evidenced by Sam and his colleagues, has been shown over time to be supported by the principles of Collective Argumentation. These principles assist teachers to utilise tasks that will permit students to generalise and objectify their thinking, to employ practices that promote consistency in student reasoning and consensus in the ways thinking may be represented, and to create contexts where students can safely discuss their ideas and accept guidance from others. Principles that not only support a Sociocultural approach to teaching and learning in the mathematics classroom, but also assist teachers to reconceptualise their sense of agency in the classroom by talking about and reflecting upon their own practice.

Not all 20 teachers involved in the larger study display conceptualisations of "teacher agency" that are in accord with that displayed by Sam and his colleagues. Teachers' conceptualisations of agency are influenced by many factors such as level of competence with the knowledge of the discipline and the amount of support provided by institutional authorities in implementing different approaches to teaching and learning. However, initial findings of the larger study suggest that talking about classroom practice with colleagues also influences the development of teachers' reconceptualisations of agency in the mathematics classroom.

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