Investigating Children's Mathematics Anxiety: The Effect of Teaching Approaches

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The concept of Mathematics Anxiety has received much attention recently, largely owing to the suggestion that it affects many people and threatens both performance and participation (Suinn, Taylor & Edwards, 1988). There are many different definitions. In this study the definition in mind was Richardson and Suinn's of 1972:

> ••.. .feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations."

There are two assumptions inherent in this definition. Firstly, research has concluded that while Mathematics Anxiety is related to general anxiety (Hendel, 1980), test anxiety (Dew, Galassi & Galassi, 1984), and other academic anxieties (Marsh, 1988), it is also specific (for example, Richardson & Suinn, 1972; Adams & Holcomb, 1986; Hembree, 1990), *i.e.* it exists in people who are not otherwise anxious (Morris, 1981). Mathematics may be particularly susceptible to the adverse effects of anxiety because of features like precision, logic and the emphasis on problem-solving ability (Richardson & Woolfolk, 1980).

Secondly, while it is agreed that anxiety can have a motivational role and therefore a positive effect on performance (Wigfield & Meece, 1988), it is also agreed that the higher mental processes such as problem-solving and divergent thinking which are required for mathematics will be negatively influenced by Mathematics Anxiety (Jones, 1986; Skemp, 1986; Fairbanks, 1992).

Much of the research on Mathematics Anxiety has concerned itself with adolescents and adults, while considering that childhood is a period of rapid change (Jones, 1984) and that the foundations of attitudes are formed early (Suinn *et al.*, 1988), it may be that anxieties have their roots in primary schooL This study will consider the presence and effects of Mathematics Anxiety in primary school children.

Background: The South African Project

The study was carried out in South Africa, because of the current project in teaching mathematics in many primary schools, which has a problem-centred approach. The approach may be considered to be more socio-constructivist and less behaviourist than the more traditional transmission approach, with the emphasis more on conceptual understanding and less on computational skill. The type of learning anticipated is more relational than instrumental (Skemp, 1976), more discovery than reception (Ausubel, 1968), and more meaningful than rote (Ausubel, 1968). The description of such

1 This research is supervised by Dr Julia Anghileri, Homerton College.

a classroom follows from Human (1990), Human, Olivier and Murray (1991a; 1991b) and Cobb, Wood, Yackel, Nicholls, Wheatley, Trigatti and Perlwitz (1991).

In such a classroom, children are free to design and choose their own methods and strategies, and ideas are then shared in small teacher-monitored groups. Mistakes are treated by discussion and reaching consensus and the pupils decide what is right or wrong. The teacher has a facilitative role, initiating negotiation and communication, choosing activities to facilitate development and introducing the taken-as-shared terminology and symbolism of wider society. Word sums (problem-solving) are used as the primary vehicle for learning. Social norms, such as explaining methods, listening while others explain, reaching consensus and accepting responsibility for learning, are continually renegotiated.

This is then compared, in terms of the children's Mathematics Anxiety, to a classroom in which the teacher demonstrates and explains standard "vertical" methods of computation for each operation and asks questions, and this is followed by individual pencil-and-paper seatwork (Romberg & Carpenter, 1986). The teacher decides what is right or wrong and intervenes in the case of mistakes. Later word sums may be used as application of methods. Social norms are more static and involve more discipline, rewards and teacher authority.

The curriculum for both approaches includes geometry, measurement and number concept. The problem-centred approach, however, emphasises the development of a versatile problem-solving ability as a primary objective, introduces variable and relationship concepts earlier, allows the use of calculators for checking answers, has no ceilings on number ranges and varies problem types rather than focusing on one at a time.

The rationale behind the project is twofold. Firstly, the view of how mathematical knowledge is acquired has changed from a behaviourist view, advocating drill and practice, to a more conceptual approach and an emphasis on meaningful learning and understanding of the underlying structures of mathematics (Resnick & Ford, 1981). Learning is seen as an active and constructive activity (for example Piaget, 1970; Lachman, Lachman & Butterfield, 1979; Kilpatrick, 1987), rather than the passive acceptance of ready-made knowledge. Children are seen as having a substantial amount of informal knowledge (for example, Ginsburg, 1977; Skemp, 1986) which should be built on, rather than ignored, as their strategies are often more conceptually based than standard methods (Schoenfeld, 1986; Carraher, Carraher & Schliemann, 1987). One way of achieving this is the early introduction of word sums (Carpenter, Hiebert & Moser, 1981). Also, social interaction is seen as facilitating learning opportunities in the mathematics classroom (Webb, 1991), through, for example, stimulating new ideas (Ausubel, 1968), cognitive rehearsal and clarification of one's own point of view (for example, Dees, 1991), conflict and controversy (Perret-Clermont, 1980; Doise & Mugny, 1984), extending schemas to incorporate others' interpretations (Skemp, 1986), exposure to higher quality thinking within the Zone of Proximal Development (Vygotsky, 1978) and metacognition (Romberg & Carpenter, 1986). Small group work can also make children more comfortable (Webb, 1991), less anxious and more confident (Ausubel, 1968) than when interacting in a whole-class situation.

Secondly, the availability of calculators means that it is less relevant for the children to focus on executing calculations in a quick and automatic manner than it is to emphasise planning and evaluating solutions of problems (Human *et al.*, 1991a). Changing needs of society suggest that standard pencil-and-paper methods are less important in preparing children for further mathematical participation than basic number concepts and an attitude that mathematics can and should be understood (Human *et al.*, 1991b) rather than the attitude that it is the form of a mathematical answer that counts (Schoenfeld, 1986).

The Hypothesis

It has been suggested (for example, Skemp, 1986) that Mathematics Anxiety may be created in the classroom. Because aspects like working in small group, using existing knowledge and emphasis on process rather than product have been named as possible ways to prevent and/or lessen anxiety in the classroom (Morris, 1981), less anxiety was initially expected to exist in children exposed to the problem-centred approach. However, because aspects like having to explain and justify solutions may actually *cause* anxiety, and pupils may be tempted under pressure to use quicker and more elegant methods which they don't understand, different *types* (profIles) of anxiety may be expected to exist in the two approaches, the mathematics anxieties being inferred from responses to a questionnaire previously constructed and validated for this purpose.

Based on research, such as Suinn *et al.* (1988) and Hembree (1990), in each approach negative correlations were expected between total responses to the Mathematics Anxiety questionnaire and performance in mathematics, as measured by internal tests in the schools concerned (only one school from each approach was used). The two approaches were not being compared in terms of performance, as aims and objectives differed for each approach.

Method

A 20-item Likert-type scale constructed to measure Mathematics Anxiety was translated and revalidated for use in South African schools. Items described a variety of mathematics-related situations inside and outside the classroom, for example calculating change in a shop and explaining a mathematics problem to the teacher.

143 children, mainly nine and ten years old took part in the study, of which 58 were boys and 74 girls, 116 were in the project school and 27 in the non-project school. The children were all white and

Afrikaans-speaking and in schools in the Orange Free State[1]. The choice of schools was limited by the avoidance of troubled areas of the country. Also, the project has proved successful with regards to understanding and progress (Human, 1990) and participation and attitudes (Bouwer, 1991), and has spread rapidly from a small number of schools in the Cape Education Department to all schools in the CED as well as some schools in other provinces, such as the Orange Free State, sometimes without the necessary training and support. In other words, project ideas may be present in nonproject schools and it is becoming increasingly difficult to find a purely "non-project" school with which one can compare project schools. The non-project school was therefore in a rural area, l00km away from the city which contained the project school.

The children all completed the Mathematics Anxiety questionnaire. The average total scores, average item responses and correlations between total scores and average performance over the year were calculated for the total and subgroups. Factor analysis, using principle component analysis, was carried out on the questionnaire for the total sample and the project school sample (the non-project school sample being too small), to see if patterns obtained in a pilot study would be replicated by either or both groups. In the pilot study carried out in Cambridge, two factors had emerged, which were called Number/Sum Anxiety (items related to doing sums and working with numbers) and Social Anxiety (items related to doing maths in a social situation).

Results

The translated instrument proved to be reliable (alpha=O.84). Validity could be inferred (Suinn *et ai.*, 1988) from the relationship with performance as criterion, the single primary factor and the children's own experience of the questionnaire as reported in interviews.

The average total score for the Mathematics Anxiety questionnaire was 32.03 for the total sample (where the minimum score was 20xl=20, and the maximum was 2Ox3=60). The average for the non-project school (35.63) was significantly higher than the average for the project school (31.19) (p<O.OOI). There was no significant sex difference (p>0.05).

The items with the highest average responses related to a maths test for which one has not been warned and to teacher questions to find out how much one knows about mathematics. The item with the lowest average response related to games involving numbers. The non-project school reacted to the following items with significantly more anxiety: the maths test, teacher questions, explaining a problem to the teacher, working out change, using symbols like + and x, adding 97+45 and playing games with numbers.

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The correlation between Mathematics Anxiety and performance was negative and significant (p<O.OI) for both the total sample and the project school. It could not be calculated for the nonproject school as the sample was too small.

Factor analysis showed one primary factor for both the total sample, and the project school, which is assumed to be Mathematics Anxiety. The findings of the pilot study were therefore not replicated. Scoring the children on two scales, Number/Sum Anxiety and Social Anxiety, with intuitive allocation of items to each scale, showed a significant relationship between the two scales (p<O.OOI). In other words, children were mainly either anxious or not anxious across the board (for both scales), with the exception of 16 cases who showed low Sum Anxiety but high Social Anxiety, and 13 who showed high Sum Anxiety but low Social Anxiety.

Discussion

There was, as hypothesized, more anxiety in the non-project school children, if this can be inferred from responses to the questionnaire. There was no evidence of different profiles or patterns (factors) of mathematics anxiety, as had been found in the Cambridge sample of children. It should be noted that a recent study of South African students' Statistics Anxiety also reported only one factor (Pretorius & Norman, 1992), so there may be cultural differences which contribute to this fmding.

The total scores were inversely related to the children's performance in mathematics, but the direction of this causality is necessarily ambiguous (Dreger & Aiken, 1957): Anxiety may cause poor performance (Hembree, 1990) or poor performance may cause anxiety (Tobias, 1987). The relationship may also be more indirect that direct (Adams & Holcomb, 1986; Meece, Wigfield & Eccles, 1990)

The limited sample, especially with regard to the non-project school, means that conclusions should be drawn with care. Any differences obtained could be ascribed to a variety of factors, including approach to teaching, general atmosphere (e.g. urban and rural) and teaching styles and personalities. The latter was evident from observations of the non-project class and the three classes in the project school. More schools would be needed in each approach to eliminate these other variables, and this is the next step in this research.

Conceptually, Mathematics Anxiety is difficult to separate from general anxiety and even more difficult to measure. Ideally, several measures should be used (Jones, 1984). Interviews were conducted with some of these children and should lead to some understanding of the specificity, dimensionality, causes and effects of Mathematics Anxiety. Analysis of these interviews is in progress.

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