Developing beliefs about the teaching of primary mathematics

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This paper relates to small-scale, mixed methodology research investigating the developing beliefs of students in Initial Teacher Education (ITE) in relation to the teaching of primary mathematics, undertaken as part of a Masters in Mathematics Education. All students were in their first year of a three year degree, studying at the University of Chichester. The major intention was to identify their emerging beliefs, with a subsidiary interest in what had shaped those beliefs. The project was set in the context of a new curriculum mathematics module, which was underpinned by my own beliefs about module content and teaching approaches. A range of questions were asked of the students through simple questionnaires and a small number of interviews.

Keywords*:* Mathematics; Beliefs; Initial Teacher Education; Primary

Background and methodology

The motivation for this small-scale research project was a desire to find out about the mathematical beliefs of first year undergraduates in ITE, noting however that one may "not be fully aware" of one's beliefs (Noyes 2007, vii). Hodgson (2001, 501) recognises that the development of teaching beliefs span "various periods of the teachers' life", starting in infancy, and Stigler and Hiebert imply that through "cultural participation" (1999, 83) students are likely to teach as they themselves were taught unless challenged, leading to a subsidiary interest in where beliefs originate and whether the year one curriculum mathematics module was successful in getting the students thinking about their views. It should be noted that a mixed picture emerges from the literature with regard to whether initial teacher education actually has the capacity to alter students' beliefs. Bramald, Hardman and Leat (1995), writing about their research with 162 student teachers argue, however, that previous research has been "too pessimistic"; let's hope we can make a difference!

My research followed very much a mixed methods (Creswell 2003) and emergent (Denzin and Lincoln 2000) approach as I grappled with trying to uncover my students' beliefs about the teaching of primary mathematics. I relied mainly on questionnaires and interviews to collect qualitative data, with informal observation an additional method. Most of my 'questionnaires' were non-traditional; short activities designed to gather responses from my two teaching groups (53 students in total, not all of whom responded every time thus the potential bias of non-response should be noted) with open-ended questions posed in a variety of ways during and between sessions. Ten individual interviews were undertaken, in particular to elicit whether those students believed they wanted to teach mathematics in a way similar to their own experiences as a child. These took place after the module had finished, but before the students' second school block in the summer term, as did the final questionnaire to the whole cohort (n=94). The 250 individual submissions (written and interview), collected on six different occasions, were treated with equal weighting, a potential limitation of the methodology. Another limitation of the study itself was not being in a position to investigate whether taught modules really did impact on the students' classroom teaching. There are also issues associated with transferability of results, nicely illustrated by Denzin and Lincoln (2000, 370):

> Every instance of a case or process bears the stamp of the general class of phenomena to which it belongs. However, any given instance is likely to be particular and unique. Thus, for example, any given classroom is like all classrooms, but no two classrooms are the same.

Findings

Once all the submissions were gathered and assigned individual reference codes, the inductive exploration of the data began (Janesick 2000) resulting in the identification of various themes, four of which are reported here with anonymous quotes given to help to bring it to life and to "transport readers to the setting" to support validity (Creswell 2003, 196). Quotes are shown in italics with spellings and punctuation reproduced as in the original. The numbers in brackets following reported comments indicate the code of the respondent.

Classroom climate and enjoyment of mathematics

Starting from the premise that mathematics is something to be savoured and enjoyed, practitioners in ITE must accept the fact that some students' perceptions need to be challenged (Goulding, Rowland and Barber 2002). Through investigating students' developing beliefs about the teaching of primary mathematics, in particular in the interviews (I), the data suggests that the quality of the teaching at any stage of education can affect and alter people's views about mathematics quite considerably.
Fifteen respondents recalled *frightening* experiences of school mathematics and talked about being afraid to try answering mathematics questions for fear of being wrong. The theme of *fear*, *panic...* was a common one with 50% of those interviewed stating that they had not enjoyed mathematics as a child. Interviewee I1 spoke of teachers who are positive and make you feel good about yourself. Others attributed lack of enjoyment to the serious and fast-paced nature of the lessons (I3), to a staid and regimented approach (I1, I5), to a lack of relevance (I7, I8) and to a boring, dull or dry approach (I2, I4, I6, I8, I9), including not being challenged. All ten interviewees exhibited positive current views of mathematics despite previous experiences. One respondent found herself looking forward to coming to sessions and was surprised at the absence of a *sinking anxious feeling* whilst another stated that two-hour sessions were too short!

Of the ten people interviewed, seven said that their beliefs about how mathematics should be taught differed from their own experiences as a child; the remaining three, rather than saying that they wanted to teach as they were taught, all suggested that it very much depended on the teacher. Just as with the interviews, emotion seemed to play a big part in responding to an emailed sentence starter "Mathematics is..." (eliciting 26 responses, a 49% response rate). For example:

- *Maths is something that initially makes me panic, but is also something I can enjoy and do when I learn to relax!! (M13)*
- *Maths is better than i thought it would be! (M8)*
- *Maths is exciting and so much more than you think it is! (M7)*
- *Math's is enjoyable, and not as scary now! (M20)*

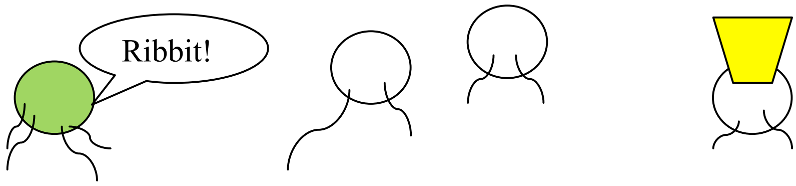
- *Maths is my favourite and my most hated subject at the same time. It manages to make me feel really clever and extremely stupid. It's a bit like a relationship for me in that it can make me cry and give me great satisfaction. (M25)*

Beliefs specifically associated with the atmosphere of the classroom were less apparent in the questionnaires but as a result of the module (questionnaire R) one student specifically commented on the atmosphere he wished to generate in his classroom: *I would like to encourage an atmosphere in which pupils are not afraid to admit they do not understand any particular aspect of a maths lesson. I want every child to be able to give an answer, even if it is "I don't know, sir"* (R17). In this questionnaire, asking students to reflect on what they would like to try within their teaching upon return to school, 10% mentioned explicitly that they wanted to afford children the opportunity to work in groups, and for a variety of reasons such as: *Create mixed ability groups or pairs so that children can see that different children tackle problems in different ways (R47).* One interviewee (I10) noted group work as a specific difference to what she had previously experienced, saying that she had *never done that in maths before*.

There were other comments relating to issues with group work, in particular three respondents to an early questionnaire (A29, 30 and 32) who all wrote about needing longer to think and work than other members of the group allowed them and two writing that others had looked at the problems beforehand and were over eager to share their methods. Within other responses to A there were various positive mentions of group work (six in total, 19%), with different benefits attributed, for example a boost to confidence through the support a group offers. Eight respondents (21%) to another early questionnaire, one on effective talk, mentioned mixed ability groupings or working with 'new' people as a positive experience. An additional three people also spoke in more general terms in favour of group work, and four people mentioned the positive benefits of working within mixed abilities in their final questionnaire (R), with I6 also noting that that she believed teaching should not just be in ability groups.

The role of talking and thinking

The role of thinking was explored in the fifth session, with the students in my teaching groups asked to reflect privately upon what had made them do the most mathematical thinking so far during the module, recording their ideas on post-it notes (T). A high proportion (57%) mentioned problem solving explicitly, so it is very clear that the decision to incorporate lots of problem solving opportunities into the module had encouraged students to think. Some respondents mentioned specific problems that had been used, with a problem involving frogs and princes (Potter 2006, 174) cited by six students in all, four on this occasion. The group solutions to this problem (how many princes/ frogs given there were 35 heads and 94 feet) were particularly notable with regard to discrepancies in levels of knowledge and, as a result, thinking. Moving around the room and listening to the groups' discussions, at least two of the afternoon table groups were discussing simultaneous equations and this approach to solving the problem was reinforced during the class discussions which followed with one mathematics specialist claiming that the use of simultaneous equations was the only possible approach. I reported that in fact no one had used simultaneous equations in the morning, all groups solving the problem comparatively simply. I shared the approach which had struck me as being particularly elegant and effective: draw 35 circles (please imagine the rest!), add two legs to each (i.e. the minimum), share out the 'spare' legs.



A19 later wrote: *The princes and the frogs problem made a difference as automatically solved it with simultaneos equations and couldn't imagine any other way of doing it.*

Beliefs associated with the benefits of giving children opportunities to talk, discuss, explain, communicate etc occurred throughout the data but were hard to quantify as they were linked to other features and referred to in so many different ways. There was some sense within the responses to the final questionnaire that my students are likely to afford children opportunities to discuss mathematics when they go back into school; obvious in some responses, implied in others (for example those who write of interaction or mathematics not being a solitary activity).

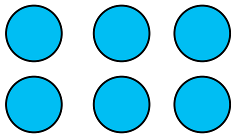
Types of activity including the use of resources

Data suggests that a number of students believe that mathematics lessons should be 'hands-on'; in fact a total of twenty-seven respondents (across three sources: I, M and R) explicitly mentioned beliefs about practical, interactive approaches to teaching mathematics. The arguments underpinning such an approach varied but broadly suggested that it was likely to engage pupils more or enhance enjoyment of learning, for example: *In the module, I learnt that maths can be more active. I would like to encompass practical activities, making the maths more visual and hands on (R51).*
Linked to the interactive teaching theme, there were twelve people who stated that resources should be used to support mathematics teaching and learning. An approach dominated by books and worksheets was noted as a negative by nine students.

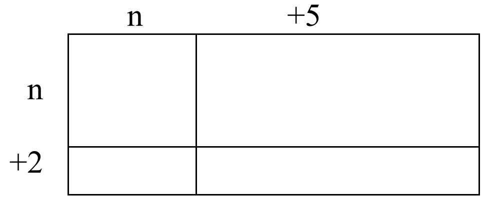
Impressions gained from thirty-two responses suggested a belief that there are benefits associated with contextualised mathematics teaching, with twenty-two people mentioning contexts linked to the real world, but I am not in a position to check the following claim: *Putting maths in to a relevant and fun context, possibly topic related. It makes learning more effective and has more of a lasting impact (R35)*! There were also four students who specifically noted that teachers should make cross curricular links apparent, with R94 suggesting links with other *current class topics* such as links between mathematics and art. I2 suggested that themes, such as 'The Romans', could bring the subject alive and put mathematics into context more than *boring worksheets*.

The extent and nature of mathematical knowledge

Whilst the year one module is designed, in part, to boost our students' subject knowledge, and to allow them to re-experience being a learner of mathematics, certain authors make a distinction between this and learning how to teach it, often referring to Shulman's work in categorising different types of mathematical knowledge. One interviewee (I8) reflected upon one of his school teacher's lack of ability *to explain things so that anyone else could understand* and later went on to specify that there is a *difference between learning mathematics and being able to teach it*. Casual observations and some of the data generated as part of this small-scale research project suggest that this first module succeeded in broadening some of the students' breadth of pedagogical knowledge. Anecdotal and questionnaire based evidence arises from comments like never having thought to represent something in a particular way, and understanding an aspect of mathematics much better as result of an alternative approach. To give a concrete example from an informal session observation, a mathematics specialist remarked on my illustration of algebra linked to multiplication using the area of a rectangle with unknown length sides n+2 and n+5. She had never seen it demonstrated in this context and was surprised at its simplicity and potential effectiveness. We had built towards this starting from arrays such as 2x3=6 to illustrate significant scope for progression.



progressing to:



Illustrations of shifts in my students' awareness of the incredible variety of ways in which people approach working things out in mathematics occurred across all six data sources, most extensively following the problem solving session (A) with 75% of respondents noting awareness of different methods and approaches in some form. Of the twenty-four linked responses, a variety of example statements are shown below:

- *I found it very helpful working through the problems and watching/ observing how other people approached the same problems. It's a very useful style of activity because it made me think about how my approach differed from others. This led me to think about how children might approach problems from different angles (no pun intended!) (A1)*
- *What I have learnt today is that it is ok if my way of working out is different to other peoples and I have found that reassuring. When I was taught at school it was in one specific way. (A3)*
- *To listen to others (which I often don't do!) has made me appreciate other's techniques and ways of thinking without dismissing them out of hand (A28).*

One student's post-it note comment (T12) implies metacognition in that he/ she wrote: I have tended to do maths on an "I've always done it that way" basis. I've now had to consider why I do things a certain way.

Conclusion

The 'path of discovery' (Denzin and Lincoln 2000) during the past year's research has been a fascinating, if at times challenging, journey. All students were able to articulate beliefs regarding how primary mathematics might be taught; these beliefs were informed by, rather than necessarily consistent with, their experiences as children, with training seeming to have nurtured a more positive attitude in some of those interviewed. It was apparent that the image of mathematics we had presented had surprised some, for example that mathematics can be discussed, that group work, including mixed ability, is possible in lessons and that it is acceptable to solve problems and calculations in different ways. As originator of the module, I was conscious of its bias to reflect my own beliefs and, like Goos, Galbraith and Renshaw (2004, 107), found students' responses "remarkably well attuned to the teacher's goals".

Having now completed this small-scale research project, I am confident in the appropriateness of the selected methodologies and, for my part, have an enhanced understanding of research processes and potential limitations, such as an inability to isolate particular 'voices' across data sets as not all submissions were named. Lincoln and Guba (2000, 183) refer to the process of critically reflecting on one's own role as researcher, and the examination of personal views as "reflexivity"; a conscious awareness "of the self as both enquirer and respondent, as teacher and learner, as the one coming to know the self within the processes of research itself". I certainly feel that as well as a developing understanding of the research process, I also now know more about my own beliefs relating to the teaching of mathematics. I have not yet been in a position to prove whether the nature of the year one module might result in better mathematical experiences for children, but the privilege of visiting some of the original interviewees on future placements would allow some investigation of transferability of beliefs to the school context. Finally, I intend to continue to "involve the trainees in articulating and discussing beliefs and practices associated with mathematics" given the likelihood that reflection will result in more effective practices (Williams 2001, 447). Lastly, as teachers we "convey messages about the nature of mathematics by the way we teach it" (Nickson 2004, 43), therefore I will continue engaging students in mathematics in a way which reflects *my* beliefs about how mathematics should be taught!

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