"I was in year 5 and I failed maths": Identifying the Range and Causes of Maths Anxiety in first year Pre-service Teachers.

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Mathematics anxiety affects primary pre-service teachers' engagement with and future teaching of mathematics. The study aimed to assess the level and range of mathematics anxiety in first year pre-service teachers entering their teacher education course, and to investigate the sources of this anxiety as perceived and identified by them. Data collection methods included the RMARS survey, and Critical Incident Technique. The results indicate that the most common negative impacts on pre-service teacher mathematical self-concept involved experiences with teachers. However, their current mathematics anxiety is most commonly aroused under testing or evaluation situations.

Introduction and Context

Anxiety towards mathematics has been identified as an issue nationally and internationally (OECD, 2015). Students compete globally in a world that is strongly based on using mathematics confidently. Successfully engaging with mathematics has social, economic and political implications. Mathematical know-how is widely regarded as essential not only to the life chances of individuals, but also to the health of communities and the economic well-being of nations (Walls, 2009).

This paper is part of a study that investigates primary (elementary) pre-service teachers' (PSTs') mathematics anxiety (maths anxiety), how it impacts upon their engagement with their teacher education course, and how it might be addressed. This is important, with increased scrutiny of teacher education courses, for example, the Australian Institute for Teaching and School Leadership (AITSL) stated that universities need to establish strategies to ensure PSTs have the required standard of numeracy to engage effectively in mathematics units in a rigorous program, (AITSL, 2011).

This paper examines the level and range of first year primary PSTs' maths anxiety at the beginning of their course. The research questions addressed by this study are:

1. With what range and extent of maths anxiety do first year PST present?
2. Is there any indication in the critical incident written responses as to what has stimulated this anxiety?

Theoretical Framework

The interpretive tradition is characterised by prioritising lived experiences, with a focus on meaning of interactions and events. The study aimed to access the narrative or storied nature of PSTs' experiences. The self-analysis of an emotionally-charged experience is an opportunity to analyse past actions and emotions; and the process of writing can be used to reflect on responses and decisions. The 'transactional model of emotion' (Lazarus, 1991) links motivational, social and cognitive dimensions. According to Lazarus, a lived experience consists of contextual and personal factors, which determine whether the event will be appraised: firstly as harmful or threatening (negative emotion), or challenging or beneficial (positive emotion); and secondly, for likely future outcomes, and their potential

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coping strategies. The appraisal can be analysed using binary or thematic analysis of written responses.

Literature Review

Two bodies of research informed this study. The first concerns maths anxiety in PSTs, and the second the use of reflective strategies, especially critical incident technique (CIT) in teacher education. Researchers of primary PSTs report high levels of mathematics anxiety, low confidence levels to teach elementary mathematics, and low mathematics teacher efficacy (Swars, Daane, & Giesen, 2006); and that high levels of teacher mathematics anxiety impact on student achievement (Beilock, Gunderson, Ramirez, & Levine, 2009) and can be perpetuated in classrooms (see Wilson, 2012). This transfer of mathematics anxiety from teacher to student has long-term educational implications.

The first year of study at university is particularly important (Krause, 2005), Recent research (e.g. Martin, 2012) reported success with strategies to increase engagement and reduce of anxiety in a first year education unit that linked practical activities with theory, and more studies of first year pre-service teachers are needed.

Surveys investigate the sources of maths anxiety. They measuring the existing level of maths anxiety by asking participants to rate the level of anxiety induced by different situations. Studies on gender differences in maths anxiety vary, with a number of studies reporting that females have higher levels than males. Age is another factor where contradictory findings are reported in the literature (see discussion in Wilson 2012).

Mathematics anxiety and its impact on students have been identified for many years. "Impoverished school mathematics experiences have left many pre-service teachers with strong *negative* affective responses about mathematics" (Namukasa, Gadanidis, & Cordy, 2009, p. 46 - 47). Previous researchers have investigated causes of maths anxiety, using a range of methods. Reflective thinking is important for professional practice to identify the assumptions that underlie thoughts and actions.

> During mathematics methods courses, it is important to give preservice teachers tools to deal with their recollections and experiences: If students reflect on occasions in their mathematical autobiography and discover that the interpretations of events can be changed, it can free them to search for new perspectives on their mathematical past and future (Kaasila, Hannul, & Laine, 2012, p. 991).

A number of researchers have used PSTs' mathematics autobiographies (Ellsworth & Buss, 2000; Sliva & Roddick, 2001; Lutovac & Kaasila, 2009). They identified the powerful effects of teachers. Teachers who are hostile, hold gender biases, or embarrass students in front of peers play a powerful role in maths anxiety (Vukovic, Keiffer, Bailey, & Harari, 2013). The perceptual changes that occur as a result of mathematics classroom experiences are persistent and enduring.

> People who claim that they were born without mathematical ability will often admit that they were good at the subject until a certain grade, as though the gene for mathematics carried a definite expiry date. Most people will also recall an unusual coincidence: that the year their ability disappeared, they had a particularly bad teacher (Mighton, 2004, p. 20).

Critical incidents have been used to foster reflection in teaching. Lerman (1994) developed "the idea of reflective mathematics teaching, offering the 'critical incident' as a device to stimulate reflection on teaching" (p. 52). The critical incident technique (CIT) focuses on real-life incidents. The advantages of using critical incidents come from their focus on observable behaviours (Pedersen, 1995) and participants' lived experience.

> "When analysing a critical incident, reflective individuals ask: Why did I view the original situation in that way? What assumptions about it did I make? How else could I have interpreted it? What other action(s) might I have taken that could have been more helpful? What will I do if I am faced again with a similar situation?" (Serratt, 2010, p. 379)

These incidents are descriptions of vivid events that people remember as being meaningful in their experience, and often can be identified, upon looking back, as a crisis or tipping point (Wilson, 2014). This study used CIT to investigate how PST feel about themselves as learners and future teachers of mathematics, by asking them to recall a critical incident which impacted on the way they feel. The critical incident may not have happened as they remembered. The aim of this writing is not to determine whether that event actually happened as remembered, but to help PST reflect on their perception of that event and its impact on their construction of what it means to learn mathematics and on themselves as a learner of mathematics.

> Like all data, critical incidents are created. Incidents happen, but critical incidents are produced by the way we look at a situation: a critical incident is an interpretation of the significance of an event. To take something as a critical incident is a value judgement we make, and the basis of that judgement is the significance we attach to the meaning of the incident (Tripp, 1993, p 8).

A benefit of CIT compared to mathematics autobiographies, is that instead of researchers selecting which parts to analyse for themes, in CIT the participant chose the experience and identifies the impact. Participants were not guided towards the selection of a negative experience, so their choice provides data on the proportions of PSTs' positive and negative responses.

Methodology

The study used two methods. A survey of level of anxiety responses to various situations was used to determine the range and type of maths anxiety. Ethics approval, based on accepted informed consent procedures, was received from the university's ethics committee, and agreement to use the RMARS survey was received from the author.

Given the complex nature of the phenomenon, and the aim of the study to access the narrative or storied nature of experience, a qualitative approach was appropriate to investigate the causes of this anxiety. This study is based in the interpretive paradigm. People create and associate their own meanings of their interactions with the world. PSTs' current experiences are filtered through their perceptions, reinforcing their attitudes.

The research study population consisted of two cohorts of students undertaking their first year mathematics unit on a major metropolitan campus and a smaller regional campus of an Australian university, in two successive years - a total of approximately 450 level 1 students from the Bachelor of Education (Primary) course. The data were collected in the participants' setting.

Methods

The RMARS (Alexander & Martray, 1989) was chosen for the survey because of its length, fit with the research question, appropriateness for group and strong psychometric information. It has been widely used in academic research, rigorously tested, and found to be psychometrically sound (Baloglu & Kocak, 2006; Dunkle, 2010). The RMARS is a 25-item, five-point (1 = not at all, to 5 = very much) Likert-type instrument. Thus, potential Total Anxiety scores range from "not at all" = 25, to "very much" = 125.

The RMARS assumes the multidimensionality of the construct, (Alexander & Martray, 1989, Baloglu, 2002), and has three subscales, for mathematics test anxiety (MTA, items 1-15), numerical task anxiety (NTA, items 16-20), and mathematics course anxiety (MCA, items 21-25). Possible scores for MTA could range from 5-45, and for NTA and MCA could range from 5-25.

The RMARS was used with minor modifications for the Australian context. A set of demographic questions was also used in the study. These asked for information such as age, gender, mathematics courses studied in high school, and the number of years/months since their last mathematics course. Data were coded onto an excel spreadsheet and analysed with the Statistical Package for Social Sciences (SPSS) 20.0. Means and standard deviations for the total scale scores on the RMARS were computed. Gender and age differences were examined for the total scale scores on the RMARS as well as the three subscales.

A critical incident approach was selected as the underpinning qualitative method as the study aims to access the narrative or storied nature of experience. In tutorials, PSTs were asked to write a written description of a critical incident (positive or negative) from their own school mathematics education that impacted on their image of themselves as learners of mathematics. PSTs were identified only by a code used to match CIT reflections with other data. Reflections were sealed in envelopes immediately and sent to the researcher. The data were not merged, as the use of the survey was pragmatic to answer the research question concerning the levels of anxiety. The qualitative data was used to explore the meaning individual PSTs ascribe to the problem of maths anxiety. Some initial results from the preliminary binary analysis (Lazarus, 1991) are presented. The binary analysis will be completed and followed by a more extensive thematic analysis.

Results and Discussion

Surveys from 219 PSTs were collected at the beginning of Semester 1, 2012. Sample 1 (57 PSTs: 45 female, 12 male) came from a city in a regional area and Sample 2 (162 PSTs: 140 female, 21 male, 1 not specified) was from a campus in a major metropolitan city. Response rates were 98% (Sample 1) and 70% (Sample 2). Surveys from 208 PSTs from the same two campuses were collected at the beginning of Semester 1, 2013. Means and standard deviations for the total scale scores on the RMARS were computed, and are shown in Tables 1 and 2.

Table 1
Total Anxiety Scores as measured by the RMARS, Semester 1, 2012

PST samples	n	range	mean	S. D.
Total PST	219	31-116	63.32	16.74
Campus 1	57	31-104	66.02	19.19
Campus 2	162	34-116	62.78	17.86
Females	185	31-116	64.01	18.44
Males	33	35-108	62.24	17.90
Less than 25 years	192	31-116	62.44	17.73
25 years and over	26	35-112	73.58	19.75

The PSTs exhibited a broad range of anxiety levels, ranging from almost no maths anxiety to very high levels of anxiety. An independent-samples t-test was conducted to compare

campus differences in maths anxiety. In both years, there was a wide range within the cohorts ranging from very little maths anxiety to very high levels of anxiety, with half of the participants showing at least a fair amount, and 2% high to very high levels, of anxiety.

Table 2
Total Anxiety Scores as measured by the RMARS, Semester 1, 2013

PST samples	n	range	mean	S. D.
Total PST	208	30-116	64.74	18.39
Campus 1	63	30-110	64.05	18.07
Campus 2	145	31-116	65.03	18.58
Females	177	30-116	65.97	18.52
Males	31	33-89	57.71	16.19
Less than 25 years	192	30-116	64.43	18.42
25 years and over	16	32-103	68.44	18.75

No significant differences in Total Anxiety were found between the cohorts from the two campuses in either year. They were statistically equivalent on the total RMARS scores, as well as the three subscales (MTA, NTA, and MCA) (shown in Table 3).

Gender and age differences were examined for the total scale scores on the RMARS as well as the three subscales. In the first year, no significant differences were found between females and males on the total RMARS scores, or on the three subscales. However, in the 2013 cohort, female students had significantly higher levels, consistent with previous findings of gender differences in the RMARS scores (Alexander & Martray, 1989; Brady & Bowd, 2005; Baloglu & Kocak, 2006). In addition they had a significantly higher MTA component of their maths anxiety.

In the first year, significant differences were identified between age cohorts. The older group demonstrated higher levels of mathematics anxiety and larger standard deviations. Statistically significant differences were found between the scores of the younger and mature-age PSTs on the total RMARS scores, ($t(217) = 2.97$, $p < 0.005$); and on the three subscales (MTA, $t(217) = 2.12$, $p < 0.05$; NTA, $t(217) = 3.47$, $p = 0.001$; and MCA, $t(217) = 3.09$, $p < 0.05$), with mature-age PSTs receiving higher scores. This supported the findings of Baloglu and Kocak (2006) that older college students show higher levels of mathematics anxiety than younger ones. However, in 2013, there were no significant differences between age groups. This indicates that, although there were no significant differences between campuses, the level and distribution of maths anxiety in groups of incoming PSTs may vary from year to year.

Table 3 shows the factor analysis for the three contributing factors (MTA, NTA and MCA) for each of the two years. The score for each of the factors depends on the number of questions that contribute to that factor. In order to compare the levels of the anxiety components, each is presented as a score out of 5. The analysis shows that for both years, the mathematics test anxiety factor is much higher than the other two factors. This indicates that the primary factor that arouses PSTs' maths anxiety is testing or evaluation.

In the RMARS survey, participants rated their emotional responses to certain mathematical experiences in their lives, whereas the CIT identified past incidents that impacted on their feelings about themselves. Thus, both research methods focus on aspects of emotional responses to lived experiences (Lazarus, 1991), although the CIT involved open-ended responses, and the survey involved reducing the emotions to five levels.

Table 3
Means and Standard Deviations of the Sub-scales of the Revised Mathematics Rating Scale*

Factors	Years	
	2012 (n=219)	2013 (n=208)
Mathematics Test Anxiety (MTA) /5	2.98 (0.82)	3.06 (0.83)
Numerical Task Anxiety (NTA)/5	1.77 (0.81)	1.85 (0.84)
Mathematics Course Anxiety (MCA)/5	1.80 (0. 81)	1.90 (0.85)

* Standard deviations are reported within parentheses.

Preliminary binary analysis (Lazarus, 1991) has been completed on critical incident reflections from the 2012 Campus 2 cohort of PSTs. The participants chose the salient experiences and identified their impact. The initial analysis divided incidents into positive and negative experiences, based on Lazurus' (1991) characterisation of appraisal as harmful (negative emotion) or beneficial (positive emotion). Of the 236 descriptions of critical incidents, 102 (39%) were positive, 157 (61%) were negative and 2 (1%) described a neutral incident. These figures support findings by previous researchers (Namukasa et al., 2009).

The researcher then analysed the accounts for the most common factor. This was the teacher. Comments were coded as "teacher", only if they included the word "teacher". If a comment mentioned two teachers, in separate years, both were counted separately. Of the 236 PSTs, 135 (57%) wrote about the teacher. Analysis of the 140 comments about the teacher, found 46 (33%) were positive and 94 (67%) were negative. To illustrate the preliminary findings, the following examples of positive experiences show the impact of teachers who provided safe and supportive learning environments:

> Year 8 – my teacher made me comfortable and helped me understand the task in a way that was not uncomfortable.
>
> Year 11 to 12. Previously I had never been very good at maths. My teacher found ways to connect maths in ways I could relate to, making it fun. This developed my maths skills and attitude towards maths.

However, some PSTs retained intense memories of their experiences with disabling teachers, and these ranged from primary school to senior secondary. The following are examples of critical incidents that were coded as negative:

> In year 3, I didn't understand. The teacher gave up, gave me 'colouring in' while other students learned maths.
>
> Year 6 – I couldn't understand the concept of long division so the teacher gave up on me and said don't worry about it. Looking back it makes me feel like a failure.
>
> In primary school I had one teacher who would always put you on the spot in front of a class and he would read out everyone's results in front of everyone too. This always made me anxious and from then on I aimed to avoid maths.
>
> In year 9, my teacher would make us answer questions on the board and if we got it wrong, he would say "Poor _____. What can we do with you?"

> Year 11 … My teacher made it hard for me to learn and understand because he would give the class a time to finish answering a question and if I didn't know an answer, he would look at me and say "You should know this".

These comments reflected findings from other researchers (Ellsworth & Buss, 2000; Sliva & Roddick, 2001; Wilson & Thornton, 2008; Lutovac & Kaasila, 2009) on the important impact of individual teachers.

In addition, in some critical incident descriptions, PST identified that failure in tests had implications for their self-concept as learners of mathematics:

> I was in year 5 and I failed maths and since that day I hate maths. This experience makes me feel that I don't know anything about maths.

Combined with the survey findings of the significant contribution of MTA to high levels of maths anxiety, this has important implications for teacher education. The survey showed that maths anxiety may present differently in different situations, but evaluation and testing were identified as the most common source of maths anxiety. The connections between experiences identified in critical incidents as causes of maths anxiety and current sources of maths anxiety will be explored by further analysis of the data.

These results indicate that beginning teacher education students vary in affective responses towards learning mathematics. Teacher educators should be aware of the extent of range of anxiety that PST may present with at the beginning of their teacher education course, and hence that the needs of students coming to their teacher education mathematics units may vary considerably.

Conclusions

This paper demonstrates that PST come to their teacher education courses with a range of existing maths anxiety, identified through the RMARS survey. The initial findings of the binary analysis of the critical incidents indicate teachers and testing as important factors to be investigated. Further analysis is need to explore the connections between experiences identified by the initial analysis of the critical incidents as potential causes of maths anxiety, and current sources of maths anxiety identified by the survey. To achieve this, the qualitative data will be further analysed in terms of themes.

Participation of PST in writing critical incidents and reflections, provides insights into their views of themselves as future teachers of mathematics, and potentially impacts on their future teaching of mathematics and hence the achievement of their future students. The larger study will also investigate the impact of using bibliotherapy to address maths anxiety on engagement of PSTs in their mathematics units. This research has the potential to make an important contribution to the strategies available in teacher education courses to address maths anxiety.

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