INVESTIGATING RURAL PRE-SERVICE TEACHERS' MATHEMATICS ANXIETY USING THE REVISED MATHEMATICS ANXIETY SCALE (RMARS)

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ABSTRACT

Engaging successfully in the modern technological society requires a command of mathematics. Hence, successfully engaging with mathematics has social, economic and political implications. There has been a history over a long period of time of significant numbers of people not forming productive relationships with learning mathematics. Failure in mathematics can have an impact that may extend far beyond the classroom. Mathematics anxiety leads to avoidance of mathematics, limiting opportunities for people to reach their full potential.

Mathematics anxiety is an important research topic in the mathematics education community. Significant numbers of students come to their tertiary teacher education with limited mathematics understandings, and a pattern of avoidance and anxiety. International researchers of primary pre-service teachers report high levels of mathematics anxiety, low confidence levels to teach mathematics and low mathematics teacher efficacy. Pre-service primary teachers' mathematics anxiety affects their engagement with and future teaching of mathematics, as high levels of teacher mathematics anxiety can be perpetuated in classrooms (Martinez, 1987, Furner & Berman, 2005).

The project investigated the range of mathematics anxiety in a sample of pre-service teachers (PST) starting a teacher education course in an Australian university. 219 first year primary PST enrolled in the Bachelor of Education (Primary) degree course from two campuses completed the survey in the first few weeks of the first semester of their university course. PST responded to the Revised Mathematics Anxiety Scale (RMARS) (Alexander & Martray, 1989) and a set of demographic questions. Sample 1 was from a campus in a regional city and Sample 2 from a metropolitan campus. Age differences in anxiety were found to be significant, and relationships were found between the RMARS scores and students' self-perceptions of their current mathematics anxiety levels. Pre-service teachers who had attended rural high schools demonstrated a range of levels of mathematics anxiety. This research showed that these anxieties may present differently when taking a mathematics test, doing mathematical computations, or undertaking a mathematics course. 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.

INTRODUCTION

Engaging successfully in the modern technological society requires a command of mathematics. Hence, successfully engaging with mathematics has social, economic and political implications, as "… in this changing world, those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures. Mathematical competence opens doors to productive futures. A lack of mathematical competence keeps those doors closed." (NCTM 2000, p. 5). Productive relationships with mathematics are important because "as our knowledge expands and the economy evolves, more people are working with technologies or in settings where mathematics is foundational. Processing of information, problem solving, and using numbers and symbols to communicate are becoming routine job requirements" (Minton, 2007, p. 4).

High mathematics anxiety impacts on performance and achievement in mathematics (Betz, 1978; Ma, 1999; Sheffield & Hunt, 2006). Mathematics anxiety is related to success in higher education (Stubblefield 2006). Students with high mathematics anxiety avoid mathematics in their courses and

careers (Scarpello 2005). Thus, mathematics anxiety leads to avoidance of mathematics, limiting opportunities for people to reach their full potential.

CONTEXT OF THE STUDY

This research is located at the intersection of the literature on issues in rural education, and the impacts of mathematics anxiety on primary teacher mathematics. International studies such as the Programme of International Student Assessment (PISA), have reported lower levels of mathematical literacy in Australian students from rural and remote schools The PISA 2009 results focused on mathematical literacy, and showed that students attending schools in metropolitan areas "performed at a significantly higher level than students in schools from provincial areas and remote areas, and students in provincial areas significantly outperformed students in remote schools" (Thomson et al., 2011, p. 190). The SiMERR national survey of science, mathematics and ICT education in rural and regional Australia (Lyons et al, 2006) identified factors affecting student achievement in rural and remote schools. Many of the issues faced by rural and remote students in their schools are likely to have implications on their university enrolments. For example, rural and remote students are less likely to attend university than metropolitan students and higher university attrition rates have been reported for remote students nationally.

Studies focused on the number of Australian youth who do not complete year 12 found year 12 completion rates are a lower for rural students (CSHE 2008 Participation and equity report) and researchers have reported a trend for young people educated in rural communities to be under-represented in post-compulsory education (Lamb et al., 2000; Alston & Kent, 2003).

In aspirations of students towards tertiary education "… rurality and low socio-economic status combine to produce the greatest educational disadvantage" and students from urban areas have higher retention rates at university (Heagney 2004 p. 5). Reviewing international access to higher education, Baldwin and James (2010) state "… the rates and patterns of access to and participation in higher education are significant policy issues in most countries" (p. 334) and that groups underrepresented include people from rural or remote areas. They report that the factors that underlie underrepresentation include:

> *lower school-completion rates, lower levels of educational attainment in schools – thus limiting opportunities in the circumstances of competitive entry based on academic achievement – lower levels of educational aspiration, and lower perceptions of the personal and career relevance of higher education, alienation from the culture of universities, and a range of interrelated financial factors: the expense of university fees, the lack of availability of income support while studying, and the loss of potential income while studying (p. 337)*
> .

They emphasise that the interrelationships between these factors are not well understood, as some represent explicit barriers to participation and others the absence of factors in the environment that encourage aspiration to higher education, and conclude that "the imbalances in higher education participation often reflect endemic educational disadvantage that begins in the earliest years of schooling" (p. 337). Bush (2005) proposes that collaborations among rural teachers, mathematicians, and mathematics educators will enhance the mathematics teaching and learning in rural contexts and "broaden students' view of the nature, role, and utility of mathematics" (p. 5).

Mathematics anxiety

Failure in mathematics can have a powerful emotional impact that may extend far beyond the mathematics classroom (Boaler, 1997), culminating for many in an ongoing state of mathematics anxiety. Mathematics anxiety is an important research topic in the mathematics education community. Many students suffer from mathematics anxiety and this seems to be independent of whether they are good at mathematics or not (Furner 1996). Mathematics anxiety is more than a dislike for mathematics (Vinson 2001). Burns, (1998), characterises maths as a phobia "right up there with snakes, public speaking and heights" (p. ix)

Among the early researchers of mathematics anxiety, Dreger and Atkin, (1957, p. 344), identified "emotional reactions to arithmetic and mathematics". Richardson and Suinn, (1972, p. 551) elaborated

"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". Smith (1997) characterises mathematics anxiety in a number of ways ranging from uneasiness when asked to perform mathematical task, to avoidance, feeling of physical illness, dread and panic, thus theoretical models of mathematics anxiety have multidimensional forms that incorporate attitudinal (dislike), cognitive (worry) and emotional (fear) aspects, (Hart, 1989; Wigfield & Meece, 1988).

Gender differences in mathematics anxiety have been extensively studied. The results are inconsistent, with a number of studies reporting that females have higher levels of mathematics anxiety than males (for example, Alexander & Martray, 1989) and others not confirming significant differences. Baloglu and Kocak (2006), controlling for mathematics experience, found that gender effects of mathematics anxiety varied with the context.

Age is another factor where contradictory findings are reported in the literature. Hembree, (1990), did not find any age-related differences, but Baloglu and Kocak (2006) found that older pre-service teachers exhibited more total mathematics anxiety than younger ones, particularly in mathematics testing and course situations. The issue of mature age students detailing the sacrifices they are making in undertaking tertiary studies has emerged as a new topic, and it is recommended that further research should investigate whether this issue connects with the concept of persistence, and is therefore a possible variable that should be incorporated into the current debate on attrition and retention (Krause, 2005).

Mathematics anxiety and Pre-service teachers

Pre-service primary (elementary) teachers' mathematics anxiety has important impacts on their studies and on their future students. Previous research has investigated the use of bibliotherapy to address pre-service teacher mathematics anxiety (Wilson & Thornton, 2008; Wilson, 2009). This paper, part of a larger project to build on that research, examines the range of first year primary pre-service teachers' (PST) mathematics anxiety.

Mathematics anxiety is of particular significance in pre-service primary teacher education. Many pre-service primary or early childhood teachers have a fear of mathematics, and see themselves as unable to learn effectively (Haylock, 2001). Many students come to tertiary teacher education with limited mathematics understandings, and a pattern of avoidance and anxiety. Researchers of primary PST report high levels of mathematics anxiety, low confidence levels to learn and teach mathematics and low mathematics teacher efficacy, for example, Perry (2007) freported: "These results provide some evidence that a mismatch between the personal achievement goals of students and the classroom goal orientation result in lower confidence in learning mathematics and therefore, higher levels of mathematics anxiety." (p. 136-7)

Mathematics anxiety affects not only their current study but also their future teaching of mathematics and hence the attitudes of their future students. Researchers have identified teacher preparation programs as sources of mathematics anxiety (Uusimaki & Nason, 2004, p. 370). Dunkle (2010) warns of the consequences of this:

> *anxiety with regard to mathematical concepts can be passed on to the next generation of students by their teachers. Thus, there is an urgent need to overcome this anxiety in preservice teachers so that they may more appropriately model their skills to their students, and thus break the cycle of math anxiety that appears to be becoming generational in nature. (p. 14)*

The way individuals perceive themselves as learners of mathematics is integral to their subsequent identity as teachers. In previous research (Wilson & Thornton, 2008; Wilson, 2009) many PST described an interaction during their schooling that led to them thinking of themselves as persons who couldn't learn mathematics, and said that this still impacted on their self-images as future teachers of mathematics. Some of the consequences of these experiences can be seen in their levels of mathematics anxiety and self-perceptions as future teachers of mathematics. Identities remain open to revision during the time of their course. Hence, Walshaw, (2004, p. 557), argues that "teacher education must engage the identities of pre-service students".

Mathematics anxiety has been associated with inappropriate teaching practices (Hasbee, Sam, Nur, & Tan, 2009, Uusimaki & Nason, 2004). The teacher's attitude has been identified as a major factor (Vinson, 2001). Teachers' beliefs about their own ability are significant in their approach to teaching mathematics and can produce unwillingness to teach upper primary classes (Wilson, 2009). Minton, (2007) states that

> *negative beliefs and assumptions have permeated our culture and, in effect, have limited people in their daily lives and had long-term consequences on their livelihood. Because innumeracy in today's world deprives students of opportunity as well as competence in everyday tasks, it is vital that students understand the mathematics they're learning (p. 3).*

Researchers have found that high levels of teacher mathematics anxiety can be perpetuated in classrooms (for example, Martinez, 1987, Furner & Berman, 2005). Therefore, "preventing math anxiety begins by helping teachers confront and control their own fears of math" (Martinez, 1987, p. 117). Researchers (Nye et. al., 2004; Clotfelter et. al., 2007) have found evidence that teacher experience is related to student achievement gains, and reported larger teacher effects on mathematics achievement than on reading achievement.

Perry (2007) reported that "rural pre-service teachers had less confidence and were more likely to view mathematics as a male domain than non-rural pre-senvice elementary teachers" (p. vi).

There was a statistically significant difference between the rural group and the nonrural group for confidence in learning mathematics, with the rural group displaying less confidence.

In summary, PST with mathematics anxiety are less likely to engage with mathematics, and have low confidence and low self-efficacy, impacting on their identity as teachers of mathematics. Wolodko, Willson and Johnson (2003) write "… our challenge is to help pre-service teachers confront their past experiences and anxieties about teaching and learning of mathematics. If these are openly dealt with during their university education, fewer teachers may be content to teach just as they have been taught" (p. 224). Negotiating this issue has the potential to transform learning and teaching beyond that of the PST to the future students. Empowering PSTs contributes to social justice in that it can make a difference not only for them but for their future students and hence impact on social change. It is for these reasons that teacher education has become a crucial site for further research.

Mathematics anxiety scales

Researchers have sought way to assess levels of mathematics anxiety. Anxiety is a construct and not able to be measured directly. There are international units and standards for some measurements, but to attempt to quantify a construct such as anxiety is much more problematic. Observed or reported activities lead to inference of anxiety in anxiety scales.

A range of instruments has been developed after Dreger and Atkin, (1957), produced the first standardised mathematics anxiety instrument, the Number Anxiety Scale. In 1972, the Mathematics Anxiety Rating Scale, (MARS), a major scale used in research and clinical studies, was developed by Richardson and Suinn. It has been widely used with high reliability and validity reported. Recently, Dunkle (2010) used the RMARS to provide valid and reliable results for measuring PST math anxiety over time.

The original MARS was found to be time-consuming to administer because of its length. In attempting to reduce the number of items in the scale, Plake and Parker developed the Mathematics Anxiety Rating Scale–Revised (MARS–R) in 1982, and Alexander and Martray developed the Revised Mathematics Anxiety Rating Scale (RMARS) in 1989, reducing the original 98-item MARS (Richardson & Suinn, 1972), to 24 and 25 items respectively. The MARS also interpreted mathematics anxiety as one factor, whereas the RMARS measures three factors - mathematics test anxiety (MTA), numerical task anxiety, (NTA), and mathematics course anxiety (MCA). The RMARS has been widely used in academic research, rigorously tested, and found to be psychometrically sound (Revak, 1996; Bowd & Brady, 2002; Haynes, 2003, Baloglu & Kocak, 2006).

Baloglu & Zeldhart's (2007) confirmatory factor analysis supported the 3 factors identified by Alexander & Martray, but 5 of the MTA items did not map to that factor and were removed to produce a 20-item RMARS). Baloglu and Zelhart (2007) reported that this version of the RMARS "was found to be a valid

and reliable measure of college students' mathematics anxiety levels" (p, 608). They reported that, based on reliability investigations, the total scale and subscales were highly reliable, and they confirmed the three-factor structure. A range of other instruments has been developed (for some examples, see Table 1), but their analysis is beyond the scope of this paper.

Table 1: Examples of mathematics anxiety scales

Author	Year	Number of items	Instrument
Dreger & Aitken	1957		Number Anxiety Scale
Richardson & Suinn	1972	98	Mathematics Anxiety Rating Scale (MARS)
Plake & Parker	1982	24	Mathematics Anxiety Rating Scale–Revised (MARS-R)
Wigfield & Meece	1988	22	Mathematics Anxiety Questionnaire (MAQ)
Alexander & Martray	1989	25	Revised Mathematics Anxiety Rating Scale (RMARS)
Suinn & Winston	2003	30	Mathematics Anxiety Rating Scale – Short Version (MARS-SV)
Hopko et al	2003	9	Abbreviated Mathematics Anxiety Scale (AMAS)
Bursal & Paznokas	2006	30	Revised-Mathematics Anxiety Survey (R-MANX)

THE STUDY

This paper reports the first stage of ongoing research investigating maths anxiety in PST in education courses in an Australian university. The project aims to investigate the range of anxiety that first year PST feel towards mathematics, and ways that they might change the way they approach their mathematics studies, their affective responses to mathematics and engagement with mathematics in their university mathematics units. This paper reports the results of the first part of this project, which aimed to investigate the range of anxiety that first year PST feel towards mathematics, using the RMARS survey.

Research questions

The following research questions were investigated:

1. With what range and extent of mathematics anxiety do PST present?
2. Do first year PST from rural localities demonstrate significantly different levels of mathematics anxiety from their metropolitan counterparts?

METHODS

The participants

The participants comprised 219 first year PST enrolled in the Bachelor of Education (Primary) degree course at a multi-campus Australian university. Cohorts of PST from two campuses were surveyed for this study. Both came from campuses in metropolitan areas, with sample 1 from a city in a regional area, and Sample 2 from a major metropolitan city. Samples of 57 (45 females: 12 males) and 162 (140 females: 21 males: 1 not specified) completed the survey instrument. Response rates were 98% and 70% respectively. They were surveyed in first few weeks of the first semester of their university course.

Instruments

A range of mathematics anxiety surveys was considered (see Table 1.) The RMARS (Alexander & Martray, 1989) was chosen because of its length, fit with the research question, appropriateness for group and strong psychometric information. The RMARS is a 25-item, five point (1 = not at all, to 5 = very much) Likert-type instrument. (Possible Total Anxiety scores range from "not at all" = 25, to "very much" = 125). It has three sub-scales MTA, (items 1-15); NTA (items 16-20); and MCA (items 21-25). The original RMARS was used with minor modifications for the Australian context. The RMARS rating forms plus a set of demographic questions were used in the study. These asked for information such as age and gender, location, mathematics courses studied in high school, and the number of years/months since their last mathematics course.

Procedure

Ethics approval was obtained from the university ethics committee, and agreement to use the RMARS survey was received from the author. Participants were surveyed at the start of their first semester with the RMARS instrument to collect data on student mathematics anxiety. They were asked to rank the extent to which they feel anxiety about activities involving maths, and to score their anxiety about mathematics. In addition to the survey the PST were asked to rate their general mathematics anxiety level, confidence and current mathematics anxiety level after completing the questions on a scale between 0 and 100, where higher scores related to higher levels. As current literature suggests that mathematics anxiety is a transitory-state construct (Baloglu & Zelhart, 2007), this question sought to obtain a measure of the mathematics anxiety that PST were currently experiencing when completing the survey. Data were coded onto an excel spreadsheet and arranged so they could be analysed with the software program Statistical Package for Social Sciences (SPSS) 20.0.

RESULTS AND DISCUSSION

Means and standard deviations for the total scale scores on the RMARS were computed (see Table 2). The PST exhibited a broad range of anxiety levels. Scores ranged from 31 - 116, with a mean score of 63.32 (which corresponded to levels intermediate between "a fair amount" and "much" anxiety) and a standard deviation of 16.74. This indicates that beginning teacher education students are not uniform with respect to the level of their affective responses towards learning mathematics.

Table 2: Total Anxiety Scores as measured by the RMARS.

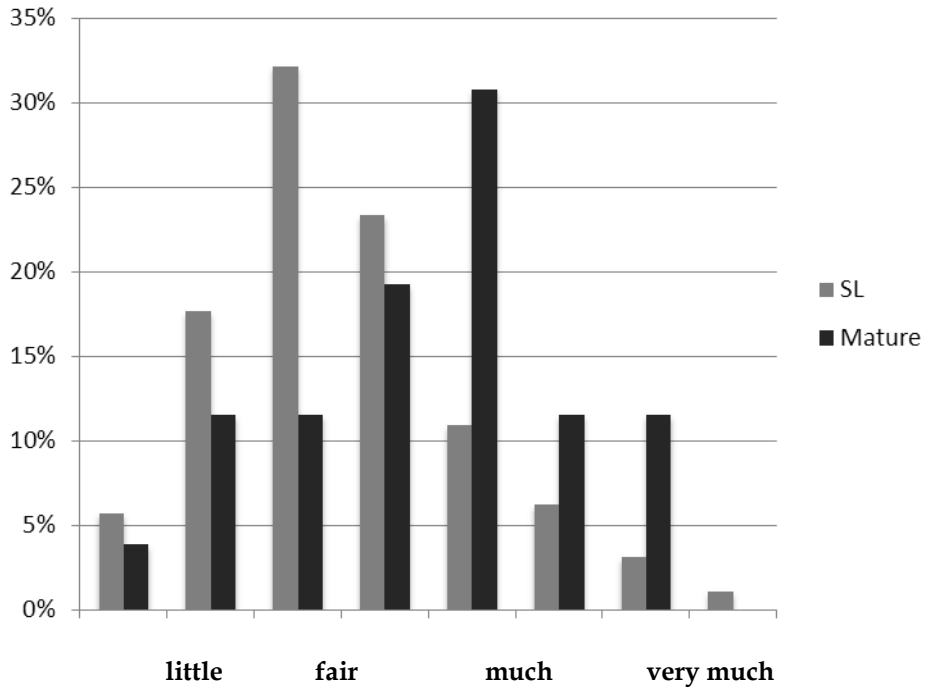
Student samples	range	mean	S. D.
Total students	31-116	63.32	16.74
Campus 1	31-104	66.02	19.19
Campus 2	34-116	62.78	17.86
Female students	31-116	64.01	18.44
Male students	35-108	62.24	17.90
Less than 25 years	31-116	62.44	17.73
25 years and over	35-112	73.58	19.75

Comparing PST from the two campuses, Sample 1 had a mean score of 66.02 and a standard deviation of 19.19, and sample 2 had a mean score of 62.78 and a standard deviation of 17.86. No significant differences were found between the cohorts from the two campuses. Sample 1 and sample 2 were statistically equivalent on the total RMARS scores, ($p < 0.25$), as well as the three subscales (Mathematics Test Anxiety (MTA), $p < 0.33$; Numerical Task Anxiety (NTA), $p < 0.09$; and Mathematics Course Anxiety (MCA), $p < .73$). These results indicate that there was a wide range of mathematics anxiety within the cohorts, but that the cohorts as a whole were not significantly different. Scores of students from rural or provincial areas were not significantly different from those of their metropolitan counterparts.

Gender differences were examined for the total scale scores on the RMARS as well as the three subscales. No significant differences were found between females and males on the total RMARS scores, $p < 0.61$, nor on the three subscales (MTA, $p < 0.32$; NTA, $p < 0.71$; and MCA, $p < 0.30$). The results for gender differences reported by researchers vary and this underlines the complexity of this issue.

Significant differences were identified between age cohorts. For the purpose of this study, and in line with published research, mature-age PST were defined as those 25 years and over. Age differences were examined for the total scale scores on the RMARS as well as for the three subscales. The older group demonstrated higher levels of mathematics anxiety than the younger group (see Figure 1).

***Figure 1*. Percentages of Mathematics Anxiety scores of under 25 (SL) or 25 and over (Mature) PST.**



Significant differences at the 95% level were found between the scores of the younger (mean 62.44, standard deviation 17.73) and mature-age (mean 73.58 standard deviation 19.75) on the total RMARS scores, ($p < 0.003$); and on the three subscales (MTA, $p < 0.035$; NTA, $p < 0.001$; and MCA, $p < 0.016$), with MTA and MCA significant at the 95% level and NTA significant at the 99.9% level (Wilson, 2012). This supports the findings of Baloglu and Kocak (2006) that older college students show higher levels off mathematics anxiety than younger ones, however they reported that MTA and MCA contributed more to the anxiety of their older cohort than NTA.

Concurrent validity of the instrument was investigated by examining the relationships between the RMARS scores and students' self-perceptions of their general and current mathematics anxiety levels, using paired t-tests. The analysis showed that there was a correlation between the PST' estimates of their general levels of mathematics anxiety, and their estimate of their current level of mathematics anxiety. The RMARS scores were significantly different to the general mathematics anxiety level rating ($p < 0.009$), but not to their current level of mathematics anxiety. This indicates that the RMARS scores were a better indication of their perception of their current level of mathematics anxiety, than their general level.

CONCLUSIONS

This study indicates a need for further research to identify factors that impinge on rural students' achievement in mathematics and to identify the extent to which their beliefs about and attitudes towards mathematics affect their access to university education courses. In particular, extending this research in the light of and Perry's (2007) research on the impact of rural PST' mathematics anxiety on

their successful engagement with their university education courses, will provide insights about factors contributing to rural student and PST retention.

Results from preliminary data on the range of mathematics anxiety experienced by PST in their first few weeks of their teacher education course at university show that in some cases these anxieties may present differently when taking a mathematics test, doing mathematical computations, or undertaking a mathematics course. Teacher educators should be aware of the extent of the range of anxiety that PST experience at the beginning of their teacher education course, and especially that mature-age PST experience anxiety differently in mathematics courses compared to younger PST, and hence the needs of mature-age students coming in to teacher education may be different to those of younger students. The findings from this study will be used to investigate strategies to foster a more positive orientation towards mathematics in pre-service teachers.

Of particular interest to teacher educators will be the second part of the project which will build on previous research (Wilson & Thornton, 2008) on the impact of the participation in writing about experiences and reflections on the development of PST evaluations of themselves as future teachers of mathematics. The reflections produced during the project will be used, with permission, as tools for developing teacher educators and teachers' personal and professional knowledge. This has the potential to transform learning and teaching beyond that of the PST to their future teaching of mathematics and hence the attitudes of their future students. It is also anticipated that examples related to reflective practice and developed during this project may be useful for a wider audience of teacher educators and PST, extending the strategies available in teacher education courses to address mathematics anxiety.

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