Aspects of Children's Mathematics Anxiety

Karen Newstead

This study[1] focuses on mathematics anxiety in nine- to eleven-year-old children and compares the mathematics anxiety of pupils taught in a traditional manner with that of pupils whose teachers adopted an alternative teaching approach emphasising problem-solving and discussion of pupils' own informal strategies. One finding is that pupils who were exposed to a traditional approach reported more mathematics anxiety than those who were exposed to the alternative approach, particularly with regard to the social, public aspects of doing mathematics. The question is raised whether it is these public aspects of doing mathematics in the presence of teachers and peers which actually evoke mathematics anxiety in many pupils, and not working with numbers or doing sums. However, the majority of pupils in this study reacted with either high or low anxiety to both aspects of doing mathematics.

Background

The construct of 'mathematics anxiety' has received considerable attention among researchers and mathematics educators in recent years. Most previous studies of mathematics anxiety have focused on high school students or adults, while mathematics may also provoke strong and adverse reactions in children (e.g. the Cockcroft report, 1982). Ages 9 to 11 seems to be a critical stage for the development of attitudes and emotional reactions towards mathematics (McLeod, 1993b). In addition, childhood, being a period of rapid change, may be a time when anxiety is especially evident. Although attitudes may deepen or change throughout school, generally, once formed, negative attitudes and anxiety are difficult to change and may persist into adult life, with far-reaching consequences.

Some of these consequences include avoidance of mathematics (Hembree, 1990), distress (Tobias, 1978; Buxton, 1981) and interference with conceptual thinking and memory processes (Skemp, 1986). Even for children there appears to be a negative relationship between mathematics anxiety and achievement in mathematics (Hembree, 1990). Although this relationship may be indirect and is necessarily ambiguous with respect to the direction of causality, it is often assumed that high levels of anxiety impair performance.

Some researchers expand the concept of mathematics anxiety to include both facilitative and debilitative anxiety. Wigfield and Meece (1988), for example, claim that the negative affective reactions component of mathematics anxiety may be debilitating while the cognitive component might actually have some positive motivational consequences for the amount of effort students put into mathematics and thus for mathematics performance. Depending on the individual and the task, a moderate amount of anxiety may thus actually facilitate performance. Beyond a certain point, however, anxiety becomes debilitating in terms of performance, particularly in the case of higher mental activities and conceptual processes (Skemp, 1986). Thus although mathematics anxiety may in some cases have positive effects, it is perhaps more important for educationalists to focus on its possible negative consequences for performance.

In fact, the pioneers in the study of mathematics anxiety, Richardson and Suinn (1972), defined mathematics anxiety *in terms of* the (debilitating) effect of mathematics anxiety on performance: "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".

The suggestion that mathematics anxiety threatens both performance and participation in mathematics, together with the indications that mathematics anxiety may be a fairly widespread phenomenon (e.g. Buxton, 1981), makes studies like this concerning mathematics anxiety in children of extreme importance.

Although there seems to be sufficient evidence for a specific mathematics anxiety which cannot be adequately explained in terms of general anxiety or test anxiety (e.g. Sepie & Keeling, 1978), there is lack of agreement on the dimensions of mathematics anxiety. Richardson and Suinn (1972) originally assumed that the construct of mathematics anxiety was unidimensional. However, factor analytic studies have yielded a variety of factors of mathematics anxiety scores (see Newstead, 1995, for a review). The only factor that most studies seem to have in common is a primary factor which relates to test or evaluation anxiety. The current study investigated the dimensions of mathematics anxiety in pupils whose mathematical understanding had never been assessed using tests.

There is also some lack of agreement about the possible causes of mathematics anxiety in children (see Newstead, 1995, for a review). Suggested causes include teacher anxiety, societal, educational or environmental factors, innate characteristics of mathematics, failure and the influence of early-school experiences of mathematics. The argument that the beginnings of anxiety can often be traced to negative classroom experiences seems particularly strong and well-documented (for example Tobias, 1978; Stodolsky, 1985). Thus it is considered critical to examine classroom practice and establish whether the roots of mathematics anxiety may be in instructional methods and in the quality of mathematics teaching in elementary school.

More specifically, rote-memorised rules and the manipulation of symbols with little or no meaning are harder to learn than an integrated conceptual structure, and this can result in affective stumbling blocks for the child (Skemp, 1986). Resulting beliefs about mathematics (see Schoenfeld, 1988) may cause anxiety about mathematics. Teachers can therefore create anxiety by placing too much emphasis on memorising formulae, learning mathematics through drill and practice, applying rote-memorised rules, and setting out work in the 'traditional' way (Greenwood, 1984). Mathematics anxiety may therefore be a function of teaching methodologies used to convey basic mathematical skills which involve the mechanical, 'explain-practise-memorise' teaching paradigm, which emphasises memorisation rather than understanding and reasoning.

Alternative instructional formats have been suggested in order to prevent or limit mathematics anxiety, but there is as yet little empirical evidence of the effects of such alternative teaching approaches on mathematics anxiety. It can be expected that an approach which includes a more personal and process-oriented teaching method emphasising understanding rather than drill and practice will reduce anxiety. It has also been suggested that encouraging students to work with peers in small co-operative groups may have important affective consequences, including a reduction in anxiety (von Glasersfeld, 1991; Vacc, 1993). In addition, Greenwood (1984) suggests that problem solving and the discussion of various strategies for solving these problems is important for the prevention of mathematics anxiety.

However, a certain amount of anxiety can be expected to exist in such classrooms as well. Active learning, the novelty and difficulty of non-routine problems, and the need to communicate about problems are expected to give rise to more intense affective responses than being expected to simply practise low-level computational skills (McLeod, 1993a). This is especially true if there is too much emphasis on justification and explanation without the necessary positive, supportive atmosphere, in which pupils feel at ease to ask questions and take risks without fear of criticism.

It is also possible that a strong teacher presence in a transmission-type classroom actually *lessens* discomfort and (already-formed) anxiety for some students who lack confidence in their own intuitions (Clute, 1984; Norwood, 1994). Vinner (1994) suggests that the use of procedures and rules, which are cognitively simpler, clearer and easier to handle than concepts, is an expression of the pupil’s emotional need for security: starting with something to help one solve the problem, rather than having to create one's own solution procedure. Although some pupils like to know 'why' as well as 'how', others may be more interested in this security and structure than in responsibility and creativity.

It can therefore not be the case that more traditional teaching approaches *always* lead to mathematics anxiety and ‘alternative’ classroom approaches (which henceforth refer to approaches which emphasise understanding, discussion and problem solving) do not. Both approaches may cause specific anxieties related to doing mathematics, and individual differences exist. However, in line with the research which argues that pupils’ beliefs about and attitudes towards mathematics are directly influenced by aspects of mathematics teaching and classroom experiences, this study aims to take account of evidence, albeit mainly anecdotal, that such alternative approaches to teaching mathematics have positive affective consequences and may thus help to reduce anxiety.

In this study, such an approach is represented by the CAN (Calculator Aware Number Curriculum) project which existed in the UK until 1992 (Duffin, 1987 - 1992). CAN was initially intended to investigate the impact of free availability of calculators in the primary mathematics classroom, but CAN teachers developed an alternative, investigational, teaching style: traditional standard algorithms for the four basic operations were not taught but were replaced by a number curriculum based on the calculator; pupils’ own devised methods and informal strategies for solving real-life problems were encouraged; and the discussion of these strategies in small groups was an integral part of the approach.

Research Questions

Comparison of ex-CAN and non-CAN approaches in terms of pupils’ mathematics anxiety formed a large part of this study. In addition, a general quantitative analysis of pupils’ scores on a mathematics anxiety questionnaire was carried out. The following research questions were investigated:

1) It is expected that the mathematics anxiety questionnaire scores will be multidimensional (at least bidimensional);

2) It is expected that pupils who have been exposed to an alternative teaching approach will have lower average mathematics anxiety total scores than pupils who have been exposed to a more traditional teaching approach. In addition, it is expected that pupils will exhibit different profiles of mathematics anxiety, in terms of dimensions identified by factor analysis, depending on the teaching approach to which they have been exposed.

Sample and Data Collection

The sample included 246 Years 5 and 6 pupils in five mixed-sex primary schools in a relatively rural environment in the U.K. 48.4% of the sample were girls and 51.6% boys. 5.7% of the sample were nine years old, 49.6% ten years old and 44.7% eleven years old.

The research took place in June/July 1994. In the U.K., this is towards the end of the school year, and after nearly a full school year in the same classroom environment, pupil and teacher behaviours may be assumed to be relatively stable and representative. Pupils' mathematics anxiety was measured using a mathematics anxiety questionnaire which had been designed in a previous study in the absence of suitable scales for this age group (Newstead, 1992). The questionnaire included items on general disliking of mathematics; working with numbers and sums (working out 97+45, working out change, doing sums, doing division with big numbers and doing word sums); and more everyday activities (playing games using numbers, working out the time and shopping for cool drink). Other items related to classroom- or homework-related situations: the teacher asking questions, explaining a mathematics problem to the teacher or to classmates, watching or listening to the teacher or other pupils explaining a mathematics problem, doing mathematics in front of other people, being given a mathematics quiz, not finishing first in the group, hearing how others in the group solved a problem, using mathematical symbols and using a mathematics textbook.

The validation of the questionnaire is described in Newstead (1992, 1995). The validity of any single method of measurement of anxiety in children may be considered doubtful, but in this case the validity of the questionnaire was well supported using interviews, and the reliability confirmed by statistical analysis (in previous studies, α varied from 0.82 to 0.87). The questionnaire was introduced, administered, read aloud and, where necessary, explained, by the researcher.

Four of the schools used for the general analysis were used to compare mathematics anxiety across teaching approaches. All four schools were in a particular Local Education Authority which had a strong tradition of involvement in, amongst other projects, the CAN project. They were selected on the basis of possible contrast as far as the approach to teaching mathematics was concerned, but relative comparability in terms of (rural) geographical position and catchment areas: The two 'ex-CAN schools' had been involved in the CAN Project while funding was available and were still following mathematics schemes and policies which expressed a similar view of learning and teaching to CAN. The two 'non-CAN' schools, on the other hand, were using textbook-based published schemes which emphasise individualised learning through practice.

Characterising Teaching Approaches

For the purpose of comparing pupils’ mathematics anxiety, teaching approaches were characterised as either ‘alternative’ or ‘traditional’. The following is meant by a ‘traditional’ approach: pupils are taught standard, pencil-and-paper methods of computation, by teacher demonstration followed by individual practice. Word sums are given as application after practice and mastering of methods. In an ‘alternative’ approach, on the other hand, pupils use and discuss their own strategies for solving word sums, which are used as the principal vehicle for learning. Solving non-routine problems and discussing strategies in small groups are of primary importance.

These two approaches imply very different roles, obligations and expectations for the teacher and pupils, but as these are implicit and not usually measurable, teaching approach was operationalised using a teacher questionnaire and observation schedule. The design and validation of both these instruments is described in Newstead (1995).

The teacher questionnaire included items on both classroom organisation and teacher beliefs. The classroom organisation section included proportion of time spent on whole-class, group and individual work; emphasis on concepts and strategies vs. practising skills; and emphasis on standard procedures vs. pupils' own strategies and procedures. The beliefs section included beliefs about: the role and function of the teacher (whether or not the teacher is the source and distributor of knowledge; adjudicator of correct and incorrect answers; and demonstrator when the pupil is stuck); the role of the pupil (active or not); the nature and process of learning (receiving knowledge; self-discovery; co-operation and discussion; memory, practice and rote); and other aspects of classroom practice (rewards and punishment; competition; word (story) sums; mistakes and misconceptions; standard methods; pupils' own methods; and limits for number ranges).

Although teachers' beliefs about mathematics and mathematics teaching can be contradicted by actual classroom practices in the classroom (Ernest, 1989), in general they can be expected to influence teachers' teaching strategies profoundly and can thus be used as an indication of teaching approach. However, the reliability of self-reported classroom organisation and beliefs as the only source of data on teaching approach is questionable. The observation schedule was thus used to describe the process in the classroom during a mathematics lesson.

Four broad categories were included in the observation schedule: Firstly, the ‘Context’ category included a brief description of the arrangement of seating and the availability of materials and equipment. Secondly, ‘Teaching Organisation’ included proportion of time spent on the teacher having class contact, the teacher having group contact, co-operative activity (without the teacher present, or monitored by the teacher), individual activity and no directed activity. This category would indicate whether or not discussion between pupils plays an important role in the classroom.

The ‘Verbal Interaction’ analysis, on the other hand, indicated the relative importance of the teacher, other pupils and other sources as sources of information and feedback. For characterising and discriminating between different teaching approaches, some interesting ratios might include the proportion of teacher-initiated talk which involved giving problems or concepts rather than giving facts, number of incidents in which the teacher directed the pupils to themselves or other pupils rather than to him/herself or to other sources; number of incidents in which the teacher reacted to maintain or extend participation rather than terminate it; and incidents of pupil-initiated talk to self and other pupils as compared to pupil-initiated talk to the teacher. There were also categories for the monitoring of co-operative activity by the teacher and written work, silence, confusion and management interaction.

Finally, pupil talk was broadly indicated as either convergent ‘Cognitive Level’ (low level, knowledge of information) or divergent level (high level, showing deeper understanding). Thus an indication was obtained whether higher level thinking (for example, explanation and justification) was considered important in addition to factual information. A distinction was also made between product questions, which elicit short, simple, predictable answers, and process questions which are broader, eliciting more expanded thinking e.g. why or how.

Each class concerned was observed for at least one mathematics lesson. The subject matter varied in the lessons observed, and this is important to note in that teaching approach and method would of course vary within any class according to the subject material. The observation focused on the teacher and what was occurring in his/her vicinity although where group work was in progress, observation of groups not currently interacting with the teacher was also included.

The following specific criteria based on these instruments were used to characterise the teaching approaches to be compared, namely alternative (in line with CAN) and traditional (non-CAN): As far as the teacher questionnaire was concerned, each teacher was assigned to one of two groups according to his or her total score on the questionnaire - above and below the average total score for the eight teachers. Secondly, the data from these teachers was included in a cluster analysis, specifying two clusters and confirming results using discriminant analysis, and their cluster membership was saved as an indication of the allocation of each teacher to one group or the other (see Newstead, 1995). Thirdly, the teachers were allocated to one of two groups depending on their responses to the items which were most significantly related to cluster membership in the pilot study, namely whether they agreed or disagreed that 'Pupils learn mainly by receiving mathematical knowledge from the teacher, textbooks and other sources', and whether they strongly agreed or just agreed that 'Pupils play an active role in mathematics learning, constructing their own knowledge'. Finally, the self-reported emphasis on either developing computational skills through exercise or exploration of concepts and strategies was used as a criterion as this classroom organisation item had been found in the pilot study to discriminate significantly between the two clusters.

The following ratios from the results of the observation schedule were used as criteria for discriminating between the two types of classrooms: the proportion of five-minute units of time which included teacher contact with the whole class and teacher contact with a group (or groups); the proportion of incidents of teacher-initiated talk (non-questions) which involved giving a fact or rule; the proportion of teacher questions which were process questions; and the proportion of incidents of pupil responses and pupil-initiated talk directed at the teacher or other pupils which could be classified as 'divergent'.

Satisfying all but in a few cases one or two out of these criteria, two teachers (58 pupils) were assigned to the 'alternative' Group 1 and four teachers (113 pupils) to the 'more traditional' Group 2. For these teachers, there was no discrepancy between the measures of beliefs and classroom behaviours, and the observational criteria were satisfactory indicators of one approach or the other. The pupils of two teachers were excluded from the analysis. One of these teachers reported beliefs in line with an alternative approach but observation of her classroom verbal interaction showed a more traditional teaching approach. Another teacher’s classroom behaviour failed to satisfy one of the most important criteria related to the observation schedule, namely that there be a significant amount of divergent pupil-initiated interaction. It should be stressed that the decision to exclude this data is based on subjective judgement on the part of the observer and also on observation of a single lesson (although a variety of different activities took place in this particular lesson). The limited number of observation sessions, although unavoidable, was a serious limitation of this characterisation of teaching approach.

General Analysis and the Dimensions of the Mathematics Anxiety Questionnaire

Analysis of the questionnaire data from all five schools was carried out by means of SPSS/PC^{+}.

The questionnaire item responses were scored as 1 (least anxious response) to 3 (most anxious response). The items which elicited the most anxious responses involved the teacher asking the pupil questions (average response 2.27), division with big numbers (2.20), a maths quiz (2.16), explaining a maths problem to classmates (2.11), explaining a maths problem to the teacher (2.02), and having someone watch one while doing maths (1.94). It is notable that most of these have a social or public aspect, with the exception of the item regarding division with big numbers. High anxiety regarding the latter can be expected on the grounds that pupils often report that both big numbers and division sums are especially difficult (Newstead, 1995). The items which elicited the least anxious responses involved deciding which cool drink is cheaper in the shop (1.24) and working out the time in 25 minutes (1.21), thus everyday situations. These items also elicited more uniform responses.

The dimensionality of the mathematics anxiety scores was analysed using factor analysis. Following exploratory analysis, two items, concerning disliking having to do maths and sums in general, were excluded from the factor analysis as they were very general and could be interpreted differently by different pupils depending on the context which they envisage, thus confounding interpretation of the factors. Another item, concerning division with big numbers, was also excluded from the analysis, as in the exploratory factor analysis, this item did not load significantly on any factor, and on a plot of the unrotated two factors, it exhibited odd behaviour. Both of these indicate that a two-factor solution may have 'forced' this item arbitrarily into one factor or the other.

Using principal components analysis, two factors were extracted. Factor One mainly concerned doing actual sums and working with numbers: working out the time in 25 minutes, adding 97+45 on paper, working out the change from £5 after spending £3.87, mathematical symbols like + and x, working out which cool drink is cheaper, using a mathematics textbook, playing games using numbers and doing story sums. Factor Two included more social or public aspects of doing mathematics: the teacher asking questions about how much one knows about maths, watching or listening to the teacher explaining a problem, explaining to the teacher, having a classmate finish first, feeling under pressure to change one's method after hearing someone else's, having someone watch while doing mathematics, a maths quiz and having to explain a problem to classmates.

The exception to this interpretation was the item involving understanding another child explaining a problem which loaded significantly on Factor One. Listening and trying to understand does not necessarily involve social or public pressure, and therefore this item may have fitted better into this Sum/Number factor than into Factor Two.

An alternative explanation may be that the one dimension (here Factor Two) related to actual mathematics *lessons* (hence the presence of the teacher and/or classmates in all the situations) and the other (here Factor One) related to *mathematics* in a situation which may be but is not necessarily a mathematics class. These interpretations are compatible, as the public aspect of mathematics is inevitable in mathematics lessons, where the presence of the teacher and peers makes humiliation possible, while this is not necessarily so in other mathematics situations.

Given the strong relationship between the two factors (r=0.49), there is, however, some doubt as to whether there *were* actually two factors in these scores. If a single primary factor existed, pupils with high (low) Number/Sum Anxiety could be expected to have high (low) Social Anxiety and *vice versa*, where 'high' is taken to mean above average and 'low' is taken to mean below average. In other words, pupils would be mainly either anxious or not anxious across both dimensions, with some exceptions. This was indeed the case for this sample, as shown in Table I.

	Low Social Anxiety	**High Social Anxiety**	**Row Total**
Low Sum Anxiety	88 (36.2%)	42 (17.3%)	130 (53.5%)
High Sum Anxiety	29 (11.9%)	84 (34.6%)	113 (46.5%)
Column Total	117 (48.1%)	126 (51.9%)	243 (100%)

Table I:

Distribution of Pupils According to Number/Sum Anxiety and Social Anxiety Scales

It is possible that for a large proportion of the sample, the mathematics anxiety scores were in fact unidimensional (hence the large correlation between factors), but that a subsection of the sample were anxious about *either* more social situations *or* sums. Thus the two factors described above may be describing different pupils, but the majority of pupils may be either anxious or not anxious across all mathematics-related situations. In order to investigate whether this was in fact the case, the 172 pupils who were in the Low Sum Anxiety/Low Social Anxiety and High Sum Anxiety/High Social Anxiety categories (first sub-sample) were separated from the 71 pupils in the other two categories (second sub-sample).

Factor analysis using principal components analysis for the first of these two sub-samples revealed only one primary factor, assumed to be mathematics anxiety. This factor explained 36.7% of the variance in mathematics anxiety scores. Thus, for the majority of the main study sample, the mathematics anxiety scores were indeed unidimensional.

However, factor analysis using principal components analysis and oblique rotation revealed two factors (r=0.20) in the second sub-sample, indicating that a group of pupils were anxious only about *certain aspects* of mathematics. The first factor explained 19.4%

of the variance, while the second factor explained 10.4% of the variance in total mathematics anxiety scores.

At first glance these two factors appeared to be slightly different to the Social/Number dimensions expected, and indeed it should be kept in mind that the sample size for this sub-sample (71) was too small to provide definitive results. The bipolarity of both factors or, alternatively, the presence of one strong bipolar factor and a number of items which are not clearly linked, as well as evidence from the unrotated factor loading plot for this subsample (see Newstead, 1995), confirmed, however, that some pupils were either anxious about public aspects of mathematics or about number and sum aspects of mathematics.

Comparison of Pupils' Mathematics Anxiety Across Teaching Approaches

As described previously, only where the teaching approach was clearly 'alternative' (Group 1) or 'traditional' (Group 2) based on empirical criteria, were the classes included in this study. Group sizes for the comparison study were 58 for Group 1 and 113 for Group 2.

Hypothesis 2, namely that pupils who have been exposed to alternative teaching approaches will have lower average mathematics anxiety total scores than pupils who have been exposed to more traditional teaching approaches, was confirmed. The average total score for Group 2 (34.30) was significantly higher than for Group 1 (32.43) ($p<0.05$). Group 2 also responded to the questionnaire with greater variance (as indicated by a standard deviation of 6.71) than that of Group 1 (as indicated by a standard deviation 4.97). There were no significant differences between the different age or gender groups at the 0.05 level. It can be concluded that there was, in this sample, a significant difference between the mathematics anxiety of pupils in the two teaching approaches, with the traditional approach pupils responding with more anxiety than the alternative approach pupils.

It is interesting that the highest average total mathematics anxiety score was obtained by one of the classes which was in fact excluded from the comparison analysis because the teacher's behaviour did not satisfy all of the observational criteria for the alternative teaching approach. This teacher had in conversation expressed concern that secondary schools would demand more formal recording and presentation of mathematics. This teacher's concern about this matter and her teaching of some more formal methods may have lead to an inconsistent or mixed teaching style which could explain why her class had a high average anxiety total. More research with larger groups of children is needed to investigate mixed teaching approaches as well as inconsistencies between teacher beliefs and behaviour, and their subsequent effect on pupils' anxiety.

Two items showed significant differences between the two groups. The pupils in the non-CAN traditional schools (Group 2) disliked mathematics significantly more ($p<0.01$), and were more anxious about having someone watch while they were doing maths ($p<0.01$), than the pupils in the ex-CAN school (Group 1). Group 1 pupils should be accustomed to sharing their methods and this explains their lack of anxiety about the latter situation.

The second part of Hypothesis 2, namely that pupils will exhibit different profiles (dimensions) of mathematics anxiety, depending on the teaching approach to which they have been exposed, was confirmed: the pupils exposed to the traditional (non-CAN) teaching approach were significantly more anxious on the Social Anxiety dimension than was the case for the pupils exposed to the alternative (ex-CAN) teaching approach ($p<0.05$). There was no significant difference on the Sum/Number Anxiety dimension at the 0.05 level.

To further investigate the relationship between the teaching approaches (group membership) and anxiety profiles (as defined by the dimensions identified by factor analysis), the distribution of cases in each group in each teaching approach is shown in Table II. In each case 'anxious' or 'not anxious' was taken as above or below the average score for each dimension.

Anxiety Group	**Not anxious about either aspect of doing mathematics**	**Anxious about both aspects of doing mathematics**	**Anxious only about the social aspects of doing mathematics**	**Anxious about doing mathematics but not about the social aspects**	**Total valid cases**
Group 1	28 (48.3%)	14 (24.1%)	7 (12.1%)	9 (15.5%)	58
Group 2	37 (33.0%)	40 (35.7%)	20 (17.9%)	15 (13.4%)	112
Total	65 (38.2%)	54 (31.8%)	27 (15.9%)	24 (14.1%)	170

Table II:

The Relationship between Anxiety Groups and Teaching Approach

This analysis had not been anticipated, as it was not foreseen that there would be different groups of anxious pupils. The sample sizes for these anxiety groups were therefore small. This was particularly the case for the group who were only anxious about social aspects of doing mathematics, and also for the group who were anxious about doing mathematics but not about the social aspects of doing mathematics. Statistical analysis was thus prohibited. By inspection it is noteworthy that the percentages in the cells of Table II above do in fact support the finding that pupils exposed to the CAN approach were less anxious than those exposed to traditional approaches, particularly with regard to social aspects of doing mathematics. The distribution of pupils in these categories thus confirms that it is not only pupils' *level* of anxiety which is affected by the teaching approach adopted by their teacher, but also the *type* of anxiety that they experience.

Discussion

The data presented in this report provide evidence to support the assertion mathematics anxiety is a phenomenon which *begins at an early age*. One of the most significant findings was that children between the ages of nine and eleven reported a significant amount of anxiety about the social, public aspects of doing mathematics in the presence of their teachers and peers in the classroom. In fact, in this study there was a group of pupils who were anxious *only* about these aspects of doing mathematics and not about actually doing sums and working with numbers. If pupils learn to do mathematics before they are able to explain problems and communicate about mathematics, then mathematical questions and the need for explanations could cause anxiety at the crucial age between the development of skills for *doing* mathematics and the development of skills for *explaining* mathematics. This finding has consequences both for research on mathematics anxiety and for teaching primary school mathematics.

As far as implications for research are concerned, mathematics anxiety in pupils of this age group may not be the simple, unified concept that it was often previously thought to be. The suggestion that there may be different *kinds* of anxiety related to doing mathematics in different pupils emerged after the dimensionality of mathematics anxiety was explored quantitatively: The majority (70.8%) of the sample were anxious in all mathematics-related situations or not anxious in any such situations, in line with Richardson and Suinn's (1972) original assumption that mathematics anxiety is a unidimensional construct. The rest of the pupils, however, were anxious only in certain situations, and their mathematics anxiety total scores were thus bidimensional or, alternatively, there was one strongly bipolar factor present. A small number of pupils were anxious only about doing mathematics *per se*, that is working with numbers and doing sums. Perhaps most significantly, some pupils were anxious *only* about the social, public aspects of doing mathematics, like explaining problem solutions to teachers and peers and doing mathematics in their presence. Clearer evidence of the relationship between teaching approach and types (dimensions) of anxiety needs to be presented with larger samples.

Although the Number/Sum Anxiety dimension might coincide with some previously-identified ‘number anxiety’ factors such as Resnick, Viehe & Segal’s (1982) ‘Arithmetic Computation Anxiety’ factor, the Social Anxiety dimension of mathematics anxiety which emerged during this study did not seem to have been reported previously except by the author (Newstead, 1992). Some overlap may exist between this factor and Chiu and Henry’s (1990) ‘Mathematics Teacher Anxiety’. Alternatively, this factor may represent a more general personality-trait anxiety rather than a situation-specific anxiety. It is suggested that future research on mathematics anxiety should include measurement of such general anxiety, and also clarify the specificity of mathematics anxiety as opposed to, or as related to, anxieties about other school subjects and school in general.

Several factor-analytic studies involving adults and pupils have demonstrated that mathematics anxiety scores are bidimensional or multidimensional, but the debate to this point has been whether mathematics anxiety is or is not mostly test or evaluation anxiety. In this study, test anxiety could not be a dimension of the scale since in this English sample, the pupils’ mathematical understanding had not been assessed using standard tests. Finding two dimensions which are unrelated to test anxiety therefore confirms that mathematics anxiety is in fact more than (and possibly different to) test anxiety.

The relationship between test anxiety and mathematics anxiety is, however, perhaps not the most crucial issue which the findings of this study raise for consideration. It is an entirely different debate which arises from this research, concerning whether mathematics anxiety in the age group of 9 to 11 is actually about doing sums or working with numbers, or whether it concerns the public aspects of doing mathematics in the classroom. If children report mathematics anxiety as an expression of anxiety about doing mathematics in the presence of others and communicating about mathematics, rather than as an expression of anxiety about actually working with numbers and doing sums, then previous research may have been focusing on the wrong aspects while measuring mathematics anxiety or 'Number Anxiety'.

That the social aspects of doing and explaining mathematics cause much anxiety in young children and that different groups of anxious pupils exist has implications for teaching elementary school mathematics. Teachers need to be aware of these individual differences and adopt appropriate strategies for addressing these groups accordingly. This social (external) dimension is particularly important, as modern society requires adults who can communicate about mathematics rather than carry out computations in a quick and automatic way (for example, the Cockcroft report, 1982).

It has been suggested that an alternative teaching approach which emphasises discussion and problem solving may facilitate the development of such communication skills (Duffin, 1991) as well as a reduction in mathematics anxiety. In this study it was found that pupils exposed to such a teaching approach (ex-CAN) reported significantly less mathematics anxiety overall than pupils whose teachers adopted a traditional (non-CAN) teaching approach. The non-CAN school pupils disliked mathematics significantly more and were significantly more anxious about having someone watch them while they were doing maths than the pupils in the ex-CAN schools. Pupils in ex-CAN classrooms would be accustomed to sharing their ideas with their peers in groups, as discussion is an integral part of alternative teaching approaches like CAN.

Importantly, the pupils in the ex-CAN schools also reported significantly less Social Anxiety than those in the non-CAN schools. The significant difference in Social Anxiety but not in Number Anxiety confirms that it may be the organisation of the class and the teaching approach adopted by the teacher which affects pupils' mathematics anxiety rather than mathematics itself.

It is particularly interesting that the pupils exposed to the alternative teaching approach responded with less overall anxiety and less Social Anxiety than those exposed to the traditional approach, given that certain aspects of an alternative approach can actually be expected to *cause* much anxiety in some pupils. For example, an emphasis on discussion and the explanation and justification of strategies for solving problems may cause anxiety. Indeed it was reported in this study that pupils exposed to both teaching approaches responded to items representing the social aspects of mathematics with the highest average scores. However, this research has confirmed that in approaches such as CAN which allow pupils to construct their own strategies for problem solving and discuss these with peers, such peer interaction and group work can successfully provide support. Such a support system may help to reduce anxiety and encourage social norms which enable pupils to express their ideas without risk of embarrassment or humiliation.

The finding in this study that a more traditional approach in the crucial early stages of mathematics education is associated with more highly anxious *young children* does not necessarily contradict the finding that a traditional approach can *reduce* the *already established* levels of mathematics anxiety in college students by making them feel more secure (Clute, 1984; Norwood, 1994). It is suggested that studies are required which investigate the long term effects of these two teaching approaches, and indeed other teaching approaches, on pupils' anxiety, and also the influence of age differences and individual differences. It was not possible to gain access to performance data in the case of this study, but the relationship between mathematics anxiety and pupil performance in mathematics also needs clarification by careful research.

This research has examined only one factor which may contribute to mathematics anxiety, namely the teaching approach to which pupils are exposed. The free availability of calculators which was central to the CAN approach was not specifically investigated in this study but the impact of technology could certainly be an important factor to consider when investigating young children's mathematics anxiety. Further research needs to be conducted on the numerous other possible classroom-related and non-classroom-related causes of mathematics anxiety, for example related to parents, peer dynamics, the very nature of mathematics itself, the existence of a mathematically anxious social identity and teacher anxiety. The possibility that mathematics anxiety may be perpetuated in the classroom by mathematics anxious teachers is especially interesting in the light of Bush's (1989) findings that highly mathematics anxious teachers tend to teach in traditional ways and in the light of this research which has confirmed that such a teaching approach may in turn affect pupils' mathematics anxiety.

The value of this research lies partly in its contribution towards the establishing of connections between research on *attitude* and *contemporary theories of learning*, incorporated in alternative teaching approaches like CAN. If affective responses in general and, more specifically, mathematics anxiety, are related to teaching approach, and if it is accepted that these affective responses can be improved and the mathematics anxiety minimised by using aspects like problem solving and social interaction in the classroom, we have made some progress towards solving the problem clearly voiced by von Glasersfeld (1991) who states that "all too frequently the present ways of teaching mathematics generate in the student a lasting aversion against numbers, rather than an understanding of the useful and sometimes enchanting things one can do with them".

[1] *This study formed part of a Ph.D. project at the Department of Education, University of Cambridge, under the invaluable supervision of Dr Julia Anghileri, Homerton College.*

References

Bush, W.S.: 1989, 'Mathematics Anxiety in Upper Elementary School Teachers', School Science and Mathematics 89, 499-509.

Buxton, L.: 1981, Do You Panic about Mathematics? Heinemann Educational Books, London.

Chiu, L.-H., & Henry, L.L.: 1990, 'Development and Validation of the Mathematics Anxiety Scale for Children', Measurement and Evaluation in Counseling and Development 23, 121-127.

Clute, P.S.: 1984, 'Mathematics Anxiety, Instructional Method, and Achievement in a Survey Course in College Mathematics', Journal for Research in Mathematics Education 15, 50-58.

Cockcroft, W.H.: 1982, Mathematics Counts: Report of the Commission of Inquiry into the Teaching of Mathematics in Schools, Her Majesty's Office, London.

Duffin, J.: 1992/1991/1990, The CAN Continuation Project: Third/Second/First Annual Report 1992/1991/1990.

Duffin, J.: 1987/1988/1989, NCC Primary Initiatives in Mathematics Education Project: Annual Report on Evaluation of CAN Component of PrIME Project 1987/1988/1989.

Ernest, P.: 1989, ‘The Impact of Beliefs on the Teaching of Mathematics’. In P. Ernest (Ed.) Mathematics Teaching: The State of the Art, Falmer, London, 249-254.

Greenwood, J.: 1984, 'My Anxieties about Math Anxiety', Mathematics Teacher 77, 662-663.

Hembree, R.: 1990, 'The Nature, Effects, and Relief of Mathematics Anxiety', Journal for Research in Mathematics Education 21, 33-46.

McLeod, D.B.: 1993a, 'Affective Responses to Problem Solving', Mathematics Teacher 86, 761-3.

McLeod, D.B.: 1993b, 'Research on Affect in Mathematics Education: A Reconceptualisation'. In D.A. Grouws (Ed.) Handbook of Research on Mathematics Teaching and Learning, Macmillan Publishing Co., London, 575-596.

Newstead, K.: 1995, Comparison of Young Children's Mathematics Anxiety Across Different Teaching Approaches, Unpublished Ph.D. Dissertation, Cambridge University.

Newstead, K.: 1992, The Validation of an Instrument of Mathematics Anxiety for Primary School Children, Unpublished M. Phil. Dissertation, Cambridge University.

Norwood, K.S.: 1994, 'The Effect of Instructional Approach on Mathematics Anxiety and Achievement', School Science and Mathematics 94, 248-254.

Resnick, H., Viehe, J., & Segal, S.: 1982, 'Is Math Anxiety a Local Phenomenon? A Study of Prevalence and Dimensionality', Journal of Counseling Psychology 29, 39-47.

Richardson, F.C., & Suinn, R.M.: 1972, 'The Mathematics Anxiety Rating Scale: Psychometric Data', Journal of Counseling Psychology 19, 551-554.

Schoenfeld, A.H.: 1988, 'When Good Teaching Leads to Bad Results: The Disasters of 'Well-Taught' Mathematics Courses', Educational Psychologist 23, 145-166.

Sepie, A.C., & Keeling, B.: 1978, 'The Relationship between Types of Anxiety and Under-Achievement in Mathematics', Journal of Educational Research 72, 15-19.

Skemp, R.R.: 1986, The Psychology of Learning Mathematics, Penguin, Harmondsworth.

Stodolsky, S.S.: 1985. 'Telling Math: Origins of Math Aversion and Anxiety', Educational Psychologist 3, 125-133.

Tobias, S.: 1978, Overcoming Math Anxiety, Norton, New York:

Vacc, N.N.: 1993, 'Teaching and Learning Mathematics Through Classroom Discussion', Arithmetic Teacher 41, 225-7.

Vinner, S.: 1994, 'Traditional Mathematics Classrooms: Some Seemingly Unavoidable Features', Proceedings of the Eighteenth International Conference for the Psychology of Mathematics Education IV, 353-360.

Von Glasersfeld, E. (Ed.): 1991, Radical Constructivism in Mathematics Education, Kluwer Academic Publishers, Dordrecht.

Wigfield, A. & Meece, J.L.: 1988, 'Math Anxiety in Elementary and Secondary School Students', Journal of Educational Psychology 80, 210-216.

Karen Newstead
Mathematics Learning and Teaching Initiative
Research Unit for Mathematics Education of the University of Stellenbosch (RUMEUS)
Department of Didactics
Private Bag X1
Matieland 7602
South Africa