Mathematics education for student teachers: Disciplining the pedagogy.

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ABSTRACT

The paper outlines the dilemmas and paradoxes faced by lecturers and students as they come to deal with their concerns regarding mathematics as a discipline and a language, and appropriate pedagogies for the teaching and learning of mathematics.

For the lecturer there is a tension between comforting and challenging the students. Are they to be wooed into a more positive attitude to mathematics, at the cost of avoiding the complexity of the discipline; or are they to be challenged by the unique language of mathematics at the risk of alienation and exclusion? The latter is the more difficult and quite often returns students to their original perception of maths as a harsh and unforgiving subject which is beyond their capabilities as they struggle with unfamiliar concepts and the discomfort of not knowing.

For student teachers there is paradoxically a desire to "instil understanding" when they themselves may not fully understand. They idealise what is good practice but deny it in their own learning.

Finally the paper will consider the problematic nature of students' orientation to nurturing so that children "may be happy at school" and their reconciliation of this view with the perceived intellectual demands of mathematics teaching and learning.

Introduction

The paper discusses the dilemmas and tensions that exist in the interactions between lecturer, student and the discipline of mathematics during a first year mathematics education subject. The subject is offered in a university teacher education program for prospective primary school teachers.

The beliefs of the students entering the subject, and of the

lecturers responsible for that subject, are examined and disparities in beliefs are described. These disparities are the cause of tensions in the process of disciplining the pedagogy.

Student beliefs about mathematics education

Literature on prospective teachers' beliefs about mathematics and the teaching and learning of mathematics agrees that most student primary school teachers see mathematics as a series of rules, formulas and procedures dealing with arithmetic, a dull subject which involves a great deal of rote learning and drill work (Ball, 1989; Wilcox, Lanier, Schram & Lappan, 1992; Schuck, 1993a)

Prospective teachers have undergone an "apprenticeship of observation" (Lortie, 1975) during their twelve or thirteen years at school. They have sufficient experience of being in a classroom to have developed a clear picture of the role of the teacher. Consequently most prospective teachers see the role of the teacher of mathematics as telling students the "facts"; providing clear demonstrations and explanations of the mathematics for students, and marking assignments and exercises from textbooks and checking their correctness (Wilcox et al, 1992).

Additional to the above beliefs about the work of the teacher in a mathematics classroom, students bring other notions of what a teacher is into their tertiary studies. Good teachers make lessons interesting and enjoyable, and are supportive of their pupils, enthusiastic about their subject and knowledgable about how their students learn (Holt-Reynolds, 1991a; Schuck, 1993b).

Beliefs of Mathematics Teacher Educators

Like the students, teacher educators wish to develop enthusiasm in their students, and to improve their attitudes about mathematics learning and teaching. In an American study, Teacher Education and Learning to Teach, conducted by the National Center for Research on Teacher Education (Floden, McDiarmid and Wiemers, 1990), methods instructors at three universities were interviewed about their syllabi for their methods courses. All three of them felt that their priority was to promote positive attitudes towards mathematics rather than assist students develop understanding of what it means to do mathematics. Instructors assumed that their students had sufficient knowledge of the mathematical content of the primary school curriculum and they would teach content only when it became apparent that it was not known by their

students. To some extent, this situation is mirrored in Australia where many mathematics educators in teacher education programs focus on fostering positive attitudes to mathematics.

However, fostering positive attitudes about mathematics is only one of many goals of the teacher educator. Most teacher educators will also firmly uphold the belief that student teachers need to be aware of what children already know in order to effectively help them construct new knowledge (Holt-Reynolds, 1991b). They believe that the role of the teacher is to provide a rich environment in which children can actively construct their own knowledge, rather than be passive recipients of the teacher's knowledge.

As a consequence of these beliefs many teacher educators see their role as one of challenging the beliefs of the prospective teachers as they enter their courses. They wish student teachers to become aware of the complex and uncertain nature of teaching (Feiman-Nemser, McDiarmid, Melnick & Parker, 1989). They further wish to help student teachers see that knowledge is open-ended, that it is connected to other knowledge and that it is not infallible (Reid, 1991).

Dilemmas and Paradoxes

The above beliefs and their juxtaposition lead to a number of tensions and dilemmas for both students and teacher educators

in mathematics education subjects offered in teacher education programs. This paper draws on the experiences of both prospective primary school teachers and teacher educators involved in the offering of a first year mathematics education subject. This subject is part of a primary teacher education program at an Australian university.

Data for this study was collected by a variety of means. In phase I of the data collection, paired interviews were used, in which the first year students were asked to each formulate a set of five questions which would elicit from another class member their current attitudes towards mathematics and mathematics teaching and also indicate how these have been affected or influenced by past mathematical experiences. Students then answered each other's questions and results were audio taped. The questions posed were regarded as being of as much interest as the responses they evoked, as they indicated what student teachers believed to be problematic issues in the teaching and learning of mathematics.

The next phase of data collection involved the responding to a

questionnaire in which most questions were open-ended. The questions were developed out of issues arising from the first phase of data collection and so were well grounded in the initial data. Finally, in-depth interviews were conducted by the researcher, with eight of the student teachers, in order to provide triangulation and to furnish further detail. All students in two classes were involved in the first set of interviews and the questionnaire; the eight students chosen for the second set of interviews were selected so that a mixture of mature age students and recent school leavers would be present and there was a continuum of students in terms of their ability to reflect on their teaching and learning.

In this paper the beliefs of student teachers regarding the nature of mathematics teaching and the nature of good practice are discussed. Herein lies the first dilemma for the prospective teachers at the beginning of their teacher education course. Their beliefs about the pedagogy they wish to adopt in the mathematics classroom are at variance with their beliefs about mathematics and mathematics learning and teaching. A series of issues arise for them:

Student teacher belief: Enthusiasm is of prime importance in being a good teacher. Yet most of the students in the first year group being studied did not feel particularly rhapsodic about mathematics, due to their past experiences in that subject.

Consider a typical quote by Judy:

I don't think I can go into teaching a maths class now with the same attitude that I had when I was at school because my attitude was a bit negative and as a teacher I've really got to have a positive attitude to everything that you [sic] do. So I guess ...my experiences didnt shape my attitude, I've got to change my whole attitude to fit what I'm teaching...

From where are these students to muster enthusiasm in order to teach a subject that they perceive as dull and difficult? Is the task of the teacher education course in mathematics education to develop this enthusiasm?

Student teacher belief: The teacher's role is to instruct the students in the procedures and algorisms of mathematics. Yet many students in the teacher education course do not feel that they are successful users of this type of mathematics themselves. While repeatedly stating

the importance of teaching "the basics", that is the multiplication tables, and algorisms and rules to which they themselves were subjected, students also admit that they do not feel confident about their mathematical ability, and indicate that their mathematical experiences in the past have not been particularly appropriate.

What kind of mathematics are prospective teachers going to need to know, in order to be the type of teachers they wish to be? Is the mathematics to be the rule-oriented, unconnected vision to which they were exposed in the past? They will feel comfortable teaching in this way as they have clear models of this type of pedagogy. However, it is precisely this conception of a procedure-based, rote-learned mathematics that alienated many of them in the past.

Related to this dilemma is another problem: student primary teachers are constrained by their subject knowledge. Many of them are terrified that their pupils will ask them questions about the conceptual underpinnings of a procedure; questions that they are convinced they will not be able to answer with their current knowledge base. However, they believe that children should be answered if such questions are posed. Student teacher belief: Good teaching involves encouraging the asking of questions by pupils, and the answering of these questions by the teacher. How, then, are they to find out the answers? How can they instil understanding when they themselves may not fully understand?

Borko et al (1992) show how a student teacher's beliefs about good mathematics teaching, particularly in the area of answering questions about why a procedure worked, were challenged by the student teacher's weak conceptual knowledge base and her lack of commitment to serious and difficult mathematical thought.

Another aspect of good practice is recognition that each child is different and has the right to individual attention. Paradoxically, though, children who may be gifted in mathematics are shunned as pariahs.
Student teacher belief: Good teachers always have the answers. Gifted children challenge and threaten this notion. A quote from Gail, a first year student teacher, about her experiences on practicum, sums up the general feeling in this regard:

"So I often sidled up to those children [who were having

> difficulties] and I guess in some ways I have more affinity to them because the really good ones are too threatening to me. You know, they'd be way ahead of me. So I was happy to leave it to them just to achieve the examples I had worked out beforehand and I knew [that
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> they] got it right. But the weaker ones who had trouble ... I really loved working with them."

Again good practice is being denied, this time because of a tension between a weak knowledge base on the part of the student teacher, and a belief that the teacher must always be the expert.

Given these beliefs, what, then, do prospective student teachers see as the role of their teacher education courses in mathematics? Certainly such courses should be engendering enthusiasm for the subject of mathematics. Mathematics education courses should also be teaching prospective teachers the strategies and jargon that will show them how to explain procedures in different ways to their pupils. Consider another quote by Gail, talking about an incident during the practicum:

> It was obvious that the children didnt know what three times three was. .... The teacher showed me that I was to say three lots of three is nine.... instead of me saying three times three is nine, she said no, I must say three lots of three is nine. And I thought to myself, "These are the rules that I really want to get to know. What are the words that you use so that the child understands; what phrases do you use that unlocks a child's ... blockage of understanding?" That's what I want to get out of maths.

Mathematics education courses at university should also be helping the prospective teacher to carry out remedial work in the classroom. However, most students did not feel the same need to discuss a pedagogy for mathematically gifted children. Typically, an avoidance response was shown about this - "I hope I dont have anyone like that in my class" - and student teachers indicated a deep seated belief that they themselves would not be able to do the mathematics needed to extend and stimulate gifted children. Consequently any discussion of subject matter knowledge or pedagogical knowledge (Shulman, 1986, p. 26) specific to the teaching of mathematically gifted and talented pupils was dismissed as irrelevant, as students could not visualise a scenario in which they would either be experts at the work themselves, or be comfortable in allowing

pupils to investigate mathematics in which they themselves did not feel competent. Consequently such situations were to be avoided and hence did not need to be discussed in a mathematics education subject.

Framing the above requirements for a teacher education course in mathematics education, are the educational orientations of the students. Educational orientation is a term coined by Gibbs, Morgan and Taylor (1984) to describe students' reasons and goals for undertaking a particular course at university.

Gibbs et al describe a number of educational orientations that students may follow: academic, vocational, social and personal; and further identifies aspects of these orientations that could be described as extrinsic or intrinsic. For example, students whose orientation is vocational intrinsic are eager to learn the subject in order that it may help them to perform well in future careers. Extrinsic vocational orientation would be the valuing of the course for the

certification it provides on completion.

The students in the present study are almost all vocationally oriented, not surprisingly, as they are enrolled in a vocational course which has the professed aim of equipping them for the job of teaching. This orientation effects the way mathematics is studied, as the primary aim for most students studying the mathematics subject is to learn how to teach mathematics to primary school pupils. Consequently, if the application of a subject in the teacher education course to their future teaching is not made explicit, the students do not value the subject. This point will be discussed further on in this paper as there is a dilemma inherent in this, for the lecturer.

Finally, a note should be made of a deep silence existing in one area of students' views on teacher education and mathematics education in particular. This is a silence on the topic of the cognitive part of learning; on the need for understanding the conceptual underpinnings of primary school mathematics. Students believe that if the teacher is enthusiastic and the lesson is practical and interesting, understanding must occur; and if it does not then the learning of a set of necessary phrases and actions will be a satisfactory solution.

Set against the above context of student teachers' perceived requirements for a teacher education course, the lecturer's tensions become apparent. To engender enthusiasm for

mathematics and mathematics teaching and learning means to avoid the feelings of frustration and failure that students have experienced in their past learning of mathematics. However, students are accustomed to reacting to difficult mathematics in exactly this way. If a problem cannot be solved immediately, past experience has taught them that it is not within their capabilities; if the mathematics that is encountered is different from their perception of what mathematics should be, then it is disregarded; and if the mathematics education subject is not seen to be teaching the skills that students require in order to enable them to clearly explain algorisms to their future pupils, then it is dismissed as irrelevant. Consequently, what the lecturer regards as good teaching in the tertiary situation is often met with lack of enthusiasm, frustration and disinterest, creating a tension for the lecturer in terms of the conflicting goals of engendering enthusiasm and challenging student beliefs. Are students to be wooed into a positive but limited view of mathematics or are they to be exposed to a different and possibly more complex view of the discipline with the concomitant danger of distress and alienation?

Exacerbating the situation are the students' brief encounters with the classroom on their teaching practicum, in which they see the so-called "real world of teaching" which reinforces their conceptions of teaching as telling and mathematics as rule bound. Many report that teachers have told them that what is being done in the university subject is impractical and irrelevant and given the world view of these teachers and their pupils, this is probably true: pupils are not used to being active mathematical thinkers in these classrooms and the student teacher's attempts to implement any new ideas that might have arisen as a result of the university course will often end in failure. This same problem may not arise in other areas of the curriculum as primary school teachers tend to be more confident and knowledgeable about areas of the curriculum other than mathematics and often lack the necessary pedagogical and subject matter knowledge, described by Shulman (1986), in the area of mathematics in particular.

The culture of the students studying the mathematics education subject is such that there is a strong pressure on the lecturer to tell the students how to teach; to give them rules for teaching mathematics; and to show them the steps that make up various procedures that are, in the student teachers' eyes, the very essence of mathematics. Attempts to involve students in searching for patterns; making conjectures and then proving

these (or at least justifying them); of searching for the conceptual underpinnings to the primary mathematics they will teach; and of seeing the connections between various areas of mathematics are often met with cries of "Is this in the syllabus?" or "How will primary school children understand this when I find it so difficult?" While idealising notions of good practice, the students constantly deny it in their own learning. The lecturer consistently has the dilemma of choosing not to give the students what they believe is essential preparation for their lives as teachers of mathematics in the primary school; of choosing between comforting and challenging the students.

In challenging student beliefs about what it means to do mathematics, and how to learn and teach mathematics, the teacher educator has to resist a socialisation process almost as strong as the one students will encounter on practicum and as beginning teachers. There is a recursive aspect to the whole scenario; lecturers' ideas of good teaching in the tertiary area are exposed to a similar set of dilemmas and contradictions as are their students' ideas, in their learning to teach.

In order for the lecturer to implement good teaching, he or she has to experience the dilemmas, tensions and uncertainties that the students will experience in their teaching, if they choose to teach for change rather than maintain the status quo.

References

Ball, D. (1989). Breaking with experience in learning to teach mathematics: The role of a preservice methods course (Issue Paper 89-10). East Lansing, Michigan: The National Center for Research on Teacher Learning.

Borko, H., Eisenhart, M., Brown, C., Underhill, R., Jones, D. & Agard, P. (1992). Learning to teach mathematics: Do novice teachers and their instructors give up too easily? Journal for Research in Mathematics Education, 23, 3, 194-222.

Feiman-Nemser, S., McDiarmid, G.W., Melnick, S. & Parker, M. (1989). Challenging beginning teachers conceptions: A description of an introductory teacher education course (Research Report 89-1). East Lansing: Michigan State University, National Center for Research on Teacher

Education.

Floden, R.E., McDiarmid, G.W., & Wiemers, N. (1990). Learning about mathematics in elementary methods courses (Research Report 90-1). East Lansing: Michigan State University, National Center for Research on Teacher Education.

Gibbs, G., Morgan, A. & Taylor, E. (1984). The World of the Learner. In Marton, F., Hounsell, D., Entwistle, N. (Eds.) The Experience of Learning. (pp. 165-188). Edinburgh: Scottish Academic Press.

Holt-Reynolds, D. (1991a). The dialogues of teacher education: entering and influencing preservice teachers' internal conversations (Research Report 91-4). East Lansing: Michigan State University, National Center for Research on Teacher Learning.

Holt-Reynolds, D. (1991b). Practising what we teach (Research Report 91-5). East Lansing: Michigan State University, National Center for Research on Teacher Learning.

Lortie, D. (1975). Schoolteacher: A sociological study. Chicago: University of Chicago Press.

Reid, G. (1991). Transforming knowledge in undergraduate teacher education (Craft Paper 91-1). East Lansing: Michigan State University, National Center for Research on Teacher Learning.

Schuck, S. (1993a). Teaching and learning mathematics - First year primary student teachers' perspectives. Paper presented at the Contemporary Approaches to Research in Mathematics and Science Education Symposium, Melbourne, November.

Schuck, S. (1993b). Attitudes and beliefs of pre-service primary teachers and their effect on learning. Discussion paper presented at the Adult Learners Special Interest Group, Mathematics Education Research Group 16th Annual Conference, Brisbane, July.

Shulman, L.S. (1986). Paradigms and research programs in the study of teaching: A contemporary perspective. In M.C. Wittrock (Ed.), Handbook of research on teaching (3rd ed., pp. 3 - 36). New York: Macmillan.

Wilcox, S., Lanier, P., Schram, P. & Lappan, G. (1992). Influencing beginning teachers' practice in mathematics education: Confronting constraints of knowledge, beliefs, and context (Research report 92-1). East Lansing, Michigan: The National Center for Research on Teacher Learning.