Addressing the Needs of Mathematically Anxious Preservice Primary Teachers

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There has been concern for some time about how mathematically anxious preservice primary teachers can best be helped to deal with their fears and negative feelings about mathematics so that they can move on to focus on how best to teach children mathematics. This study reports on the effectiveness of a course that was especially established to meet the needs of such students in a preservice primary teacher education program.

Every year the School of Education at the University of Waikato has approximately two hundred new people entering their Bachelor of Teaching degree. As part of their teacher education program these students are expected to take and pass one and a half compulsory mathematics education courses during their first and second years. Of these students, there is always a significant number who are mathematically anxious; they have real concerns about their own understanding of mathematical ideas and processes. This anxiety is largely the result of their past mathematics experiences. They know that in three years time they will be expected to teach mathematics competently from beginning primary through to intermediate school level (Years 0-8) in New Zealand. Hence they feel a need to take an optional paper that will hopefully help them understand the mathematics itself (as distinct from the mathematics education addressed in the compulsory papers) and thus alleviate their anxiety.

Previous Studies

There have been a number of studies regarding the importance of teacher mathematics knowledge (or lack of it) and the effects of the ensuing teacher anxiety on children's learning (Mewborn, 2001; Howard, Perry & Keong, 2000). The issue of preservice primary teacher anxiety is cause for concern because, as Clarkson (1998) noted, teachers who have long term problems can cause pupils harm if their mathematical insights are not given an opportunity to develop. It is generally agreed that teacher's beliefs about mathematics, mathematics learning and mathematics teaching will affect both the way they teach mathematics and their expectations of what children should be able to do. (Beswick & Dole, 2001; Biddulph, 1999; Clarkson, 1998; Howard et al, 2000; Mewborn, 2001).

A variety of reasons have been suggested for such anxiety. These include a lack of conceptual understanding where students may have a grasp of mathematical facts and algorithms, but lack understanding of underlying concepts (Biddulph, 1999; Mewborn, 2001). Further reasons include their school experiences of outdated teaching methods (Battista, 1999; Cornell, 1999), a belief that that the role of the mathematics teacher is to transmit mathematical knowledge and verify that learners have received this knowledge (Howard, et al., 2000) and a belief that some people have a 'mathematics mind' while some do not (Beswick & Dole, 2001), implying that learning mathematics will be limited to those who already show they have some ability in mathematics. Overall the literature indicates that dealing with mathematically anxious people is a very complex issue and to simply deal with the mathematical knowledge alone is not enough. Students have feelings, perceptions and beliefs that they need to express and clarify regarding what mathematics

is, its purpose and how it should be learnt (Grootenboer, 2003). Their environment, the people in it, the tasks they engage in, the pedagogical practice as well as the relationships they build, are all factors that need to be considered and are major reasons for considering constructivism and humanistic theory in supporting these learners (Biddulph, 1999).

In terms of helping preservice teachers deal with their anxiety, there have been a number of avenues that have been explored with positive results. Some of these include incorporating a compulsory mathematics unit into mathematics education courses, encouraging student interaction when solving problems set in meaningful and relevant contexts and the valuing of a variety of strategies of solving problems (Clarke and Clarke, 1996; Owens, Perry, Conroy, Geoghegan & Howe, 1998). Tooke and Lindstrom (1998) suggest also that the use of manipulatives to physically represent parts of problems can be helpful.

The Mathematics Course

The course that students enrolled in was an option course available only to Year 1 preservice teachers in the first semester of their teacher education program. Participants self-selected at the interview stage or when they enrolled if they felt that their mathematical knowledge was inadequate or if they were anxious about mathematics. The focus of the course was to help students develop their mathematical knowledge and understanding and thereby increase their confidence to work in mathematics. The course consisted of 24 two-hour sessions over 12 weeks. There were two classes of 23 and 18 students. The paper was taught by two lecturers each of whom took a class for all of their sessions. The author took the class of 23.

Theoretical Framework of the Study

The theoretical framework chosen for the study was an amalgam of social constructivism and humanistic learning theory. In social constructivism, 'knowledge' is not seen as an eternal body of truths but is socially constructed (Ernest, 1994). It is that which is agreed upon by the group and for this to occur, interaction is necessary. This approach to learning seemed to be most appropriate for this group of learners because it allowed them to learn mathematics in a variety of ways and contexts while constantly interacting. It meant also that learners could begin 'constructing' from where 'they were at', using strategies that made sense to them.

Humanistic Learning theory promotes the notion that emotions play a large part in learning in that they can either inhibit or facilitate it. Key principles from humanistic learning theory espoused by Biddulph (1997) include notions of relevance, control, temporary discomfort, success and genuine interaction. Learners need to be involved in mathematical learning which they can see as relevant. This in turn leads to them being involved in some decision-making regarding the content of the course. Feeling a little threatened and uncomfortable for short periods of time is also expected as ideas are challenged and changes are made. Success is necessary and needs to occur often so that confidence can build. Learners also need to feel they are interacting with others who are 'genuine' that is, they are with people who 'care' about them and their learning and in whom they can trust. Therefore, it was these two key ideas that informed and underpinned the course process. They provided an appropriate framework to interpret the data collected during the course.

Course Activities

One of the key aims of the course was to help students develop their mathematical knowledge and understanding and thereby increase their confidence to work in mathematics. Encouragement for students to begin reflecting on mathematical ideas, activities and their performance was an important feature of the course. These reflections contributed to the final assignment, namely an individual journal maintained throughout the semester in which the course was undertaken.

The course activities meant that because most student participants were not in their comfort zone at the beginning, it was necessary to ensure that they felt that what they had to say was important to the lecturer and that it would also contribute to the course content. Initial activities designed to reflect this thinking involved the use of metaphors for their thoughts about mathematics, discussing and acting out past experiences regarding their mathematics learning and actively engaging in mathematics activities designed for them to show what they knew or understood.

A range of topics and ideas were covered in the course. These were a combination of suggestions that students had made in the first week of the course and ideas that the lecturer considered would be useful for them to clarify or gain some understanding about. These included algebra, fractions, solving word problems, percentages, perimeter and area.

In addition to studying these topics or ideas in class, Assignment 1 also meant that students needed to find and carry out a mathematical investigation, recording the process that they went through, and Assignment 2 allowed them to present a seminar and write a report on how a particular mathematics idea or topic of their choice is linked or can be linked to experiences in real life. Suggestions included our numeration system, other numeration systems, Pythagoras' Theorem, measurement used in another culture and the Fibonacci Sequence.

The Study

The study focussed on whether or not the course was effectively addressing the needs of the mathematically anxious students in the course. Data were collected from one of two groups of students who opted to enrol in and undertake the course. This was the group that I taught myself. It consisted of 23 students, 20 of whom were female. 15 of the 23 were less than 30 years of age and one student was over 40. Only 30% of this group had achieved any formal school mathematics qualification

Data collecting procedures involved two questionnaires being given to all students with one at the beginning and an anonymous one at the end of the semester. These were part of the normal teaching of this course and were designed to inform the teaching process and course content as well as illuminate any changes that may have occurred for individuals throughout their time in the course. Three interviews were also conducted in weeks one, five and twelve with a sample of six students (approximately 25% of the group) to gain deeper insights into what the experiences of undertaking the course meant for them.

Systematic observations were also undertaken, focussing on students' involvement in and responses to, activities which formed part of the course. These observations were recorded as field notes and were necessary to capture some of the spontaneous sharing of ideas and questions that were generated during class activities.

Student journals were a normal requirement of the course, and they were examined to gain insights into the journey that students made along the way in the course.

Findings and Discussion

In this section the findings will be presented and discussed in four broad themes that emerged from the data. The results suggested that there were some changes in students' views about mathematics, the learning and teaching of mathematics, their conceptual understandings, and their attitude and confidence level. For many of the participants, this led to an overall feeling of empowerment in mathematics which meant that they were no longer as afraid of 'doing' mathematics as they were prior to participating in the course, and they were not as anxious also about participating in the compulsory Year 1 course on the teaching of mathematics in the following semester.

Views About Mathematics

The results showed that 19 out of 23 of the students expressed a view that the relevance of mathematics was more accessible to them. For example, Nina stated:

> …it's switched to be more realistic… I quite like that idea because it's real and it feels real and you can relate. Basically the focus has changed to real life and it's more relevant…

Another commented on how it really was something you could "use":

> Now I see maths as just a tool you use like a language. You just use it to get what you want. (John)

However, it was clear that these views were by no means firm. Student comments throughout and at the end of the course showed that, for many, mathematics was still a static body of knowledge rather than a dynamic creation that they could be a part of. Students had become more accepting of processes for constructing solutions being more dynamic, but still considered that all mathematical content and knowledge had already been invented and was 'out there' somewhere in front of them.

> There's an answer out there somewhere and I need to find it. (Carey)

They felt they still needed to learn that knowledge. Their perception of **how** to do that had been altered greatly and they had been empowered by knowing they could find or 'construct' a way that would make sense to them. This awareness of constructing their own pathways is consistent with social constructivism as espoused by Ernest (1994).

Views About the Learning and Teaching of Mathematics

Although the course was not specifically about mathematics education, 18 of the 23 students commented on how the learning and teaching of mathematics was not as they expected. For example, James stated:

> …it would be more like we did at high school. 'Here's a maths book. We're going to do numbers 10-20. These are the different ways you can get the solution'. I thought it would be more like that. I'm kind of glad it isn't.

Mathematics could now be seen to be fun and enjoyable and these were not aspects that they previously associated with learning mathematics. There were a number of factors that contributed to this including various games as well as activities that took them outside.

> I realise maths can be fun and we can laugh, like for example, when we were doing the carpark exercise." (Joy)

Feelings of 'enjoyment' correlate with thoughts from Owens et al, (1998) and Maxwell (2001) who suggest that such dispositions can contribute to changes in attitude and mathematics thinking. The modelling of a mathematics pedagogy that was consistent with

the tenets of social constructivism and humanistic learning theory allowed for such changes, which seemed to be crucial for the positive development of these mathematically anxious students.

Conceptual Understanding

Throughout the course many of the students struggled to remember 'rules' when considering the mathematics rather than 'what would make sense'. For example, when striving to understand the "mean/average" number of letters in student names in our class, it was found that there were 3 'leftovers' to which some students promptly decided that we should *'start another row'*. When asked what others thought of this idea, some decided that this was not a good idea because we couldn't *'invent another student for our class'*. They decided that it would make '*better sense'* to cut up the 3 leftovers and share them out between the 19 students there. Students struggled to leave behind previously suggested rules and algorithmic patterns in order to develop such conceptual understandings.

However, students did report new mathematical understandings in a range of areas including the fact that area could be different depending on how the perimeter was arranged; that when multiplying decimal numbers less that 1, the product would be smaller that either of the factors; how to calculate interest on student loans and mortgages; the idea that mathematics was made up of numerous patterns and how to find a rule for a growing pattern to then work out a generalisation.

Much of the literature has suggested that a lack of conceptual understanding is a major contributor to the state of mathematics anxious students (Battista, 1998; Biddulph, 1999; Clarke & Clarke, 1996; Mewborn, 2001). This also seemed to be the case with the students involved in the research reported here. In the beginning, mathematics was seen by many students enrolled in the course as unpalatable 'rules without reason' thus, any attempts to help such students emphasised developing a 'sense-making' approach and practise to doing mathematics to avoid the 'confusion' that many associated with their previous mathematics experiences. Such an approach seemed to be very helpful with these mathematics anxious students.

Changes in Attitude and Confidence

Of the 23 students, 13 expressed a change in attitude and growing confidence in their ability also to engage with a mathematics problem, even when it might look initially difficult. Carey states:

> Yeah I feel more comfortable towards maths….I just break it down now, make it more manageable…… I was pretty afraid of maths….Even though a lot of maths still scares me, I'm not afraid to tackle it. (John)

It seemed that their new sense of mathematical efficacy lowered their anxiety levels so that they could engage positively with the mathematics. This is consistent with the humanistic learning theory which proposes that as students start to feel successful about their work in mathematics, their attitude and confidence will grow.

Factors Contributing to Changes

There were two main factors that seemed to contribute to the changes. They were (i) the use of social constructivism and (ii) the development of a safe learning environment. Some of the key aspects regarding these two factors are discussed below.

Social Constructivism

As mentioned earlier, the course was established within a social constructivist framework. This was evident in the data in three main facets: (1) relevant contexts; (2) student interaction; and (3) use of manipulatives. These are now discussed in turn.

Because of previous experiences, it was necessary that the mathematics studied in the course be seen by students to be important, useful and relevant so that they would engage with each other and the mathematics. Hence, a problem-solving approach to perceived relevany contexts, was deemed to be a major part of the course. Students needed to learn mathematics related as much as possible to their world. Providing the ideas in contexts they could relate to was essential (for example, parking at the university; budgeting, finding the GST of an item). This concept of perceived relevance is consistent with programs promoted in the literature (Battista, 1998; Clarke & Clarke, 1996; Cornell, 1999).

A major tenet of social constructivism is the idea of much student interaction during mathematics learning. 13 of the 23 students commented on how useful it was to work with other students on a number of activities and tasks. This helped firstly, to facilitate the development of useful strategies, secondly, to clarify ideas, which in turn, as Owens, et. al (1998) suggest, helped in overcoming negative feelings towards mathematics because it contributed to an increasing level of confidence. It helped to interact with others to find solutions. Also, other people (including the lecturer), upon understanding and agreeing, would affirm a student's thinking, which again helped confidence levels to rise. The exposure to a variety of possible strategies and the valuing of them seemed to have a very positive effect on increasing the confidence levels of mathematically anxious students (Clarke & Clarke, 1996). 19 out of the 23 students commented on this:

> You can ask them or get advice from them, or say, "'How did you do this?' and they might say, 'I did it like this.' So you attempt something because you think, well, if they can do this and they're doing it then I can too. (Carey)

> It's the sharing, I think, of the knowledge. It gets you involved in it….Working with others has helped me to ask better questions. I feel like my questions are more on task. (Jolene)

Another major factor in helping students with the mathematics was the use of equipment such as tiles, blocks or counters to physically represent components of the problem. 17 of the 23 students commented positively about this.

> Using physical pieces makes it clearer than just examples on the blackboard. (Sylvia)

This correlates strongly with such ideas suggested by Tooke and Lindstrom (1998).

A Safe Learning Environment

A safe learning environment for all was essential for feelings to be considered as espoused by the Humanistic Learning Theory (Biddulph, 1997). Some ways initiated by the lecturer included the fact that students knew that often they could choose to work independently, or in pairs or if appropriate, in groups. Many often chose to work with at least one other. Also, the promotion of the idea that there may be a variety of ways to solve a problem seemed to alleviate the pressure to find the 'right way' to solve problems (Owens, et al., 1998). The lecturer also did not often ask a specific person to answer a question, but directed questions to the class generally or to a specific group so that people could choose to answer. As people became comfortable with each other in class, so did their level of speaking increase. Other strategies employed by the lecturer such as not ever saying anyone or anyway was 'wrong', but rather asking questions to help unravel a

possible misconception, helped to promote the notion of risk taking and asking students to assess their own learning via regular reflections in their journal and informal discussions in class, all helped to contribute to the course environment and their responsibility to their own learning process.

Conclusion and Implications

This course does seem to have addressed some of the needs of these mathematically anxious students. It appears that many benefited in some ways. They gained confidence in their ability to do mathematics, gained more understanding about some mathematical ideas especially number, felt that they had some problem solving strategies to access and engage successfully with mathematical tasks and realised that mathematics could be enjoyable and relevant to them. This would seem to indicate that it would be beneficial for those people who teach mathematically anxious students, to include a social constructivism perspective in their practice.

Furthermore, it seems helpful for such students to focus for a time, only on their own conceptual development as learners of mathematics rather than on how to teach mathematics, at the same time. This relieves students of additional pressure.

The issue of time also needs consideration. A twelve week semester of four hours a week means prioritising key mathematics ideas that can be explored with students who have taken years to develop their mathematics anxiety. Not everything can be covered in such a limited time. Further research could involve determining the benefits of focussing on particular content ideas only (e.g., number and algebra).

On the whole, while some very small successes may be claimed here, the literature reveals that this is a very complex issue and is worthy of time and effort for further exploration.

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