New knowledge/new teachers/new times: How processes of subjectification undermine the implementation of investigatory approaches to teaching mathematics.

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The research presented in this paper confronts head on the difficult question of teacher change. It was carried out with preservice teachers in a mathematics methods course in the second year of their teacher education program. Collected data reveal how students' prior experiences of institutionalised mathematics reveal patterns of subjectification which actively undermine the future implementation of more investigatory methods of teaching. I use the poststructuralist concepts of knowledge, positioning and subjectivity: initially as analytic tools to expose the coercive operation of the mathematics discourse; and collectively, as a conceptual base from which to think about possibilities for change.

Introduction

One does not have to go far to find policy and curriculum documents in mathematics education (*A National Statement on Mathematics for Australian Schools*, 1990; *Curriculum and Evaluation Standards for School Mathematics*, 1989; *Mathematics Counts*, 1982) extolling the virtues of investigatory or inquiry methods of teaching mathematics. This is in keeping with a view of mathematical knowledge as an active personal construction, where learning refers to "the creation or building up of relationships in the mind of the individual" (*A National Statement on Mathematics for Australian Schools*, 1990, p.17). However, the changes in teaching methods required have not impacted classrooms as readily as many would have hoped. Price and Loewenberg-Ball (1997) believe that any changes have been mainly cosmetic and what students learn and how they learn it remains largely unaltered.

Despite all the talk of mathematical empowerment, of students and teachers together searching for mathematical patterns and connections and communicating these with confidence to enhance and develop mathematical ideas, teachers continue to teach largely as they were taught (Foss and Kleinsasser, 1996). It appears that they hold on tenaciously, even though they may not admit it (Schuck, 1996), to a view of mathematical knowledge as facts, skills, rules and procedures to be transmitted, and to the absolute authority of teacher and text. Any creative and investigative impulses are negated when confronted by established notions of mathematical knowledge and how it should be taught.

In this paper I use a poststructuralist view of knowledge to theorise the difficulties preservice teachers experience in attempting to implement inquiry or investigative approaches when teaching mathematics. The interconnected concepts of power/positioning, knowledge/storylines and subjectivity are used as analytic tools to explore the processes of subjectification experienced by five preservice teachers in institutionalised mathematics classes. My aim is not to reject or replace prior views of knowledge, but to overlay and deepen these with a view of knowledge which explains how preservice teachers are made subjects such that they *know* at an intuitive, or visceral level, what mathematics is and how it should be taught. This has implications for future teaching practice because the poststructuralist conception of knowledge holds that "in our *action* is our *knowing*" (Lather, 1991, p.xv: my emphasis). Future classroom practices will be based on students' knowing about themselves (their subjectivities) and about mathematics, neither of which may include the investigative processes encouraged in teacher education programs.

From the data presented I attempt to explore both the possibilities and limitations of what might reasonably be accomplished in teacher education, given the processes of subjectification these students have experienced prior to entering the program. They have

lived and know an institutionalised discourse of teacher and text as authoritative keepers of mathematical truths and their mathematical dispositions have been constructed within the regulatory power of the mathematical discourse. It is in making this constructedness visible that they may be able to find ways of moving beyond teaching-as-usual to search for alternative strategies that "invert, invent, and break the bonds of existing discourses" (Davies, 1994, p.44). The argument I pursue in this paper is that agentic new teachers for new times, knowing the coercive nature of all discourses, will be enabled to change classroom uses of language and practices which potentially disenfranchise students. That is, in recognising the problems with practice based on competition for the one correct answer, they may initiate more investigatory approaches which should enfranchise more students mathematically.

Subjectification

Mathematics is a discourse which comprises "socially organised frameworks of meaning that define categories and specify domains of what can be said and done" (Burman, 1994, p.2). Relationships of power/knowledge/subjectivity constantly circulate throughout the discourse producing or suppressing numerate behaviour in students. The environment or context for learning is never neutral. This is a central concern of this research.

I have grouped the data collected into three(3) segments which constantly bump into each other and overlap. However, for ease of analysis the data appear under these headings: knowledge/storylines; power/positioning and subjectivity. I will briefly summarise the poststructuralist interpretation of each of these concepts as I use them to analyse the data. Each of the five(5) preservice teachers spoke for one half to one hour on recollections of past experiences in mathematics classrooms. The recollections were privately spoken into a tape recorder and later transcribed. There was no interview as such. The data were collected in 1997.

Knowing Mathematics

Within the discourse of mathematics, students construct what we might identify as mathematical knowledge. Simultaneously, they are themselves constructed by the power laden language and practices of classrooms which authorise and maintain mathematical and pedagogical "truths", or knowledge. From the data below, we can see that the preservice teachers have learned what counts as authoritative mathematical knowledge and they have learned that as learners of mathematics they are collectors or gatherers of information and procedures, reproducers of others' knowledge, rather than creative initiators or seekers of new and personally relevant knowledge.

> **Hashi**: I remember doing lots of tables, we had to learn our tables off by heart. I remember long division, and working out angles. The teacher would get up in front of the class and teach it to us. There was hardly any discovery learning whatsoever, in fact I can't ever think of a time when we discovered a formula by ourselves. In primary school there was only one way to learn something, and that was the teacher's way. And too bad if you didn't understand it. That was bad luck.
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> **Alice**: When I was at primary school the basic facts were really, really important. We used to learn them by rote and say them every day. We, ah, had a test on them every day and your mark would go up on a chart, so it was all recorded on the wall, so it was a really competitive structure... I can just remember the teacher would put problems up on the board, for example 54 subtract 25, and just...about 10 problems, 10 um 10 subtraction problems, and then 10 multiplication problems, then 10 division problems and they'd just be all up on the blackboard of a morning, and we'd just have to do them, and that's basically how it was. Um, because we could work through the workbooks in high school, we just worked through at our own level. I'd like, finished the curriculum,

> um, in Grade 9, so I didn't have to do mathematics at all in grade 10, and so I was pretty happy, because I had a free subject. But now I look back, and I think that's really bad because for a whole year, I wasn't doing mathematics, whereas I should have been. I mean, just because I'd finished the curriculum. I don't know, I think that they should have given me different work, um like the next level. I don't know. I just find it hard to believe that I didn't do any maths in grade 10 now that I think about it.
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> **Melody**: I remember tables, pain at night, competition, quizzes, rods, long division, multiplication, testing, setting out properly, "speed" maths. I remember making patterns with the rods at lunch time and the teacher coming in and being very angry that I had been playing with them. I had to pack them all up into their little green cases.
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> Maths was always right or wrong, it was a tick or a cross. It could never be nebulous.
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> **Cathy**: I went to school in a small country town in Scotland, and I would say that learning things by memory seemed to be important. We used to learn our times tables off by heart, even in Grade 1. I remember in Grade 1 we used to stand up and recite our times tables, and if we got them wrong, we got rapped over the knuckles...

The students have come to know mathematics as tables, rules, procedures to be transmitted by the teacher and learned by rote. Once you had learned enough of these you could stop, and have spare periods as Alice did. However, it is the gaps and silences in what the students say that signal possible problems ahead for teaching mathematics in "new" times. Silences in these recollections point to the fact that students are not able to speak the "truths" of mathematics as they have been redefined for the twenty-first century. The skills and knowledges they have developed, to whatever extent, are now redundant. They do not mention exploring mathematical patterns and the various connections between mathematical ideas, the pleasures of conjecture and inquiry, the wonder of exploring mathematics from minority cultures or the excitement inherent in using technology to explore mathematical concepts. These preservice teachers have come to know mathematics as transmitted facts and procedures, and as Schuck (1996) says preservice teachers are not much interested in alternative views of knowledge more appropriate to the world of today and tomorrow.

Power/Positioning

Constructivist notions of knowledge, stressing active and collaborative involvement of students in supportive contexts, have recently become very popular in mathematics education (Klein, 1996; 1997). However, the poststructuralist concept of subjectification does not allow the passive/active binary. It recognises that the environment of learning including relationships of power/knowledge is not external to, but constitutive of, all participants. We can see in the following excerpts that the students are actively engaged in learning, even though they are in "transmission" type classrooms. They are learning through how they are positioned by classroom practices, textual and teacher authority.

> **Josh**: I cannot recall one 'math activity' in my years of schooling. It was strictly 'chalk and talk', 'pop quizzes' (lots of those), homework to hand in, and examinations. Each course had a textbook, the rest was pencil and paper, though I faintly remember recitals of tables, in front of the class by students.
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> Mathematics was entirely direct teaching. Math was like spelling. The object was to get the convention 'right'. I can not recall there being any

'remedial' groups in the schools I attended in Indiana. If students didn't 'pass' a grade, they either went to summer school or repeated the grade. This was not uncommon.

The pedagogy was very teacher directed. Students were positioned as "unknowing" and they learned that the teacher and text guarded authoritative "truths" which you had to access to do well. You had to play a certain game, where, as **Josh** stated:

> The storyline was simple as I saw it. We had to go to school. The teacher was the 'knowing' one. Pay attention, do the work, you get a decent grade. Don't pay attention, don't do the work, you flunk. Too simple!

The pedagogy was not questioned. If you did not come up with the correct answers most of the time you were simply not "paying attention" (Josh) and were "rapped over the knuckles" (Cathy). There was no indication in the data of students' being encouraged to behave autonomously, to find their own way, to explore. Melody found that making patterns with the rods was "wrong", Alice experienced mathematics as getting the correct answer to tables and operations and Melody learned the "correct" way of setting out.

Two influential "frameworks of meaning" structure classroom practice and position students as totally dependent upon the teacher. The first is developmental psychology and the notion of the "norm" or "normal" in development and behaviour. Classroom practice is premised on constructed binaries of right/wrong answers, correct/incorrect behaviours, and competent/incompetent students. Those not achieving at what was considered to be the norm were categorised as "developmentally slow" or "slow learners" and grouped accordingly (see Melody below). A second framework of meaning is liberal humanism, which assumes a unitary individual who can choose or not to be motivated and competent in the classroom. Where students fail it is seen to be because of individual personal lack, and nothing to do with oppressive positioning or inappropriate classroom practices. Josh's comments above demonstrate how liberal humanism might impact on his future practice: "Don't pay attention, don't do the work, you flunk".

Melody reflected that she was classified as a "low achiever" and sent outside the classroom with a teacher's aide to pick up some mathematical content she had missed:

> **Melody**: I can remember them saying: 'OK those in the low group go outside'. We would have to go and sit outside and often it was just going over things we had looked at before. I have strong memories of the old gestetner prints, you know how they have that very strong smell, that's the smell I associated with maths most of all. Doing pages and pages of those things that we had to repeat over and over again. And I remember looking in through the windows at the rest of the class, at my friends and wanting to be in there...I remember it as a time of desperately wanting to be somewhere else than where I was.
> **Melody**: I was made to feel that I could do better if I wanted to and it was my choice that I wasn't doing well at maths. I was the one who was responsible for it and all I had to do was to change my attitude. So the problem was with me...

These preservice teachers have been positioned in such a way in classrooms to know absolutely the unquestioned authority of teacher and text. They have come to know that some students are better at mathematics than others: they have come to know that where one fails it is one's own fault, or one's family or culture. These knowledges are not conducive to the implementation of investigatory pedagogies, where each student must be given a speaking voice, enabled to take oneself up as respected and authoritative while developing mathematical knowledges and applications.

Subjectivities

Delving below the surface of the words that the students are speaking, there is a sense in which, by involvement in the discourse, students learn about themselves according to whether or not they are able to establish themselves as empowered mathematical subjects. "Discourses", states Weedon (1987, p.108) "are more than ways of thinking and producing meaning. They constitute the 'nature' of the body, unconscious and conscious mind and emotional life of the subjects which they seek to govern". The students were positioned subserviently to the, usually, nurturing and supportive teacher, and students such as Melody who attempted to create some knowledge for herself immediately found that making patterns was the "wrong" thing to do with the coloured rods. Alice, on the other hand, appears to have been able most often to do the "right" thing, get the right answers so that she has a whole year in which she doesn't have to do mathematics. However she, as much as Melody and the others, relies on the teacher to judge her competence.

Melody, Hashi and Cathy's recollections suggest that do not consider themselves "good" at mathematics. It would appear that many past experiences have not constituted them as capable users of mathematical discourses.

> **Melody**: I felt terrible that I couldn't do better at maths. I couldn't understand why I did so well in every other subject and did so poorly at maths. I remember thinking that it must be a mind set that you're given and that if you don't have that mind set well then you can't do maths... those who were really good at maths got to go out early. In high school they got to use the computer...I absolutely hated computing because I saw it as just another part of maths and I never wanted to touch a computer because I just *knew* I would be bad at it because I was bad at maths.
> **Hashi**: I didn't really like maths very much, because I didn't feel that I was very good at it. I didn't feel that I truly understood the concepts of what was being taught, I only knew it on a superficial level, I only rote learned things and consequently, when I got to high school, I had problems doing process questions.
> **Cathy**: I had a maths teacher in Sydney and he was very chauvinistic, and um...it was definitely that boys did better at maths, because I mean like, every time there was a screech of brakes going past the classroom, it was like, you know, 'Bloody women drivers', see, you could always tell exactly how he felt about women and girls in general, you know, that we were a bit silly, and you know, waste of space really, and...so I can't say that I learned anything, it was just, I just wanted to pass the subject, and I did, I got a 'sound', and then I avoided maths at all costs, in everyday situations.

I interpret the data to read that Josh and Alice, on the other hand, have taken themselves up as agentic mathematical beings.

> **Alice**: I really enjoy mathematics. I always have a sort of positive feel about maths.
> **Josh**: I was a 'high' achiever, according to my teachers, but I took the same lessons and tests as all the other students.

It is interesting to speculate on which of these students will be most able to implement investigatory processes in their classrooms. Alice and Josh managed to get most of the answers to the traditional mathematics questions right, but does this necessarily mean that they will be competent to teach the "new" mathematics, which depends on knowledges both mathematical and pedagogical. Indeed, they may not be

keen to interrupt a set of knowledges and practices which they consider to have served them well.

The problem is compounded when these preservice teachers are out in schools, as they are not encouraged to try investigative approaches to teaching. As practising teachers, they are positioned once again as "not knowing" and not enabled to learn for themselves from trial and error.

> **Hashi**: I did suggest doing things like um, tell me everything you can about the number 35, but the teacher changed it, and wanted quick mentals done instead, which is fair enough, its his class...
> It's hard to go out in someone's classroom, and um try and introduce constructivism, especially with teachers who are used to 'talk and chalk', and its unfair to walk into their classroom, and to suddenly impose your ideas on them. It's hard too, if the children have never done this sort of thing before, you can't teach it to them in two weeks, they have to I think, learn some basic skills with cooperation and setting limits on their own ideas, and you've got a teacher marking your prac report, it makes...can behaviour. And also, too, if you walk in there and start imposing your own make life very, very uncomfortable for you if you don't abide by their choices, or their beliefs.

Competence and Agency for Preservice Teachers

The major problem we face is that students so constituted through past discourses do not readily know how to position themselves as teachers with agency who know how to teach "against the grain". They have learned some content, but it is content that can nowadays be done more efficiently by machines. Their knowledge and the context of schooling-as-usual make it difficult for them to speak the mathematical knowledges considered relevant (Australian Education Council, 1990: Department of Employment, Education and Training, 1989; National Council of Teachers of Mathematics, 1989) to the twenty-first century. They have not experienced conjecture, exploration and inquiry as important elements of knowing mathematics as a social and intellectual practice. Even where these ways of knowing are encouraged in preservice teacher education they are resisted by students who do not consider them to be important (Schuck, 1996).

A further problem ensues when these teachers begin teaching. The currently established discourses in mathematics texts of problem solving approaches to teaching, sense-making on the part of students and the use of games and concrete materials remains as rhetoric rather than becoming constitutive of practice. I believe this is because these high ideals are incorporated into teaching-mathematics-as-usual based on competition, the one correct answer and teacher authority. Thus problem solving often becomes finding the correct answer as quickly as possible, sense-making means making the teacher's sense for a tick or good marks and technologies such as games and concrete materials are used in standardised ways to practise or consolidate some skill or procedure.

Preservice teachers need to be competent mathematically and they need to be agentic. I concur with the new pedagogical discourses on the construction of mathematical ideas, connections and relationships and recognise as problematic the fact that this discourse may have been absent in their schooling. I also take seriously the notion that they must be encouraged and supported in learning to orchestrate an investigatory discourse; they must develop the skills of questioning which keep the mathematical conversation alive and which do not cut off inquiry by asking closed questions. Just as importantly, to be agentic teachers of change, they must know how the discourse of mathematics currently operates to disenfranchise learners, how they themselves have been caught up in its operations, and how classroom uses of language and practices might be changed in ways that prove to be empowering for more students. Davies (1991. p.51) states: "Agency is never freedom from discursive constitution of self but the capacity to recognise that constitution and to resist, subvert and change the

discourses themselves through which one is being constituted". Preservice teacher education is implicated here.

Making a Beginning in Preservice Teacher Education

Within teacher education, as we continue to teach basic concepts in constructivist ways and learn the skills of communicating these ideas, it is crucial that we also make processes of subjectification visible. We need to look at how, in interaction, we collectively manage to categorise and classify each other into marginal or authoritative positions within the mathematics education discourse. Discussion could focus around the following concepts (adapted from Davies, 1994) which together try to encapsulate the kind of context participants actively create for one another: positioning, subject positions made available, and storylines that are made relevant. For example,

> POSITIONING: How are the participants, the lecturer and students, mature aged students and school leavers, positioning each other? Where does authority lie? Are prior experiences made relevant? Are any gender/race/class divisions visible?
> SUBJECT POSITION/SUBJECTIVITY: What subject positions are made available? Are students receiving messages that they are "good", "bad", "slow", "dumb", "a competent student", "an unmotivated student", or "remedial" by either the words spoken, looks given, or processes such as briefness of time to answer, relative difficulty of questions asked. What subject positions does the lecturer assume? Is s/he constituted as authority, transmitter of knowledge, nurturer or perhaps uninspiring pedagogue? If the lecturer does not teach the knowledges the students consider essential, s/he may be positioned by students as out of touch with reality and too theoretical.
> STORYLINES: What storylines weave themselves through students' experiences of mathematics education subjects? Does this knowledge include such unwanted storylines as: it is important to understand what the lecturer wants so that this can be regurgitated at exam time; males are better at handling the video equipment and the computers; members of minority groups should not be asked challenging questions; problem solving is all about getting to the answer as quickly as possible; lesson planning has to follow a linear format and lesson outcomes must be established before the lesson has taken place?

Once students are aware that power relationships do exist in all pedagogical collaborative encounters, they might be encouraged to examine how taken-for-granted classroom practices constitute children in mathematics.

If these teachers are to teach in investigatory ways, they will need to recraft their eyes to recognise the limitations of teaching-as-usual: to see how filling in worksheets, hearing tables, doing irrelevant problems where there is one correct answer, streaming, practising algorithms and formulae, position the student as always unknowing and the teacher as sole authority. Furthermore, because these classroom practices are all premised on the regulatory establishment and maintenance of constructed binaries of right/wrong answers and competent/incompetent students they effectively undermine any investigative impulse. Preservice teachers need to work together to think about classroom processes that might better facilitate investigation.

Many would argue that it is the large structures of society and the school that need to change to bring about pedagogical and social change. I have argued, as has Davies (1996) that we ignore subjectivity at our peril and that the larger structures will change only when we have our schools staffed with agentic teachers of vision and voice who, with eyes recrafted to recognise potential marginalisation and oppression and agency at the local level, act to ensure a positive learning experience for as many of their pupils as

possible. Subjectivity, I would suggest, as well as constructed cognitive knowledge, significantly influences practice.

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