

Maths Anxiety Self-assessment as a Quality Assurance Measure

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Many students come to preservice mathematics teacher education programs with considerable anxiety and fear of mathematics. The challenge is to provide students with the necessary skills, knowledge and understanding for teaching, and to positively impact upon their belief systems. In this study 429 preservice students rated change of beliefs about mathematics through a self-assessment questionnaire. Results indicated a strong positive change, and together with interview data, highlighted key contributing aspects of the program and thus provided a measure of program quality assurance.

Background

The importance of all children achieving appropriate levels of numeracy properly continues to be emphasized by educational policy makers and is the focus of the National Numeracy Strategy (DETYA, 2000). While it is generally accepted that a succinct definition of numeracy is neither possible nor desirable in a constantly changing and increasingly technological society, it clearly encompasses skills that are key to enabling an individual to fully and effectively participate in society (AAMT, 1997). Importantly, it includes not only knowledge of mathematical skills and procedures but also the ability and inclination to apply them in relevant situations (AEC, 1990).

While the teaching of numeracy in schools is, like literacy, the responsibility of all teachers (AAMT, 1997; DETYA, 2000), the foundations of numeracy are located in the key learning area of mathematics. Thus, the responsibility to prepare effective teachers of numeracy falls primarily to teacher educators involved in the planning and delivery of the mathematics curriculum components of preservice programs. Such programs must seek to develop each of Shulman's (1986) types of teacher knowledge, namely a) content knowledge of the subject of mathematics, b) pedagogic-content knowledge of how to teach mathematics, and c) curricular knowledge of mathematics applied to other curriculum areas, as well as addressing the affective factors that are integral to numeracy. Indeed it is arguably in addressing the affective characteristics of preservice primary teachers that the greatest challenge lies.

The Attitudes and Beliefs of Preservice Primary Teachers

It has been well established that students enter preservice primary teacher education programmes with beliefs about mathematics that are not helpful in that they are likely to lead to teaching that emphasizes exposition, practice and memorization (Civil, 1993; Mayers, 1994). In addition research into mathematics anxiety in the 1970s and 80s established that many pre-service primary teachers have negative attitudes to mathematics and regard the subject with considerable fear (Wood, 1988). Later studies by Frank (1990) and Beswick and Dole (2001) suggest that the beliefs held by mathematics anxious individuals persist among significant numbers of current pre-service primary teachers. Research in the affective domain often does not clearly distinguish between beliefs and

attitudes, including mathematics anxiety, however, McLeod (1992) suggests that the two are similar with attitudes having a greater affective and lesser cognitive component than beliefs. Given this blurring of the boundaries between beliefs and attitudes it is reasonable to assume that many of the preservice teachers who hold negative beliefs in relation to mathematics also harbour negative attitudes to the subject and would include those who could be described as mathematics anxious.

Mathematics Anxiety and Pre-service Teachers

Mathematics anxiety has been defined as “the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem” (Tobias & Weissbrod, 1980, p. 65). This definition conveys the context specific nature of the phenomenon and suggests that the problem can be simply dealt with by avoiding mathematics and any situation that may require the use of mathematics. Such avoidance of mathematics puts the goals of school mathematics (AEC, 1990) clearly out of reach for such individuals and, when considered in relation to the accepted views of what constitutes numeracy, the mathematics avoidant must be considered, to some degree at least, innumerate.

Both the development of the negative and unhelpful beliefs that pre-service primary teachers bring to their tertiary education, and the development of mathematics anxiety have been attributed to experiences of learning mathematics at school (Baroody, 1987; Bush, 1991; Sullivan, 1989). Baroody (1987) particularly identified teaching that overemphasizes memorization as likely to lead to negative beliefs about mathematics and one’s own ability to learn mathematics, while Bush (1991) found that mathematics anxiety among students tended to decrease as teachers spent more time on small-group work. It is ironic, but perhaps not surprising, that it is the very kind of teaching that leads to negative beliefs and attitudes, that those with these negative beliefs and attitudes are likely to practice. The cyclical nature of the problem both explains its resistance to efforts to change the situation and highlights the importance of doing just that.

The fact that those with negative attitudes to mathematics tend to avoid mathematics adds to the difficulty of breaking the cycle. It is arguably these students who most need to engage with a course aimed at providing the knowledge and affective traits that they need in order to change from the traditional teaching paradigms that they are likely to hold. Indeed, unless positive changes in students’ attitudes are achieved, preferably early in pre-service teacher preparation, even excellent teaching addressing the knowledge of pre-service teachers is likely to be ineffective.

Teaching approaches that have proven effective in positively influencing the beliefs and attitudes of pre-service teachers have included the use of group problem-solving and discussion, having pre-service teachers actually engage in doing mathematics and encouraging students to reflect upon their own beliefs and practice (e.g. Civil, 1993; Malone, 1995; Schuck & Foley, 1998; Stuart & Thurlow, 2000). All of these imply an increased emphasis on instruction in small group settings as opposed to mass lectures, yet the economic constraints in which university teaching must occur are rendering such an emphasis increasingly unachievable.

The Study

This study followed from an initial investigation of the beliefs of pre-service primary teachers entering a particular Australian university that had shown that the mathematics

curriculum course that operated within the usual budgetary constraints may have positively impacted the beliefs of students. The current study sought to investigate a broader range of students' beliefs and attitudes across all of their units in mathematics education, and to identify which specific aspects of the program contributed to any desirable changes. The results of this study will serve as benchmarks against which subsequent student evaluations of the programme can be compared.

The Mathematics Curriculum Program

At the University of Tasmania, in which this study was conducted, students are required to study mathematics curriculum in three semesters in their second, third and fourth year of the education degree course. Mathematics Curriculum Studies is combined with English Curriculum Studies, therefore students study three half units of mathematics curriculum. Each half-unit is conducted over 13 weeks in one semester, delivered via a weekly one hour lecture and a one hour tutorial. Tutorials are conducted in groups of 25-30 students. Instruction in this context is designed to be interactive with students working cooperatively on activities designed to illustrate and explore information presented in the lectures. The lecturers in the program aimed to model an essentially constructivist approach to teaching in the tutorials. In both lectures and tutorials the emphasis of teaching was on promoting students' awareness of broad pedagogical ideas for meaningful learning of mathematics, such as the importance of rich mathematical learning environments for conceptual development, a mathematics curriculum that focuses on problem solving and thinking skills, and appropriate materials for concept representation. In lectures and tutorials, it was the lecturers' intention to communicate these ideas through modeling best practice, using lecture and particularly tutorial times, to engage students in activities designed for such notions to surface. A further objective of the program in total was to promote students' beliefs in the importance of mathematics and its teaching, whilst engendering their confidence, and fostering positive attitudes to the teaching of mathematics. Throughout the program, the issue of teacher beliefs was not overtly addressed in any of the lectures or tutorials, but was implied through careful planning and delivery of all lectures and tutorials.

In this study, of prime interest was data from fourth year students as they had been exposed to the Mathematics Curriculum program in its entirety.

Methodology

The study utilized quantitative and qualitative methods with students program evaluation data gathered through a questionnaire, and structured interviews with selected students.

Subjects

Four-hundred and twenty-nine students across Year 2 (178 students), Year 3 (141 students) and Year 4 (110 students) completed the Mathematics Program Student Evaluation Survey (MPSES). Fifteen randomly selected students from the fourth-year cohort participated in the structured individual interview.

Instrument

The MPSES, devised by the researchers, comprised two sections. The first section contained a list of 18 items pertaining to elements of the program the researchers

considered vital for preparing pre-service teachers to become effective teachers of mathematics. The items related to lecture content, activities presented during tutorials, issues in mathematics education, the structure and presentation of the program and attributes of staff involved in the program. Students were required to tick the elements they regarded as valuable aspects of the course.

The second section of the survey was designed to encourage students to reflect upon the course and its impact upon their beliefs about mathematics, mathematics teaching and learning. In this section, students were presented with 21 statements in total from four belief categories, as detailed below:

1. Personal beliefs about mathematics, confidence to use mathematics, feelings (Category S for Self-beliefs - 6 statements)
2. The Nature of Mathematics - what is it? (Category N for Nature - 2 statements)
3. Issues related to teaching mathematics to promote conceptual understanding - sequential planning, structure of mathematics lessons, fostering thinking, problem solving, making mathematics meaningful, teacher's energy and enthusiasm, concrete materials, calculators, assessment (Category T for Teaching -10 items)
4. Children's learning of mathematics – investigating, group work, children's thinking (Category L for Learning - 3 items).

For each statement, two rating scales were provided. Students were required to indicate on the first rating scale the extent to which they agreed or disagreed with the statement prior to commencement of the Mathematics Curriculum program by colouring a dot to correspond with a number between 1 and 5, with 1 indicating least agreement and 5 indicating strongest agreement. They were then required to consider the same statement in relation to their feelings about the statement at their current point of study in the Mathematics Curriculum program, indicating their level of agreement or disagreement on the second rating scale. An example of an item from Section II of the survey is presented in Figure 1.

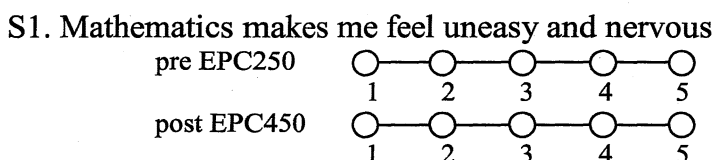


Figure 1. Sample item from Section II of MPSES Survey

Results

Data from this study is considerable, and for brevity, results reported here are confined to an analysis of mathematics anxiety levels and change upon completion of the preservice Mathematics Curriculum program.

Items from Section II of the MPSES specifically relating to mathematics anxiety are those from Category S of the four belief categories. The six statements presented to students were as follows:

- S1 Maths makes me feel uneasy and nervous.
- S2 I am interested and willing to use mathematics in everyday life.
- S3 I find mathematics difficult and confusing.
- S4 I would like to further develop my mathematical skills and study this subject more.
- S5 Maths is dull and boring.

S6 The study of maths makes me feel anxious and fearful.

Student levels of agreement with each of the 6 statements across the 3 year levels, prior to commencement of Mathematics Curriculum Studies in Year 2 and at the completion of the program in Year 4 are presented in Table 1. For clarity and ease of analysis, scores that indicated students who 'agreed' with a particular statement (that is, they selected 4 or 5 on the rating scale) or 'disagreed' with a particular statement (that is, they selected 1 or 2 on the rating scale) were collapsed together to give a single score for agreement (rather than strongly agree or agree) and a single score for disagreement (rather than strongly disagree or disagree) for that statement. Results therefore reflect three categories of response (D for disagreement, N for neutral, A for agree) for each statement.

Table 1

Percentage of Preservice Students across 3 Year Levels Who Disagreed (D), were Neutral (N) or Agreed (A) with Particular Statements about Mathematics.

	Year 2			Year 3			Year 4		
	D	N	A	D	N	A	D	N	A
S1. Maths makes me feel uneasy and nervous									
pre	39	21	40	44	20	36	37	8	56
post	58	27	15	70	20	10	73	14	13
S2. I am interested and willing to use maths in everyday life.									
pre	22	28	50	28	27	45	18	34	48
post	17	22	61	21	13	66	18	13	69
S3. I find mathematics difficult and confusing									
pre	42	25	33	44	18	39	40	15	45
post	55	26	19	70	16	14	71	13	16
S4. I would like to further develop my mathematical skills and study this subject more.									
pre	39	25	36	29	24	48	21	14	65
post	17	19	64	11	15	74	10	15	76
S5. Maths is dull and boring.									
pre	35	25	40	52	20	28	46	21	32
post	68	20	12	87	6	7	88	9	3
S6. The study of maths makes me feel anxious and fearful.									
pre	39	26	35	39	18	42	43	16	50
post	58	28	14	69	21	10	73	15	13

From Table 1 it can be seen that the extent to which students agreed with particular statements relating to mathematics anxiety changed in a positive sense as they undertook each component of the Mathematics Curriculum program, and that this change was more pronounced at the end of Year 4. For example, for item S1 (Maths makes me feel uneasy and nervous), of the second year cohort, 40% of students indicated that they agreed with the statement prior to study of mathematics curriculum but at the end of the second year, 15% agreed, 27% were neutral, and 58% disagreed. Of the third year cohort, 36% indicated that they agreed with the statement prior to mathematics curriculum study, but after third year maths curriculum studies, 10% indicated that they now agreed, 20% were neutral and

70% indicated that they now disagreed with the statement. Of the fourth year students, 56% indicated that they agreed with the statement prior to mathematics curriculum study, but after completion of the three-half semester program, this changed to 13% agreement, 14% neutral and 73% disagreement. Item S6 (The study of maths makes me feel anxious and fearful) is similar to S1 (Maths makes me feel uneasy and nervous). Students' responses to this item are almost identical to those for item S1 across the three student cohorts.

As a measure of mathematics anxiety, the results show that approximately 40% of the students indicated that they did suffer mathematics anxiety (and 40% who would not rate themselves as maths anxious). Specifically, to items S1 (Maths makes me feel uneasy and nervous), S6 (The study of maths makes me feel anxious and fearful), S3 (I find mathematics difficult and confusing) and S4 (I would like to further develop my mathematical skills and study this subject more) the percentage of disagreement is similar across all year levels. The prevalence of mathematics anxiety is a cause for concern in terms of teacher education and numeracy development of children in schools, but the fact that this drops to around 10% after Mathematics Curriculum studies suggests the positive impact of the program. Interestingly, the fourth year students indicated the highest level of mathematics anxiety prior to studies in Mathematics Curriculum of all the year groups, with 56% and 50% agreement with the statements 'Maths makes me feel uneasy and nervous' and 'The study of maths makes me feel anxious and fearful' respectively. It is also interesting to note that a greater percentage of fourth year students indicated that they wanted to develop their mathematics skills and study mathematics further prior to undertaking their mathematics curriculum studies (65%) compared to the third year students (48%) and second year students (36%). It is extremely heartening that at each point of their studies in mathematics curriculum, the number of students indicating that they would like to continue in mathematics education increased (64% for second years, 74% for third years and 76% for fourth years).

One of the items upon which students indicated the biggest change was item S5 (Maths is dull and boring). Results across the three year levels are similar with approximately 20% of students neutral and 30-40% agreeing with the statement prior to Mathematics Curriculum Studies. After Mathematics Curriculum at each year level, a dramatic change is indicated with 12% of second year students, 7% of third year students, and just 3% of fourth year students agreeing with this statement. Such a positive rating for this item suggests great promise in terms of the teaching of mathematics in these students' future classrooms. Such results provide a tantalising image of lively, energetic, interesting mathematics lessons where students are actively engaged in exploring meaningful mathematics because the classroom teacher holds a strong belief that mathematics is not dull and boring.

The item for which least change is apparent is S2 (I am interested and willing to use mathematics in everyday life). Between 45-50% of students agreed with this statement prior to Mathematics Curriculum Studies. There is a progressive increase in agreement with this statement across the three year levels (61% for second years, 66% for third years and 69% for fourth years), but the number of students disagreeing with this statement is relatively static across the three year levels both before and after Mathematics Curriculum Studies (approximately 20%). The change was in the number of students selecting neutral to this statement, possibly indicating that prior to Curriculum Studies, students had not fully considered the extent to which they could or did use mathematics in their everyday lives. It could be argued that, with a focus on mathematics through their tertiary studies,

they became more aware of numeracy and the importance of numeracy for living and this may be one reason for the change of neutral opinion to a positive opinion.

Discussion

Unpacking mathematics anxiety in terms of personal feelings about the study of mathematics, perceptions of mathematics as a subject and personal impetus to use mathematics or pursue further study of mathematics provides a picture of this belief category of a large cohort of preservice teachers. From data gathered during this study, prior to Mathematics Curriculum Studies, approximately 50% of students felt uneasy and nervous about mathematics and were anxious and fearful about the study of mathematics; 35-45% found mathematics dull and boring, as well as difficult and confusing with only 50% willing to use mathematics in everyday life. Approximately 50% of the student population in this preservice course had beliefs about mathematics that would not have been helpful in the planning and teaching of mathematics to promote numeracy and achieve the goals of school mathematics. With students indicating positive change of opinions, the program appears to have influenced such change.

Interview data provides further evidence for the positive impact of the program. The following two responses of students dealing with maths anxiety describe the impact of the program upon their beliefs:

My beliefs about mathematics before probably weren't so good because I didn't have a very good high school experience with mathematics ...but this course has proven my beliefs to be completely wrong. I was a bit scared of doing mathematics in Education.

I just didn't have good experience at school with mathematics ...when I got to Uni and had to do maths, I was really nervous...but the course has changed my whole perspective and it has made me feel fantastic about teaching mathematics.

For one student, who was clearly not mathematics anxious, the following response shows a new perspective on mathematics, which appears to be a contrast of her own mathematics experiences:

...the course hasn't influenced my beliefs about mathematics itself...but obviously it has on how you'd go about teaching it...I think of mathematics more as problem solving and patterning rather than formula memorization.

So what aspects of the course impacted upon this change? The following two comments provide further insight that augment the previous statement in which mathematics was described as patterning and problem solving:

I've seen how mathematics can be more hands-on and more group work and more talking about it...before I had just text books and chalk and board so to speak.

I've always enjoyed maths, but when I was going through school I can't remember doing the hands-on stuff

The term 'hands-on' was frequently used by students in all interviews indicating that the tutorial structure was a contributing factor to anxiety change.

Conclusion

The necessarily brief analysis of data from this study has provided a picture of a sizable proportion of pre-service teachers suffering mathematics anxiety entering preservice primary education degree courses. Analysis of survey data has indicated that Mathematics

Curriculum Studies programs at tertiary level can positively impact upon anxiety levels, and that this appears to be more positive as students continue with their studies. This preliminary analysis reinforces the need for mathematics curriculum programs in teacher education and emphasises the need for hands-on activities for students in tutorial modes. Given that the survey returned such positive results when the program delivery was via mass lecture and one weekly tutorial, the impact of such a course, for example, delivered in an electronic mode is questioned. Experimentation in other modes of delivery would be an avenue for further research. Further analysis of interview data will assist in unpacking specific aspects of the program for large cohorts of students in a tertiary program operating with limited time and resources. Such analysis will serve to provide a clearer blueprint of necessary components of a tertiary program that positively impacts future-teachers' beliefs about mathematics. What this study has provided is a self-assessment instrument for mapping change in beliefs and attitudes to mathematics, as well as a measure of quality assurance of a particular program within a degree course.

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