A Poststructuralist Analysis of Mathematical Inquiry in a Year 6 Classroom: The Rhetoric, Realisation, and Practical Implications

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Mathematics is a discipline comprising abstract ideas best accessed and understood through learner engagement in investigative or inquiry based processes leading to the development, justification and use of mathematical generalisations (Cockroft, 1982; Australian Education Council, 1990; National Council of Teachers of Mathematics, 1991). However, as I attempt to demonstrate from analyses of teaching/learning interactions in a Year 6 classroom, where students are investigating the relationships between square centimetres and square millimetres, the nature or climate of such engagements is always problematic and can have positive or negative effects on learner agency and identity. This being so, I argue that contemporary humanist notions of rational, autonomous learners currently framing practice may actually militate against genuine inquiry and engagement on the students' part, and, in the interests of responsible pedagogy, need to be tempered by the recognition that agency and identity are discursively constituted.

Mathematics has always played a significant role in the development of society, and has held a position of importance and some privilege in the school curriculum. However, students leaving school in the twenty-first century will need quite different competencies, skills and dispositions than those previously required; they will need to be competent and confident lifelong learners, problem identifiers and problem solvers, agentic participants in a learning society (Education Queensland, 1999). New times bring with them new challenges and these must be addressed by policy makers and educators as they also attempt to deal with past legacies, such as falling enrolments in mathematics at advanced levels and a shortage of good teachers (The Australian, 25.10.99, p. 25). It appears (Willoughby, cited in Burke and Curcio, 2 000) that teachers have failed to teach the appropriate mathematics, the mathematics they have taught has been taught in such a way as to make students dislike both the mathematics and the learning of it, and even if school leavers could use mathematics effectively they would be unlikely to do so. Confrey (2000) also adds that there is something in the construction of the practice and discipline of mathematics that results in certain groups being disproportionately filtered out by instructional practices and experiences that are impersonal and alienating.

Historically mathematics educators and researchers have attempted to redress any such problems by a renewed concentration on teaching method. There is always the unstated assumption that if the teaching method could be improved, by adding more physical resources, by introducing more learner collaboration, by celebrating student voice and cultural background, by more teacher development programs and so on, that learning would be more productive and all would be well. Although it is sobering to note that "the history of reform in mathematics education is largely one of failure" (Gregg, 1995, p. 444), over the past score of years there has been an enormous interest in teaching methods that "open up" (Jaworski, 1994, p. 2) mathematics through encouraging student inquiry as a means of redressing past problems.

The notion of mathematical inquiry, or inquiry based mathematics, is not simple nor uncontested. Initially (Cockroft, 1982) problem solving and investigation were presented as discrete teaching approaches that could be used to foster and encourage the construction of mathematical knowledge and higher order thinking skills. In practice, a general confusion arose over doing *an* inquiry or investigation and investigation as a general strategy, a process of inquiry permeating the entire curriculum (Morgan, 1998). Eventually, the latter interpretation gained ascendancy, among tertiary based educators and researchers at least, who saw the importance of moving away from a mathematics of recall and memorisation to a mathematics of conjecture, reasoning, investigation and inquiry as engaged in by real mathematicians. Inquiring habits of mind were to be encouraged and supported. As O'Connor (1995, p. 53) reports, the aim was to overcome the "brittle" performances resulting from pedagogies of old and to engage students "with a desire to explore the world in mathematically interesting and coherent ways and make sense out of complex situations, whether in the 'real world' or the world of mathematical structures".

The arguments above about the competencies and personal and intellectual autonomy that persons will need in the future, and the means of getting there, seem at first glance to be expressions of sound common sense. However, if one takes seriously the discursive or social construction of knowledge, the understanding that all knowledge is produced through various relationships of power in pedagogic interactions and relationships, one senses that the faith put in inquiry based approaches to teaching is too up-beat, too optimistic, too little researched (Ernest, 1996). Because notions of student identity and agency are taken for granted, as in all humanist based practice, their specific nurturing is not consciously considered in each and every learning encounter. Mathematics education, in whatever form (transmission, inquiry-based, constructivist, social constructivist), is a composite of many intersecting discourses each comprising intellectual truths, and as discursive practice, it operates to constitute the identities of individuals. 'Inquiry' based approaches also comprise power relations that position students as capable and agentic or not; the ability to genuinely inquire is a discursive positioning usually reserved for the teacher, it is not an individual attribute or disposition. We should not assume that relations of power no longer exist simply because they are not recognised, not seen.

In this paper I attempt to show that the classroom I visited, like all classrooms, is a site of struggle over knowledge and power (Davies, 1997). Although the teacher in the study imagined that her students were free to engage autonomously in the mathematical reasoning processes of conjecture and investigation, it transpires that many did not do so. Beyond this, I ponder what the effects on learner identity might be where a teacher does not recognise the positive ways in which a discourse might operate to teach intellectual knowledges and support agency. In seemingly trying to deny power, the teacher steps back where she should intervene regarding the construction of mathematical knowledge and agency.

Methodology

The poststructuralist analysis I undertake, interrupting and adding to commonsense assumptions about inquiry-based pedagogies, recognises that discursive power relations, between teacher and students, and students themselves, enable some learners to establish themselves as competent and confident while others are not nearly so well positioned. Since this relative positioning is constitutive of identity, it is important that all students are recognised, respected and valued as competent participants in the discourse (of school mathematics). The inclination to act in an investigative way though, to inquire, conjecture and explore reaches beyond competence *in* a discourse to go beyond the discursively produced truths to forge something new; it is not a skill that can be practised and applied but is rather a discursively determined way-of-being in mathematics, a learning climate, that resists closure on both the mathematical knowledge constructed and the learning/investigative process.

The aim of my research was to tease out the possibilities and limitations of some core assumptions on which mathematical inquiry appears to be based: that as there is *less teacher control*, students are *free to engage* meaningfully in the investigative process, developing *powerful mathematical structures* (Gregg, 1995). I examine each assumption in turn, using the poststructuralist concepts of power, subjectivity/identity and discourse to reinterpret the educational landscape, challenging popular assumptions and positing new ways-of-being in mathematics education. The key to the poststructuralist analysis is that language use within the discursive practice of inquiry is *constitutive* of mathematical identity and not merely *representative* of the mathematics the students know. Thus the learning context, as in transmission and all teaching approaches, is dynamic and potentially liberating or restrictive of the agency needed for students to engage in in-depth inquiry.

The classroom I visited was a Year 6 in an urban private school in North Queensland. The great majority of the students come from well to do families, the school is well resourced and the teacher renowned for her teaching excellence. On the day of my visit there were 26 students in the class, more males than females. As I had access to only one video camera, I was forced to concentrate on small sections of the classroom action at one time. The teacher provided paper, graph paper and pens for the students, and, after some preliminary asking of ‘area’ questions to set the scene, asked the students to “Investigate how many mm^2 there are in $17cm^2$”.

Is There Less Teacher Control? *Power*

Inquiry based approaches to teaching are often presented as alternatives to direct teaching where the teacher tightly controls the discourse and the process of knowledge construction through engaging students in initiate-respond-evaluate type questioning patterns. In the lesson observed, the students worked in small groups of four where they were to collaborate on the given challenge; the teacher moved around the room helping students who were having problems. A common understanding of what is happening here is that the teacher relinquishes some control or power over the direction the lesson takes to enable students to act in more powerful ways; it is as if the teacher gives power to the students to determine the direction learning takes. But if all students are presumed to have equal access to this power, they are not able to make use of it in equally powerful ways. For example:

> A male (Anglo) student, ignoring the others in the group (2 males and a female), quickly sketches the $17cm^2$, represents each cm^2 as 10×10 mm^2 and establishes the correct answer which he underlines. Group members look on with astonished looks on their faces.
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> A male from a minority cultural group (Indian) cannot get the group to attend to his reasoning although his generalisations are correct and he explains himself clearly. Although his male peers have no real idea of how to proceed, they do not attend to his argument.

From the examples above, it appears that the first male operates powerfully in the classroom, he knows the mathematics and he speaks it competently and convincingly. His understandings are robust and he is very confident in their articulation. The male Indian student, on the other hand, appears to know the mathematics just as well, but is not heard as authoritative by the remainder of the group, who do not accept his constructions nor choose him to present the eventual outcomes. It becomes clear that here power is sustained in relations; it is not a commodity that the teacher can equally mete out to the students. In all schooling contexts, power operates to structure the students' possible field of action even in this case where the teacher is not directly involved. The imperative becomes not to establish who *has* the power or control, but rather *how does power operate* in this particular context to allow some students to establish themselves in powerful ways and others not.

If we accept that power operates in this way there is a potentially dangerous side to a teacher's imagining that she can and should relinquish power. Clearly, the teacher acts in a powerful way in choosing the resources for the lesson, arranging the students in groups and choosing the topic of mathematical inquiry; as she does these things she structures to some extent at least the students' possible fields of action. However, she needs to be cognisant of this fact and recognise and build on the positive productive potential of all teaching/learning interactions. For example, the first male above could do the activity before he started; he did not need to investigate anything and merely reproduced already constructed knowledge. Although he is well positioned in the classroom discourse, if inquiry is to become part of his knowing himself as a legitimate learner, he needs to be challenged and encouraged to go beyond the given task to forge something new; he could perhaps be encouraged to investigate the relationships between linear, area and volumetric conversions. Because the power relations of the classroom are constitutive of mathematical identity, it is important that through classroom activities students come to know not only the mathematics, but to also have confidence in the structure, patterns and relationships of mathematics and in themselves as legitimate learners. Otherwise, as Ernest (1996, p. 7) makes clear, mathematics becomes "a subject with no underlying unity for the learner" and many students lose interest.

Do Participants "Freely" Engage? *Subjectivity/Identity*

A second issue concerning mathematical inquiry is that it is often assumed that students will naturally and eagerly want to involve themselves in the investigative process; the assumption may be based on a view that the topic of investigation is highly relevant to the students or that the opportunity for active engagement is much more appealing than textbook exercises. Collins (cited in Jaworski, 1994, p. 10), for example, has a very optimistic view of the efficacy of 'inquiry' teaching to engage and enable students: "Inquiry teaching *forces students* to actively engage in articulating theories and principles that are critical to deep understanding of a domain. The knowledge acquired is not simply content, it is content that can be employed in solving problems and making predictions" (*my emphasis*). In this section of the paper I address the issue of how freely students engaged in the lesson observed, and in the following section the precarious and uncertain nature of the effects of this engagement on learning, and later application of mathematical ideas.

The individual or human subject in mathematics education is generally understood to be one who is freely able to choose to act responsibly and autonomously when reason dictates; that is, all students and teachers are assumed to be able to act reasonably or rationally. However, there are some aspects of the classroom action that do not meet these criteria. For example:

> Some students do not involve themselves at all, they sit there in the group talking or playing with pencils and rulers.
>
> A female student suddenly stops explaining her reasoning to the teacher and allows a male to take over.

> The teacher does not correct the misunderstandings of a group of four boys who deliver a presentation that is mathematically incorrect.

> Students are doing an investigation but they ask no questions. Surely if students are involved in processes of investigation/inquiry there would be lots of questions to ask about the best process, the relevance of the knowledge constructed, and about area conversions in general?

Is it helpful to think of these students, and the teacher, as irrational, or to label them in some other way as perhaps just not interested? Poststructuralist understandings of the individual insist that such a course of action would be most unhelpful as naming as 'other' through labelling merely serves to conceal dangerous assumptions about free participation and blames the victim. Rather, it may be expedient to see the humanist subject as problematic, not to abandon it entirely, but to note how process of subjectification in all discourses *form* the individual student (and teacher).

Subjectivity, in a poststructuralist sense, moves beyond notions of individual consciousness or perception about action, events and ideas to describe a "way of knowing" about ourselves in the world that is both intellectual and emotional; it describes who we are and how we understand ourselves and is both conscious and unconscious (McNaughton, 2000, p. 97). Mathematical identity is one small part of this constituted subjectivity. In the examples above, we may have students who have come to *know* themselves as non-participants, a female who (probably unconsciously) *knows* males to be better at explaining mathematical ideas, a teacher constituted to *know* that it is better to accept an incorrect answer than hurt feelings and students who tell rather than ask questions because they *know* that this is the manner in which mathematics is usually done.

This analysis, however, should not be abandoned here. If it is accepted that students and teacher are pre-formed, already constituted through the ways they have been positioned and positioned themselves in a myriad of previous discourses, it is also necessary to acknowledge the constitutive force of the discourse of the moment. What storylines are being reinforced about how mathematics is done: that some students just can't do it and it is acceptable to sit and fiddle, that mathematics is really a male domain, that incorrect answers are ignored and that the dominant strategy, even when engaged in inquiry, is to tell rather than initiate questions? Power is operating to construct and support these storylines which must be interrupted. Just as it is important to keep an open mind about the mathematics constructed and how it can be extended and applied, so too is it important to resist closure on the teaching/learning processes. These must also be objects of inquiry where students are encouraged to voice how they constructed their answer, how they learn best and how the mathematics is or is not seen to be relevant and challenging. At times the teacher will not be able to convince students easily of where the mathematics will be applicable; however, this does not mean that it should not be taught but rather that in teaching it the teacher encourages the learning community to make the pedagogy, rather than the person, problematic. Again, this supports investigative ways-of-being in mathematics that are constitutive of mathematical identity.

What Knowledge is Constructed? *Discourse/Discursive Relations*

It is commonly accepted by mathematics educators/mathematicians that when students conjecture, inquire, form generalisations and solve problems, when they are able to demonstrate understanding by explaining and justifying answers that they are building a firm foundation for further study in mathematics; and I would agree. However, these signifiers of a certain 'at homeness' with the construction of mathematical content knowledge are necessary but not sufficient to ensure students regard mathematics as a useful and powerful field of study to be pursued beyond school. As learners construct content knowledge, they are also themselves produced through teaching/learning classroom relations (discursive relations) to know themselves and mathematics as compatible, or not. It is here that a poststructuralist analysis of classroom activities and processes can make a contribution to mathematics education; in its concern that agency and identity are not taken for granted, it celebrates not only rigorous and in-depth teaching of content (using whatever approach is considered appropriate), but also the making of spaces for students' speaking and writing this mathematics and building a resistance to closure on the mathematics constructed and the processes of its construction (knowledge as sense of self as agentic inquirer).

In the investigation I observed, many students correctly worked out an answer while others did not:

> Some students constantly spoke of 17 centimetres squared rather than 17 square centimetres. Two groups presented a drawing of a shape 17cm square rather than with an area of $17cm^2$. The teacher did not attempt to correct this incorrect language use and representation.

Here students speak and represent $17cm^2$ incorrectly, and of course come to an incorrect answer. My reading of this situation is that the teacher defers to humanist understandings of the students, probably imagines they just do not understand, and not wanting to embarrass them says nothing. However, the mistake could have been more productive had the teacher recognised that power could have been used positively to position these students as genuinely respected participants in the discourse, worthy of knowing the correct representation of the mathematics, who merely experienced a glitch in the investigative process. She could have said something like "I'm sorry that I didn't get to your group to show you the correct way of representing $17cm^2$; we must follow up on that…remind me". In this way she establishes that the students are respected as competent capable participants, regardless of this one problem, and that it matters that the representation is correct. She thus acts in a powerful way to transmit the knowledge these students will need if they are ever to act in similarly powerful ways.

The second sort of knowledge students form is a knowledge of themselves as capable competent participants in the discourse, or not. It is often assumed that if students sit in groups and collaborate or are given voice in some other way that this automatically positively affects identity. This, however, may not be the case. As previously mentioned, one particular student drew up diagrams, did the conversions and established the answer making little attempt to collaborate with the others. Rather, he merely repeated the answer several times when they looked amazed. In another group, the members ignored a peer's correct explanation thus not respecting and valuing his contribution; this could have a negative effect on how he sees himself mathematically. As well, when presenting findings many students were giggly and embarrassed; in demonstrating that they were not comfortable with the language or practices of the discourse they construct themselves, as others will, as not competent and capable mathematicians in the making. Some students, on the other hand, are able to establish themselves competently in this way.

The third type of knowledge, where students begin to establish a sense of themselves as agentic and able to go beyond already established facts and ways of operating, 'autonomy' in humanist discourses, was not evident in the lesson; it appeared rather that most students merely worked on the set task until they got to an answer. I began to see that students will not genuinely inquire where unrecognised power relations preclude it; for example, the set task had one correct answer that became the students' sole preoccupation, all groups who managed to get the correct answer represented it in similar ways and students had come to know a way-of-being in mathematics that had established power relations that are not easily interrupted. This was clearly established when some groups presented incorrect representations of $17cm^2$; although many students clearly knew this to be incorrect they did not say anything. My reading of this is that they saw this as the teacher's job and deferred to her authority. Or could it be that they have learned to mistrust themselves and their understandings of what it means to do and understand mathematics and merely took up "the available discursive position of subordination and (in)difference" (Kelly, 1997, p. 43)?

The answer to the problems presented in attempting to have students investigate and inquire into mathematical ideas is often seen to lie in the establishment of mathematical communities (O'Connor, 1998) engaged in group collaboration and other forms of collective sense-making. However, the community must operate in ways that reward inquiry; not by simplistic platitudes about effective group participation but by ensuring that the processes of learning are productive of a growing knowledge of, and confidence in, the patterns and relationships of mathematics and in students' developing a sense of themselves, their lives and experiences, as valued and respected in the community. Students and teacher together must be *producers* of an investigative, inquiring culture, not its recipients; and, in turn, they will themselves be a product of this culture, legitimate learners and inquirers.

Implications for Practice

Perhaps as mathematics educators, researchers and policy makers we should abandon our eternal search for the one best method and realise that regardless of the rhetorical flourishes we use to describe classroom practice, in the end what we inevitably have are teaching/learning interactions that we would hope would be productive of powerful mathematical and self knowledges for all learners. There is no one proper way to teach mathematics that could apply across all contexts and cultures. A collation of many teaching approaches can be valuable in having students come to know the mathematics and to know themselves as agentic mathematicians in-the-making. However, the teacher must act in powerful ways to gauge and take into consideration the intellectual and social experiences of her/his students. As well, s/he must strive to authorise student initiated voices and ways of making sense of the mathematics and learning procedures. As previously mentioned, to experience oneself as agentic is to have a sense of self as a respected and competent participant able to go beyond the given to forge something new; agency, or the lack of it, is discursively produced, not an individual attribute or disposition. At the completion of each lesson the teacher might ask: *what* mathematics did you learn today, *how* does it relate to what you already knew, *how* did you learn it, was it in a way that was easily understood, could it be learned in another way? In this way, the pedagogy, not the individual learner, is the object of inquiry and made problematic.

There is, too, the question of the application of constructed mathematical knowledge in new contexts. Although a large literature has developed around this issue of recontextualisation, a poststructuralist analysis of the coercive and constitutive relationships of power in school mathematics makes any simplistic notion of transfer problematic. It may be that *what* we teach, if we continue with drilled procedures and skill based strategies, will not be relevant to the world of work in these new times. Or it may be in *how* we teach we fail to inspire and challenge, we put students off further learning in mathematics and turn them away from careers where higher levels of mathematics are required. Students may end up knowing quite a lot of mathematical facts and procedures but their identity might be so fractured that they cannot countenance work or further study in this area.

Conclusion

In this paper, through a poststructuralist lens, I retheorise and reinterpret the landscape of mathematics education by drawing attention to aspects of practice often not visible. ‘Post’ structuralist in mathematics education fits, I think appropriately, as an ‘after’ or ‘addition’ to the corpus of work already done on the growth of intellectual, or mathematical cognitive structures. Poststructuralist insights, suspicious of the partiality of all constructed truths, including those of inquiry-based pedagogies, question a view of language as merely representative (ignoring its constitutive force) and of the learner as fixed, stable, autonomous (ignoring how power/knowledge relations operate to structure the possible field of action of all persons). Such insights fall outside the boundaries of the usual dialogue, but hopefully enliven debate in professional and research communities. An aim of my writing is to encourage others to ask questions about the operation of power in their own work, and cause them to reconsider their own dearly-held certainties about what it means to learn and to teach mathematics in and for a new millennium.

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