

IMPROVING STUDENT TEACHERS' ATTITUDES TO MATHEMATICS

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The research results presented in this paper were part of an action research performed with the aims of improving primary school student teachers (STs)' understanding of, and attitudes to, mathematics. The teaching strategies used to help STs' improve their understanding and attitudes were similar to the ones suggested for their future use in teaching children. The data indicated that most STs improved their understanding. Some also said that they had improved their liking for the subject and their remarks clearly demonstrated a connection between the affective and cognitive domains. Yet others said that their attitudes towards mathematics had not changed much. The two main aims of this action research remain incompatible in the perception of some of these STs.

INTRODUCTION

Research has revealed that some primary school teachers and STs demonstrate negative attitudes towards mathematics (e.g., Ball, 1990; Relich and Way, 1994 and Philippou and Christou, 1998). There are many dimensions in the literature about attitudes to mathematics (e.g., Ernest, 1989 and Relich and Way, 1994). The focus of the present study is in the liking dimension of attitudes. Skemp (1989) says that the use of mathematics by adults depends on whether they liked mathematics at school. Considering that primary school teachers have to continue studying and using the mathematics they are supposed to teach, the liking dimension of attitudes was considered more important than the other dimensions.

For Skemp (1976) relational understanding involves knowing both what to do and why it works, while instrumental understanding involves knowing only what to do, the rule, but not the reason why the rule works. Skemp argues that the development of positive attitudes to mathematics is dependent on the type of teaching. Negative attitudes can be generated by a mismatch which occurs when the teacher teaches instrumentally, and the student tries to understand relationally. Baturu and Nason (1996) explains that the main product of instrumental teaching is the lowered self-esteem of students who do not manage to memorise facts and algorithms without meaning. Research shows that some adults with a degree in other subjects (e.g., Quilter and Harper, 1988) and primary school STs and teachers (e.g., Haylock, 1995 and Brown et al., 1997) tend to blame instrumental teaching for their negative attitudes to mathematics. Brown et al. (1990) suggest that an attempt is needed to consider the way by which primary school STs construct mathematical knowledge and what attitudes result from such construction.

THEORETICAL FRAMEWORK AND RELATED LITERATURE

In this study I have adopted a socio-cultural perspective based on the ideas of Saviani (1993) who argues for a pedagogy of liberation that places great emphasis on the acquisition of the cultural content in the school curriculum: “the oppressed does not become liberated if s(he) does not master all that the oppressors master. Therefore, to master what the oppressors master is a condition for liberation” (p. 66). In a similar way, Delpit (1995) points out that teachers should help socially disadvantaged and African-American students “to learn the discourse which would otherwise be used to exclude them from participating in and transforming the mainstream” (p. 165). So STs need not only to develop a more positive attitude to mathematics, but also to acquire a mathematical understanding of an adequate level to face the responsibility of communicating the subject to children and providing effective learning experiences to socially disadvantaged students.

Researchers believe that teachers’ attitudes to mathematics can in some way influence their students’ attitudes and mathematical learning (e.g., Relich and Way, 1994). Therefore, many teacher educators think that developing positive attitudes toward mathematics should be an important aim in the education of primary school STs and teachers (e.g., Relich and Way, 1994 and Haylock, 1995). STs’ attitudes are said to affect: (a) their approach to learning how to teach (Goulding et al., 2002) and (b) the way they will teach in the future (e.g., Ball, 1988) and the classroom ethos (e.g., Ernest, 1989 and Goulding et al., 2002). Teachers are said to rely on memories of themselves as school students to shape their teaching practices (e.g., Ball and McDiarmid, 1990). These memories are also said to affect what they learn from teacher education. Some STs find it difficult to take different approaches from the ones they observed as school students (e.g., Ball, 1988). Ernest (1989) argues that teachers’ attitudes to mathematics may influence their enthusiasm and confidence to teaching the subject. This in turn may affect the classroom ethos and consequently affect their students’ perceptions of mathematics.

Bromme and Brophy (1986) think that teachers model their attitudes and beliefs during their teaching. In most cases messages are conveyed without teachers’ awareness. Yet the most direct influence of primary school teachers’ negative attitudes to mathematics on their students’ learning appears to be time allocation. Bromme and Brophy point out that “such teachers have been found to allocate more instruction time to subject-matter areas that they enjoy, and less to areas that they dislike” (p. 122). Low time allocation was found to restrict students’ opportunities to learn (e.g., Fisher, 1995). Therefore, teachers need to improve their liking for mathematics and to be aware of the benefits of high time allocation especially for activities which have the potential to develop relational understanding.

Most of the attempts to help STs improve their attitudes to mathematics in teacher education seem to involve improving their understanding of the subject. The integration between the re-teaching of mathematics and the teaching of mathematics pedagogy is said to be a way of improving teachers and STs’ understanding (Bezuk

and Gawronski, 2003) and attitudes to mathematics (e.g., Weissglass, 1983). Most of the literature reviewed concerning such integration suggests re-teaching mathematics to teachers and STs by using the same methods that could be used to teach mathematics in a relational way to school students. To develop positive attitudes to mathematics in children, primary school teachers must learn how to set up learning experiences that are enjoyable, interesting and give the learner a sense of accomplishment. In order to be able to do this, the teachers must have had such experiences themselves (Weissglass, 1983).

Haylock (1995) and Philippou and Christou (1998) report that improving STs' mathematical understanding has produced positive effects in their attitudes. Haylock (1995) presents several mathematics representations in order to help STs develop understanding of the concepts and procedures in the primary school curriculum. Philippou and Christou (1998) used the history of mathematics in order to help STs understand mathematics concepts. These teacher educators think that improving STs' attitudes is a by-product of the effort to improve their understanding. I took a similar view and in the present study the strategic actions to improve STs' understanding were thought to be helpful in improving their liking for mathematics.

METHODOLOGY

I carried out an action research (Amato, 2001) at University of Brasilia through a mathematics teaching course component (**MTCC**) in pre-service teacher education. The component consists of one semester (80 hours) in which both theory related to the teaching of mathematics and strategies for teaching the content in the primary school curriculum must be discussed. There were two main action steps and each had the duration of one semester thus each action step took place with a different cohort of STs. A teaching programme was designed in an attempt to: (a) improve STs' relational understanding of the content they would be expected to teach in the future and (b) improve their liking for mathematics. Four data collection instruments were used to monitor the effects of the strategic actions: (a) diary; (b) pre- and post-questionnaires; (c) middle and end of semester interviews and (d) pre- and post-tests. Much information was produced by these instruments but, because of the limitations of space, only some STs' responses related to changes in their attitudes to mathematics are reported.

In the action steps of the research the re-teaching of mathematical content was integrated with the teaching of pedagogy by asking the STs to perform children's activities which have the potential to develop relational understanding of the subject. The activities were designed with four other more specific aims in mind: (i) promote STs' familiarity with several mathematical representations for each concept (real world contexts, concrete materials, pictures and diagrams, spoken languages and written symbols); (ii) expose STs to several ways of representing and performing operations (with the aid of concrete materials, mentally and with written symbols); (iii) help STs to construct relationships among concepts and operations and (iv) facilitate STs' transition from concrete to symbolic mathematics.

SOME RESULTS

During the action steps of the research, STs' previous attitudes to, and understanding of, mathematics were elicited by two pre-questionnaires. One involving questions related to their liking for mathematics at school and the other asking them what they felt about their understanding of mathematics at school. In both semesters most STs who said they disliked mathematics said they often did not understand mathematics at school. A relationship between liking and understanding mathematics also appeared to exist. The majority of the STs who said they liked mathematics said they often understood mathematics at school. Some of the STs responses to the open questions in the pre- and post-questionnaires and in the interviews revealed further and qualitative evidence about the relationship between the affective and cognitive domains.

The number of first and second semester STs who responded according to a certain theme will be represented by n_1 and n_2 respectively. The post-questionnaire about understanding was answered by 24 STs in the first semester and by 38 STs in the second semester. Question (1a) of the post-questionnaire about understanding was: "What changes happened in your understanding of the mathematical content discussed in this course component? Give examples". All STs who answered the question said there had been changes in their understanding ($n_1 = 21$ and $n_2 = 27$) and/or in their pedagogical knowledge ($n_1 = 4$ and $n_2 = 11$) of the content discussed in the course component. In the second semester there were five responses about changes in their attitudes towards mathematics and towards certain mathematical content. An example is: "The most meaningful changes were the ones about the rediscovering of mathematics. I learned, for example, that a fraction is not a beast of seven heads". Those responses to a question asking about changes in understanding tends to show that some relationship seems to exist between the affective and cognitive domains for those STs.

The post-questionnaire about attitudes was answered by 30 STs in the first semester and by 40 STs in the second semester. Question (3a) in the post-questionnaire about attitudes was: "Did your involvement with the activities proposed to teach mathematics in the initial grades change, in any way, your feelings about mathematics? Tick your answer." In question (3b) the STs were asked to write about the aspects in the MTCC which they thought had contributed to the changes in their liking for mathematics expressed in the previous close question (3a). In question (3b) some STs ($n_1 = 11$ and $n_2 = 10$) included remarks about changes in their understanding of mathematics. It was interesting to notice the number of those remarks in a question asking them about the aspects in the MTCC which contributed to changes in their liking for mathematics. An example is: "The way to understand and teach fractions was very gratifying for me. I had a lot of difficulty in teaching and mainly in understanding equivalence of fractions".

Some of those remarks were also from STs who said that their liking for mathematics had not changed, like: "Actually I have always liked mathematics, although I had my

difficulties. The interesting thing in this course component was to discover the reasons for the results and to understand the mathematical reasoning". There were also remarks about changes of attitudes in other less focused questions in the questionnaires and interviews. Those responses were considered more valid as they were not prompted by the wording of the question. Some of those responses were also accompanied by remarks about changes in understanding of particular mathematical content. An example is:

(Interview) Mathematics has always been 'a stone in my shoe'. I always had difficulties in understanding it. To give you an idea, for the first time I am understanding decimals and fractions and the relationship between them. They were never taught to me in that way. I am becoming so happy that even at my age [mature ST probably in the age range of 35 - 40] I decided that I am going to learn more mathematics. There are many things I have learned later in life and mathematics is one of them.

Such responses tended to show that part of STs' dislike for mathematics was related to their instrumental understanding. Therefore, the strategic actions to improve their relational understanding were considered helpful in improving their liking for mathematics. The majority of STs also said that they had liked the idea of using children's activities: "I liked to 'see' the content as a child. The attempt to place yourself in his/her place and to try 'seeing' how (s)he thinks, how (s)he would better understand". Having said all that, it does not mean that there were not problems connected to the idea of attempting to improve STs' liking for mathematics as a by-product of the effort to improve their relational understanding of the subject. For some STs the attempts to achieve affective outcomes were considered incompatible with the attempts to maximise cognitive outcomes.

Many STs in the first semester ($n_1 = 22$) and some in the second semester ($n_2 = 18$) said that their liking for mathematics had increased. The other STs said that their liking continued the same ($n_1 = 8$ and $n_2 = 22$). Although the teaching programme was improved from the first to the second semester, the number of STs who said that their liking for mathematics had increased through the MTCC was smaller in the second semester. This result was influenced by the decision to ask the second semester STs to record some of their practical activities. I was trying to help STs acquire relational understanding at a more reflective and formal level. According to Ball (1990), this "includes the ability to talk about and model concepts and procedures" (p. 458). Recording the practical activities was thought to encourage active learning and STs' reflections on their previous actions with concrete materials. However, a ST made a comparison between the practical activities and their recording which seems to demonstrate how some STs may have contrasted the children's informal activities with the few teachers' activities included in the programme:

(Interview) I like the manipulations of concrete materials, but I do not like the reports. I find them boring. [Teacher: Why?] You are dealing with something light that comes spontaneously and then suddenly you have to record these manipulations. It gives you

the impression that we are returning to the traditional way of working.

There were also positive remarks about the reports ($n_2 = 8$). However, there were more negative ($n_2 = 10$) than positive remarks. Yet it was not appropriate to abandon the reports because soon many STs would be teaching primary school children and needed to acquire a strong relational understanding to teach mathematics to the highest level expected of students doing that stage of schooling (Bennett, 1993). Another problem was the number of STs enrolled in each class (42 in the first semester and 44 STs in the second semester). Several STs complained about the class size and explained that the number of STs did not allow me to provide the necessary amount of individual attention. These STs presented moderate to severe difficulties in re-learning the primary school mathematical content in a single semester. They thought that a slower pace and a smaller class would be more appropriate for them.

CONCLUSIONS

The practical activities were time consuming and hard work with large classes, but using children's activities proved to be an appropriate strategy to attempt improving STs' understanding of the mathematics since the majority of STs said, and many indicated in the post-tests, that their understanding had improved. The majority of STs also said that they had enjoyed using children's activities. The use of several mathematical representations, and helping students to construct relationships among concepts and operations, are important strategies in the teaching of mathematics. So the strategic actions and teaching activities did not require any changes in nature; mainly quantitative and timing adjustments were made for the third and subsequent semesters in order to maximise STs' learning during a single semester. More practical and written activities were included for the representations and content that proved to be more difficult for the STs in previous semesters. For this reason certain activities had to be excluded from the programme.

Some STs suggested increasing the teaching time for rational numbers. In the third and subsequent semesters, the activities for rational numbers concepts and operations were started at the beginning of the semester and they continued until the last day of each semester. The number of activities about operations with natural numbers alone was reduced, but there were still many activities about operations with rational numbers which included a natural number part. Through operations with mixed numbers and decimals (e.g., $35\frac{3}{4} + 26\frac{1}{4}$ or $24.75 - 12.53$) the STs experienced further activities related to operations with natural numbers and had the opportunity to make important relationships between operations with natural numbers and rational numbers. Yet taking into consideration the difficulties presented by some STs and the time necessary to a practical approach to teaching with big classes, a more appropriate solution would be to offer the MTCC over two semesters with a total of 160 hours as it was suggested by many STs. However, increasing teaching time involves institutional changes. I have been trying to make these changes, but until the time of completion of this paper the problem has not been solved.

Teaching time was the most important constraint affecting STs' learning and attitudes in this study. Changing STs' attitudes proved to be a slow process which required more than one semester of the MTCC. Philippou and Christou (1998)'s intervention involved three course components, but they argue that even more time and challenging experiences are needed to change STs' attitudes that were developed over many years at school. Without deeper understanding of mathematics STs will probably teach mathematics as a set of disconnected rules and algorithms and disseminate even more negative attitudes to the subject among primary school children. One of the most relevant results of the present study was the knowledge I gained about the time needed to help primary school STs acquire a strong understanding of most of the mathematics they will teach.

I could have focussed my teaching on teacher development by adapting content, assessment, principles and aims, but I decided to focus on my social responsibility to primary school children. Ball and McDiarmid (1990) cite the results of two studies that show that curriculum content may be transformed, narrowed or avoided by negotiations made between students and teachers. I could certainly have made my life easier by narrowing or avoiding certain content and the more formal activities in response to STs' complaints. Such negotiations were thought to be socially irresponsible because they would affect STs' learning of mathematics and of pedagogy and this, in turn, could limit their future students' mathematical learning. McDiarmid and Wilson (1991) poses a question connected to this issue and which I think has relevant connections to idea of democracy in schools:

Waiting for teachers to develop conceptual understandings of the subject matter from teaching it seems both haphazard and callous: Who decides whose children get shortchanged while waiting for teachers to develop understandings of the subject they teach?" (p. 102).

Darling-Hammond (1996) seems to have some sort of answer to this question. Poorly prepared teachers are "assigned disproportionately to schools and classrooms serving the most educationally vulnerable children" (p. 6). According to Darling-Hammond, students' right to learn is directly connected to their teachers' opportunities to learn what is needed to teach well. Without a good preparation, teachers are not able to provide effective learning experiences to socially disadvantaged students.

References

- Amato, S. A. (2001). *Brazilian Primary School Student Teachers' Understanding of, and Attitudes to, Mathematics*, Thesis Submitted for the Degree of Doctor of Philosophy, Linacre College, Oxford University.
- Ball, D. (1988). Unlearning to Teach Mathematics, *For the Learning of Mathematics*, 8 (1): 40-48.
- Ball, D. (1990). The Mathematical Understanding that Prospective Teachers Bring to Teacher Education, *Elementary School Journal*, 90 (4): 449-466.
- Ball, D. and McDiarmid, G. W. (1990). The Subject-Matter Preparation of Teachers, in W.

- R. Houston (ed.), *Handbook of Research on Teacher Education*, New York: Macmillan.
- Baturo, A. and Nason, R. (1996). Student Teachers' Subject Matter Knowledge within the Domain of Area Measurement, *Educational Studies in Mathematics*, 31 (3): 235-268.
- Bennett, N. (1993). Knowledge Bases for Learning to Teach, in N. Bennett and C. Carré (eds.), *Learning to Teach*, London: Routledge.
- Bezuk, N. and Gawronski, J. (2003). Increasing Content and Pedagogical Knowledge of Practicing Elementary Teachers, *Proceedings of the 27th International Conference for the Psychology of Mathematics Education*, Volume 1, 206, Honolulu, USA.
- Bromme, R. and Brophy, J. (1986). Teachers' Cognitive Activities, in B. Christiansen, A. G. Howson and M. Otte (eds.), *Perspectives on Mathematics Education*, Dordrecht, Holland: D. Reidel.
- Brown, M., Askew, M., Rhodes, V., William, D. and Johnson, D. (1997). Effective Teachers of Numeracy in UK Primary Schools: Teachers' Content Knowledge and Pupils' Learning, *Proceedings of the 21st International Conference for the Psychology of Mathematics Education*, 121-128, Lahti, Finland.
- Brown, S. I., Cooney, T. J. and Jones, D. (1990). Mathematics Teachers Education, in W. R. Houston (ed.), *Handbook of Research on Teacher Education*, New York: Macmillan.
- Darling-Hammond, L. (1996). The Right to Learn and the Advancement of Teaching: Research, Policy, and Practice for Democratic Education, *Educational Research*, 25 (6): 5-17.
- Delpit, L. (1995). *Other People's Children: Cultural Conflict in the Classroom*, New York: The New Press.
- Ernest, P. (1989). The Knowledge, Beliefs and Attitudes of the Mathematics Teacher: a Model, *Journal of Education for Teaching*, 15 (1): 13-33.
- Fisher, C. W. (1995). Academic Learning Time, in L. W. Anderson (ed.), *International Encyclopedia of Teaching and Teacher Education*, Cambridge, UK: Cambridge University Press.
- Goulding, M., Rowland, T. and Barber, P. (2002). Does it Matter? Primary Teacher Trainees' Subject Matter Knowledge in Mathematics, *British Educational Research Journal*, 28 (5): 689-704.
- Haylock, D. (1995). *Mathematics Explained for Primary Teachers*, London: Paul Chapman.
- McDiarmid, G. and Wilson, S. M. (1991). An Exploration of the Subject Matter Knowledge of Alternative Route Teachers: Can We Assume They Know Their Subject?, *Journal of Teacher Education*, 42 (2): 93-103.
- Philippou, G. N. and Christou, C. (1998). The Effects of a Preparatory Mathematics Program in Changing Prospective Teachers' Attitudes towards Mathematics, *Educational Studies in Mathematics*, 35: 189-206.
- Quilter, D. and Harper, E. (1988). Why We Didn't Like Mathematics and Why We Can't Do It, *Educational Research*, 30 (2): 121-134.
- Relich, J. and Way, J. (1994). Measuring Pre-service Teachers Attitudes to Mathematics: Further Developments of a Questionnaire, *Proceedings of the 18th International Conference for the Psychology of Mathematics Education*, Volume 4, 105-112, Lisbon, Portugal.
- Saviani, D. (1993). Escola e Democracia, *Coleção Polêmicas do Nosso Tempo*, Campinas, São Paulo: Autores Associados.
- Skemp, R. R. (1976). Relational Understanding and Instrumental Understanding, *Mathematics Teaching*, 77: 20-26.
- Skemp, R. R. (1989). *Mathematics in the Primary School*, London: Routledge.