Challenging beliefs about mathematics learning and teaching using an electronic learning community

Sandy Schuck and Gerry Foley
University of Technology, Sydney

Prospective primary school teachers often see mathematics as a rigid, inaccessible subject. Their fixed ideas about the nature of mathematics can often impede their learning, and future teaching. This paper investigates a web-based intervention which encouraged dialogue about mathematics between an international community of mathematics educators and the prospective teachers' local learning community. Data from two surveys and from the prospective teachers' reflective journals show that this intervention encouraged prospective teachers to examine and evaluate their own beliefs.

Introduction

Prospective teachers of mathematics in the primary school often have negative experiences in their own learning of mathematics (Pateman, 1989). Further, many have ideas about mathematics education that are at odds with the views espoused by mathematics educators interested in reforming the way mathematics is taught (Australian Education Council, 1991; NCTM, 1991). The literature in mathematics education shows that many primary school teachers and prospective primary school teachers see mathematics as a fixed and sequential body of knowledge which is most effectively learnt by rote, algorithmic and repetitive procedures (Mayers, 1994). Burton (1996) suggests that the teaching of 'immutable mathematics' has led to widespread marginalisation and failure for its learners. She propounds the view that the very socio-cultural nature of mathematics has led to a differentiation amongst its learners of those who can engage with the traditional presentation of the subject and those who are unable to do so. Her views are shared by many mathematics educators (Dengate and Lerman, 1995; Ernest, 1991) and a reform movement in mathematics education has evolved with aims of making mathematics accessible to more people.

It has been suggested (Crawford and Deer, 1993) that prospective primary school teachers' views of mathematics as instrumental might be modified "if opportunities for active and reflective participation in the learning process are provided" (p. 30) in the teacher education program. Intervention studies conducted in teacher education programs show some success (Schuck, 1997; Lappan and Even, 1989). However, many teachers still appear to start their teaching careers with the views that they held when they started their teacher education preparation. The implications of teaching with the instrumentalist views described above are that primary school students are introduced to a view of mathematics which accepts that access to the power of mathematics is available to only a few 'elite' students and denies others an entry into a world of mathematics that is culturally and socially relevant for them. If we wish more students to have access to the power and beauty of mathematics, a different vision of mathematics needs to be presented to them from primary school days onwards. For this to happen, primary school teachers, and prospective primary school teachers, need to challenge their own views of mathematics so that they become open to visions of mathematics as a dynamic, creative and problem solving discipline in which procedural methods are merely means to ends, rather than the ends themselves.

This paper considers an intervention which challenged prospective primary school teachers' beliefs about the nature of mathematics and mathematics learning through the medium of a web-based computer conferencing tool. Details of the intervention are described and the results are discussed. In addition, a few factors that inhibit change in beliefs are identified and discussed, in particular, the influence of the practicum on prospective teachers' beliefs.

The Context of the Study

Prospective teachers in an initial teacher education program for primary teachers at the University of Technology, Sydney (UTS), have a sequence of four semesters of mathematics education which begins with Mathematics Education 1 in the second semester of their first year. In 1997, one hundred and eighty five first year prospective teachers in the Bachelor of Education program at UTS enrolled for Mathematics Education 1. A major component of this subject was a substantial intervention aimed at challenging prospective teachers' beliefs about the nature of mathematics. The intervention was ongoing through the semester.

The study investigated whether the intervention, using web-based conferencing and an international community of learners, would encourage prospective teachers to examine and challenge their beliefs about mathematics, and mathematics teaching and learning.

The Intervention

The characteristics of the intervention were that it be collaborative, that prospective teachers be given access to a large number of views about the nature of mathematics, and that the material be current, relevant and challenging of prospective teachers' beliefs about mathematics.

In the first lecture prospective teachers were given two focus statements, which formed the basis of the computer conference. These were:

> *On the nature of mathematics:*
> "I'd describe maths as the calculation of certain things to do with numbers, and the use of certain formulas and methods, simplifying, counting and subtracting and things like that." (Maria, first year prospective primary schoolteacher)
>
> *On the cultural context of mathematics:*
> "Mathematics is universal, objective and unchanging. It is independent of social, cultural and political values."

The first statement had been made by a first year student teacher in a previous research study done by one of the researchers, and the second one was a compilation of comments made in that same study by a number of prospective teachers (Schuck, 1996).

The prospective teachers were then given the task of forming groups with five or six members and choosing one of the two focus statements for their study and response. They were introduced to the computer conferencing tool and the requirements of the task. Three types of material were made available to the prospective teachers: a selection of readings to be held in the library collection; a number of websites with relevant material; and responses to the focus statements by a number of respected mathematics educators, which were placed at the discussion site of the conferencing tool. The last set of materials was written specifically in response to the focus statements, by mathematics educators from a number of countries, including Fiji, New Zealand, the United Kingdom and Australia. These educators had been invited to respond to the statements by the researchers/subject developers.

Prospective teachers were required to read from each of the three sets of material, and then work collaboratively to formulate a group response to the chosen statement, based on their understandings of the material, and their ensuing discussion as a group. They were then required to post their response into the discussion site of the conferencing tool on the web. Time was allowed in the subject for group meetings and collaboration. After the groups had all posted their initial responses to their chosen statement onto the conferencing tool (approximately halfway through the semester), they were required to read each others' responses to this statement, displayed in the discussion site, and then, in the same groups as before, formulate a second response to the statement that took other groups' points of view into account.

Towards the end of the semester, the entire first year cohort undertook a three week practicum and was required to teach a number of mathematics lessons during that time. Finally, in the second last week of semester, after prospective teachers had posted their second response on the conferencing site, class discussions were held about the various responses to the given focus statements and the implications of these responses for teaching.

Methodology of the Study

Participants

One hundred and eighty five prospective teachers initially participated in the study. One hundred and sixty five of them responded to a survey, which asked for some biographical and demographic data. Of the prospective teachers responding to this survey, 101 were eighteen to twenty years of age, the remaining participants being in a range from twenty one to forty seven years of age. One hundred and forty prospective teachers were female, twenty five were male. The two researchers were the academics responsible for the subject at that time.

Data collection methods

Prospective teachers were surveyed in their first lecture about their beliefs about mathematics and mathematics education. The survey was anonymous, with prospective teachers being asked to supply code names so that each individual's survey results could be matched with the results of a later survey. Prospective teachers were then given the two focus statements that formed the basis of the web mediated discussion and asked to write down their first thoughts in response to these statements. As prospective teachers were required to maintain a reflective journal throughout the semester, the responses to these statements were in the nature of journal entries. These were not submitted to the researchers at that time. The intervention was then carried out over the semester and prospective teachers were requested to keep journal entries on the group process and their thoughts about mathematics. At the end of the semester the journals were collected by the lecturers and permission gained to use them as data. Together with the journals, prospective teachers were asked to submit summaries of the journal notes, documenting any critical incidents or new learning that had occurred during the semester.

In the second last week of the semester, the prospective teachers were given another survey which included the same set of questions about beliefs as had been asked at the beginning of the semester. The means and standard deviations for the questions on beliefs on the two surveys were then calculated. Prospective teachers were asked to use the code name chosen at the beginning of the semester.

Analysis

Four categories were created by the researchers to collect information from the reflective journals about areas of interest. The first category was one called *Beliefs*. It held material about the students' beliefs about mathematics and mathematics teaching and learning. The other categories were: *Technology* (material discussing the value of the conferencing tool, or any issues relating to this technology), *Evaluation* (material evaluating any aspect of the subject), and *Workshops* (material relating to another component of the subject). See Foley and Schuck, 1998, for discussion of the results from the *Technology* category. The present paper focuses on the first category, *Beliefs*.

A few reflective journals which expressed a view that appeared representative of a majority view were selected to be copied, and any journals that expressed a view that was substantially different in any way from other views were also copied. Two journals were read by both researchers to ensure that they were being categorised in the same way. The researchers then categorised all the selected journals. The contents that had been marked as *Beliefs* were used to supply data for this paper.

The two sets of surveys were also analysed for the information they supplied about beliefs. Prospective teachers were required to score each statement on a Likert scale. Examples of beliefs statements were the following two statements: "mathematics does not change with time, only the ways of teaching it change"; and "mathematics is value free and objective". A mean and standard deviation for the group, on each statement about beliefs, were calculated. A t-test for paired samples for means was used on the group of 18 belief statements, to test for statistical trends. Each item was also tested for significance using a t-test on the responses on each survey for that item. As only fifty one prospective teachers had put their code names on both surveys, all statistics were calculated for that subgroup (n=51) of the whole cohort, to ensure that the groups were paired.

Results

For each individual item about beliefs, the change in mean values on the two surveys is small, and only three of the 18 changes are statistically significant with $p < 0.05$. However, when the entire group of beliefs statements are considered, there is a clear trend in the direction of change of beliefs towards a more liberating view of maths ($t=3.7$, $p<0.01$).

Prospective teachers' journal entries offer more in-depth information about the intervention and other factors influencing prospective teachers' beliefs. Many prospective teachers commented in their reflective summary, written at the end of semester, on how limited their thinking had been about mathematics when they initially responded to the two statements. For example, the following text from one student's journal and summary show this kind of development. Jenny's (pseudonym) initial response to the first focus statement was as follows;

> I agree with Maria's statement. My views on maths are similar. My thoughts on maths are basically just different ways of applying figures and numbers together in order to get an answer. I think this is due to the way I was taught in maths, from a young age, through to a teenager, I found maths to be a very passive learning experience, I was told what to do and how to do it and that was the end of it. I kept on thinking this is not relevant to life, unless you wanted to become a mathematician which I had no intentions of becoming one [sic]. I don't understand or appreciate maths, therefore I can't see past the numbers, formulas, etc. Mathematics makes very little sense to me especially at the high school level - years 11 and 12.

At this point Jenny is showing the sort of thinking about mathematics that is limiting for her, and will prevent her from sharing a more dynamic view of the nature of mathematics with her primary school pupils when she starts teaching.

The next extract of text is taken from Jenny's journal after she has started reading the material provided to challenge beliefs:

> After the completion of this article [NCTM, 1989], I discovered mathematics means so much more than just numbers. It showed me the importance of the process - discovery/journey of mathematics than to get the answers. It can also link to different KLAs [Key Learning Areas], while, prior, to reading this article, I thought mathematics was an isolated subject on its own. Not forgetting maths should have relevance to life, therefore it is easier to understand. This article has given me a whole new approach of looking [at] and thinking [about] mathematics.

Finally, Jenny wrote in her summary about the new learning occurring during the semester:

> At the start of semester two I had a very narrow view of mathematics, thinking it was just boring numbers and formulas. My view was very similar to those [sic] of Maria's quote. However, as I progressed through this subject I found my views changing at a moderate pace. Ö
>
> The second group discussion gave me the opportunity to read other groups' responses which gave me an even broader knowledge on the meaning of mathematics.
>
> In conclusion, my views have completely changed. They are no longer limited. ....

So for Jenny, both the material supplied by the lecturers and the responses of her peers helped her to challenge her own beliefs. Another student also wrote enthusiastically about the value of the group discussion that was a central feature of the intervention. She wrote in her summary:

> To be honest I think that the maths discussion tested my beliefs and ideas about maths more than any test could.
>
> Thank you who ever reads this journal because I would never have thought of some of the points that came up through other people's readings and ideas, and also they really began to challenge my own.

And finally, a male student, who had shown some impatience with the way the subject had started, as shown by his comments, written in his journal about the first class held for the subject:

> Right now I'm hoping that my attitude improves greatly because I'm thinking "When the h.. are we going to do mathematics?". Ö I will try to understand why we are talking about everything but maths. I like maths and I want to do some.

He seemed to show some awareness that he had developed in his thinking a few weeks later: "Have realised by reading for the assignment that I've already started to change my thinking about mathematics. It's a lot more complex than suggested in the quote [Maria's statement]Ö."

And in his summary:

> The mathematics readings, or one in particular, opened my eyes to something else. I didn't realise that different cultural backgrounds made a difference to people's concepts of mathematics. Obviously people living in a third world country with little access to education will not be as good at it as others who have access. But I thought this was only an educational deficit, but then to read about how playing particular games in

India, girls become better at mathematics [an article from the web: http://ms.mathscience.k12.va.us/lessons/kolam.html], or hearing in the tutorials that Fijian children have little concept of mass [maths?] and number because they give and share everything [sic].[This last comment was sparked by a response by a Fijian mathematics educator to the statements on the conferencing tool.]

I think it is a good idea to keep a diary, it makes one think about what they have done during the day and reading back over it I can see where my ideas have changed about the subject. For example I can remember telling you that I basically agreed with Maria's quote, but I thought it could have been written a little better. By the time I had finished the first reading I realised that Maria and I were totally wrong. If not wrong, narrow minded in our views of what mathematics is.

There are many rich examples in the text of how prospective teachers felt that their original thinking about mathematics, as evidenced by their responses to the quotes in the first lecture, were very limited, and how they felt they had changed their thinking to some extent as a result of the discussion and sharing of material in their mathematics education community. There were also a few examples showing that even while beliefs may have been challenged by the intervention, the experience on the practicum often led to some tension between the approaches used in the university subject and those used by the supervising teacher. The following extract shows this sort of thinking:

Jake (pseudonym) started his journal by writing about his goals for the subject:

There are many goals I would like to reach by the end of Mathematics Education 1. ...

It should be emphasised through lessons that the answer is NOT the most important aspect of maths, but the method from which it derived - this method or technique I wish to begin to understand, so I can teach mathematics successfully.

Later in the journal, Jake responded to an aspect of his group's discussion:

Our conversation confirmed that attitudes are constructed through either positive or negative experiences in mathematics, the fact that, unfortunately, some teachers seek only correct responses.

But his notes on the practicum in his summary seemed to be expressing an opposite view to the above, and some dissatisfaction with the workshop approach used in Mathematics Education 1:

The greatest learning experience in the field of mathematics occurred during practice teaching. The class although challenging, allowed me to experience what it's really like to teach... Initially I made several errors, I took too long in marking the answers (should have been informed on how to mark work for optimum results) and not knowing how to answer certain questions, which I had to figure out myself.

These failures set up successful maths lessons which were highly controlled in terms of explanation, modelling and exercises. The methods I used were from my assisting teacher, as she recommended that I mark the work fast, seek exercises that are challenging and to explain concepts thoroughly. These may not sound difficult, but we never discussed this in mathematics.

Discussion and Conclusions

It would be ambitious to expect that beliefs held for many years could be changed in the space of one semester. However, there was sufficient indication in the data from the surveys and the journals to show that the intervention was successful in encouraging prospective teachers to become aware of their own beliefs, and that the process had begun to challenge their beliefs. Prospective teachers showed that they had increased awareness of the influence of school students' cultural backgrounds on their learning of mathematics, the differing nature of mathematics in different cultures, the importance of process as well as solutions, and the possibilities of integration across the curriculum.

It should be noted that the web-based conferencing tool was just that - a tool or device which was used as the medium for the intervention. In itself, it was not instrumental in changing beliefs but provided a vehicle through which contact with the international community of mathematics educators, and with the local community of learners, could occur with immediate feedback. The community of mathematics educators participated in the discussion in much the same way as the prospective teachers - they responded to the focus statements, just as the prospective teachers did, and they had the opportunity to participate in the discussion throughout the semester. Another advantage of the conferencing tool was the ease with which prospective teachers could read each others' responses to the focus statements. Prospective teachers commented that the knowledge that their response was going to be read by others encouraged them to think more carefully about the material they would submit. Having the responses placed on the web also meant that prospective teachers could use each other as the learning community and benefit from the careful thoughts of other groups. It encouraged discussion in the whole learning community of the cohort, as opposed to dialogue between the group and the lecturer. Hence the use of the conferencing tool made access to material easier and more immediate. For a detailed discussion of the value of the conferencing tool, see Foley and Schuck (1998).

Finally, some comments from the student journals clearly show a tension between approaches used in the university based part of the subject, and the experiences occurring during the practicum. Where supervising teachers saw mathematics differently from university teachers, some conflict was evident in the beliefs of the student teacher over the two periods. The implications for teacher educators wishing to challenge beliefs, are that communication between university staff and school staff must be improved, so that teachers are aware of the content and approaches of the university subjects, and academics are aware of the approaches, beliefs and constraints operating in the school classroom. With this knowledge, a better understanding of the role of the practicum can be negotiated.

In general, then, the intervention was successful in challenging student teachers' beliefs, but more attention needs to be paid to the influence of the practicum on the learning occurring in the mathematics education class at university.

References

Australian Education Council. (1991). *A national statement on mathematics for Australian schools.* Carlton, Victoria: Australian Education Council and Curriculum Corporation.

Burton, L. (1996). Mathematics, and its learning, as narrative - A literacy for the twenty-first century. In D. Baker, J. Clay, & C. Fox (Eds.), *Challenging ways of knowing English, Mathematics and Science* pp. 29-40. London: Falmer Press.

Crawford, K. and Deer, C.E. (1993). Do we practise what we preach? Putting policy into practice in teacher education. *South Pacific Journal of Teacher Education,* 21(2), 111-121.

Dengate, B. & Lerman, S. (1995). Learning theory in mathematics education: Using the wide angle lens and not just the microscope. *Mathematics Education Research Journal* 7(1), 26-36.

Ernest, P. (1991). *The philosophy of mathematics education.* Hampshire, U.K.: The Falmer Press.

Foley, G. & Schuck, S. (1998). Exploring the potential of a web-based conferencing tool in mathematics education. In *Proceedings of the ICMI Regional Conference,* August, South Korea (in press).

Lappan, G. & Even, R. (1989). *Learning to teach: Constructing meaningful understanding of mathematical content* (Craft Paper 89-3). East Lansing: Michigan State University, National Center for Research on Teacher Education.

Mayers, C. (1994) Mathematics and mathematics teaching: changes in pre-service student-teachers' beliefs and attitudes. In G. Bell, B. Wright, N. Leeson, J. Geake (Eds)*Challenges in maths education: constraints on construction - Proceedings of MERGA 17 Annual Conference,* Lismore, July: MERGA, pp. 419-428.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics.* Reston, VA, USA: NCTM

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA, USA: NCTM, pp. 5 - 12.

Pateman, N. (1989). *Teaching mathematics - A tantalising enterprise.* Geelong, Victoria: Deakin University.

Schuck, S. (1997) Using a research simulation to challenge prospective teachers' beliefs about mathematics. *Teaching and Teacher Education,* 13(5), 529-539.

Schuck, S. (1996). *Learning and teaching mathematics: Interpreting student teachers' voices.* Unpublished doctoral thesis, Sydney: UTS.