Paper Code: 00501

Situational effects of mathematics anxiety in pre-service teacher education

Audrey Cooke, Curtin University, Audrey.Cooke@curtin.edu.au
Rob Cavanagh, Curtin University, R.Cavanagh@exchange.curtin.edu.au
Chris Hurst, Curtin University, C.Hurst@curtin.edu.au
Len Sparrow, Curtin University, L.Sparrow@curtin.edu.au

Abstract

The new National Program Standards for Accreditation of Initial Teacher Education states that "applicants' levels of personal literacy and numeracy should be broadly equivalent to those of the top 30 per cent of the population" (Australian Institute for Teaching and School Leadership [AITSL], 2011, p. 13) or, if pre-service teachers enrolled in the degree have not met this equivalence, institutions "must establish satisfactory additional arrangements to ensure that all students are supported to achieve the required standard before graduation" (AITSL, 2011, p. 13). This places an emphasis on the numeracy and mathematical skills of the pre-service teachers completing the Early Childhood and Primary bachelor degrees. However, little consideration is given in their teaching qualification preparation to the anxiety these pre-service teachers may have towards mathematics. Pre-service teachers with mathematics anxiety may avoid mathematics (Isiksal, Curran, Koc, & Askum, 2009), may have lower teacher efficacy in mathematics (Gresham, 2008), may experience a negative impact on their teaching behaviours (Swars, Daane, & Giesen, 2007), may pass on their anxiety to their students (Malinsky, Ross, Pannells, & McJunkin, 2006), and may negatively influence the mathematics achievement of their students (Beilock, Gunderson, Ramirez, & Levine, 2009). The aim of this project was to determine whether a modified version of the self-report instrument developed by Cavanagh and Sparrow (2010a; 2010b) could measure mathematics anxiety in pre-service teachers. Specifically the project investigated different situations - in a university class, when completing a formal mathematics test, and when teaching. Data from 169 pre-service teachers were analysed using the Rasch Rating Scale model (Andrich, 1978a, 1978b &1978c). The results showed that data from the instrument complied with the requirements of the Rasch model. The results also enabled comparisons to be made of student scores in the three situations. The paper concludes by discussing the potential benefits of using the instrument in a diagnostic and formative way to inform pre-service teachers of the possible level of mathematics anxiety they might experience.

Key Words

Mathematics Anxiety, Pre-service Teacher Education Assessment and Measurement SIG

Introduction

This paper reports the first part of a larger research project established to consider the impact of mathematics anxiety on Early Childhood and Primary pre-service teachers completing a bachelor degree in education.

Mathematics Anxiety

Brady and Bowd (2005) described mathematics anxiety as "a form of state anxiety as it is manifested in specific situations" (p. 37). Symptoms include "being uncomfortable in performing mathematical tasks in non-formal classroom situations, avoiding formal mathematical instruction whenever possible, poor test performance and the utilization of remedial instruction to little effect" (Brady & Bowd, 2005, p. 38). Malinsky et al. (2006) believed that "math anxiety is an extremely common phenomenon among college and university students today" (p. 274).

Mathematics anxiety should not be synonymous with a lack of mathematical skills as "math-anxious people avoid math but they also perform more poorly than their abilities would suggest when they are exposed to math" (Beilock, Gunderson, Ramirez, & Levine, 2009, p. 1860). However, research has demonstrated strong relationships between mathematics anxiety and other factors surrounding mathematics and mathematics teaching:

- sufferers of mathematics anxiety may actively "avoid mathematics classes and mathematics-related activities." (Isiksal et al., 2009, p. 632);
- mathematical anxiety in pre-service teachers may "interfere with goals of improving their mathematical content knowledge." (Rayner, Pitsolantis, & Osana, 2009, p. 78);
- mathematics anxiety may affect teacher planning, as "teachers with low self-efficacy may avoid planning activities that they believe exceed their capabilities, may not persist with students having difficulties, may expend little effort to find materials, and may not reteach content in ways students might better understand" (Schunk, 2004, p. 13821);
- teachers with mathematics anxiety may have a lower range of teaching strategies, with links demonstrated between the "efficaciousness of the teacher to classroom instructional strategies, willingness to embrace educational reform, commitment to teaching, and student achievement" (Swars, et al., 2007, p. 307);
- mathematics anxiety may contribute to pre-service teacher concerns, especially "apprehension they experienced when faced with the prospect of teaching the subject during their initial practicum" (Brady & Bowd, 2005, p. 43);
- mathematics anxiety can "affect both the teaching and learning of mathematics" (Tooke & Lindstrom, 1998, p. 138);
- mathematics anxiety can affect teacher self-efficacy, with "several of those with high levels of mathematics anxiety expressed some efficaciousness … they continued to doubt their ability to teach effectively due to their mathematics anxiety" (Gresham, 2008, p. 181);
- teacher mathematics anxiety may affect the results of their students, as "female teachers' math anxiety has consequences for the math achievement of girls in early elementary school grades" (Beilock et al., 2009, p. 1862).

Measuring Mathematics Anxiety

Before mathematics anxiety can be understood, it is beneficial for it to be measured. Bursal and Paznokas (2006) stated "mathematics anxiety has been described as a multidimensional construct with cognitive as well as affective roots" (p. 173). Kazelskis (1998) stated that "six distinct but correlated dimensions of mathematics anxiety were identified within the mathematics anxiety instruments examined: Mathematics Test Anxiety, Numerical Anxiety, Mathematics Course Anxiety, Worry, Positive Affect Towards Mathematics, and Negative Affect Towards Mathematics" (p. 630). Brady and Bowd (2005) stated mathematics anxiety is manifest in certain situations and can be evidenced by a variety of symptoms.

When developing a construct model of mathematics anxiety, Cavanagh and Sparrow (2010b) considered mathematics anxiety in terms of three categories of indicators - somatic, cognitive, and attitudinal (see Table 1). Their *Situational model of mathematics anxiety* (Cavanagh & Sparrow, 2010b) acknowledged that mathematics anxiety can arise in any situation in which mathematical skills and knowledge are required" (p. 9). Furthermore, the model specified that anxiety experienced in different situations "are likely manifestations of the same construct" (p. 9). Cavanagh and Sparrow (2010b) stated that the mathematics anxiety measured would be "definable by the same indicators" (p. 9), with both high and low anxiety "characterised by a combination of attitudinal, cognitive and somatic indicators" (p. 9). They highlighted the commonality of these indicators, specifically they noted, "the indicators of anxiety are common to all situations and the relative 'severity' of the indicators is also assumed to not vary across situations. That is, one construct applies in all situations" (Cavanagh & Sparrow, 2010b, p. 9).

Table 1.
Model of mathematics anxiety from Cavanagh and Sparrow (2010b)

Dominant trait model of mathematics anxiety				
Level of anxiety	**Indicators**	**Attitudinal**	**Cognitive**	**Somatic**
High anxiety		Scared about what s/he has to do	Worried about others thinking s/he is stupid	Having difficulty breathing
Moderate anxiety		Not wanting to be doing what has to be done	Mind going blank	Heart beats more quickly
Low anxiety		Expecting to have difficulty doing what is required	Being confused	Feeling uncomfortable

Applicable to:	In-class instruction: independent work, group work, or whole class In-class assessment: formal exam or tests, informal quizzes Out-of-class applications: other subjects, at home, at work or socially

The instrument used by Cavanagh and Sparrow (2010b) was selected for use in this research as it had been demonstrated to measure mathematics anxiety in a variety of situations. Though the

participants in Cavanagh and Sparrow's (2010b) research were boys in grades 5 to 7 in primary school and there were only two situations – working as part of a whole class group and working in a test situation - the situations were similar to two of the three utilised in this research. The additional situation in this research involved the situation of the participant teaching mathematics.

Research Objectives

The aim of this research was to investigate mathematics anxiety of pre-service teachers. To address the research objectives, the following research questions were developed:

1. Can the mathematics anxiety of pre-service teachers be measured?
2. Is mathematics anxiety manifest in different ways in different situations?
3. What are the most difficult to affirm and easiest to affirm aspects of mathematics anxiety?

Methodology

Research approach

The project was designed to fit within a Post-positive/Scientific paradigm using a measurement methodology to understand further the manifestation of mathematics anxiety.

Participants

The participants were 169 first year pre-service teachers, mainly female, enrolled in first year education units as part of the Bachelor of Education (Primary) program (116 pre-service teachers) or the Bachelor of Education (Early Childhood) program (53 pre-service teachers) at a large university in Western Australia.

Data collection

The Cavanagh and Sparrow (2010b) measurement instrument (questionnaire) was modified to incorporate an additional category of *mathematical knowledge or understanding* (see Table 2). The additional category comprised four items to elicit data on knowledge and understanding of mathematics. Three forms of the instrument were administered. Each had the questions in the same order and participants were asked to consider their responses for the three situational variables in terms of the description provided at the heading of each page. Pre-service teachers selected from four response categories, strongly agree, agree, disagree, and strongly disagree and these were scored from 1 to 4 respectively. Data were entered into RUMM2030 and the scores were reversed and a score of 9 entered for missing data.

Table 2.
Instrument items – domain by item

Domain	Label	Item	Question Number
Somatic	S1	I feel uncomfortable	16
	S2	I shake or tremble	19
	S4	I have difficulty breathing	18
	S5	My heart beats more quickly	20
	S6	My mouth becomes dry	22
Cognitive	C1	I am worried about others thinking I am stupid	10
	C2	I feel threatened	15
	C3	I am aware of previous failures	1
	C4	I can't think clearly	11
	C5	I forget things I normally know	17
	C6	I become easily frustrated	3
	C7	I do not feel I am in control of what I need to do	8
	C8	I am confused at the start or quickly become confused	2
	C9	My mind goes blank	21
Attitude	A3	I don't want to be doing this	13
	A4	I expect to have difficulty doing what is required	14
	A5	I am not confident I can do what is required	4
	A6	I am scared about what I have to do	9
Mathematical knowledge/ understanding	M1	I am not confident to ask questions or contribute	5
	M2	I feel I'll lack the knowledge to do what is required	6
	M3	I am scared I will make a mistake	7
	M4	I don't think I know enough about maths	12

Data Analysis

Rasch Rating Scale model analysis of the data (Andrich, 1978a, 1978b &1978c) was conducted. The Rasch model was chosen as anxiety scores can be considered to "conform to some reasonable hierarchy of 'less than/more than'" (Bond & Fox, 2001, p. xix). It also enabled the identification of items that were harder to affirm and would provide an indication of whether pre-service teachers with greater anxiety were more likely to affirm the more difficult items (Bond & Fox, 2001, p. xx). The computer program RUMM2030 was used to conduct this analysis. The average calibrated score for each situation was calculated for each student to determine which of the three situations pre-service teachers scored the highest anxiety. The number of pre-service teachers reporting highest average anxiety for each of the situations was determined and a total count provided for each situation, that is, a Classroom learning situation, an Assessment/Test situation, and a Teaching situation.

Results and Discussion

1. Can the mathematics anxiety of pre-service teachers be measured?

The pre-service teacher use of response categories was examined by estimating the thresholds between adjacent response categories. A threshold is the pre-service teacher anxiety score where there is an equal probability of selecting either of the adjacent response categories. RUMM 2030 produces category probability curves that plot the probability of pre-service teachers selecting a particular response category against their anxiety scores. The intersections of the adjacent curves for Item 3 CC6 – *becoming easily frustrated* in a Classroom situation – presented in Figure 1 show ordered thresholds indicating a logical use of the response categories. That is, pre-service teachers with higher anxiety scores selected more affirmative response categories.

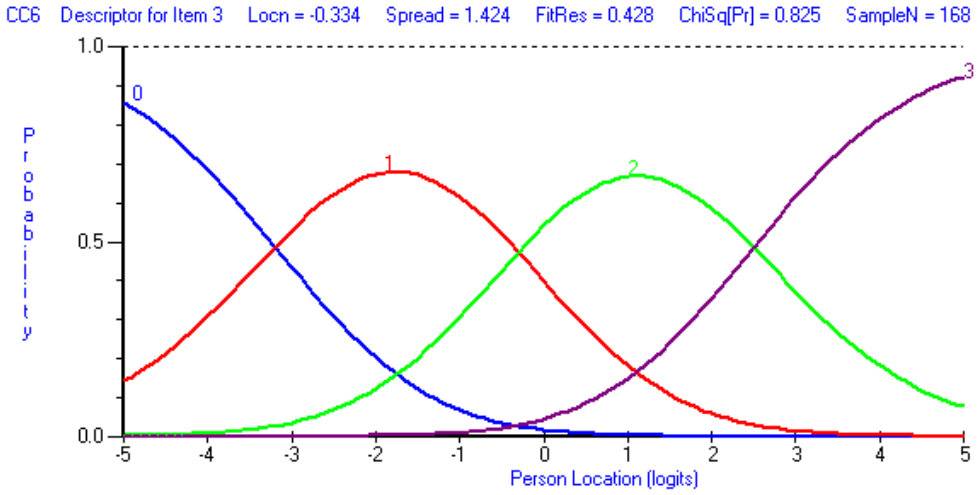

Figure 1. Category probability curves for Item 3 CC6

However, the intersections of the adjacent curves for Item 57 TA3 – *not wanting to be doing this* in a Teaching situation – presented in Figure 2 demonstrate disordered thresholds, indicating pre-service teachers did not use the response categories in a logical manner. Item 18 CS4 – *difficulty breathing* in a Classroom situation – also produced data with disordered thresholds. Though these two items obtained data with disordered thresholds, they were retained for subsequent analyses.

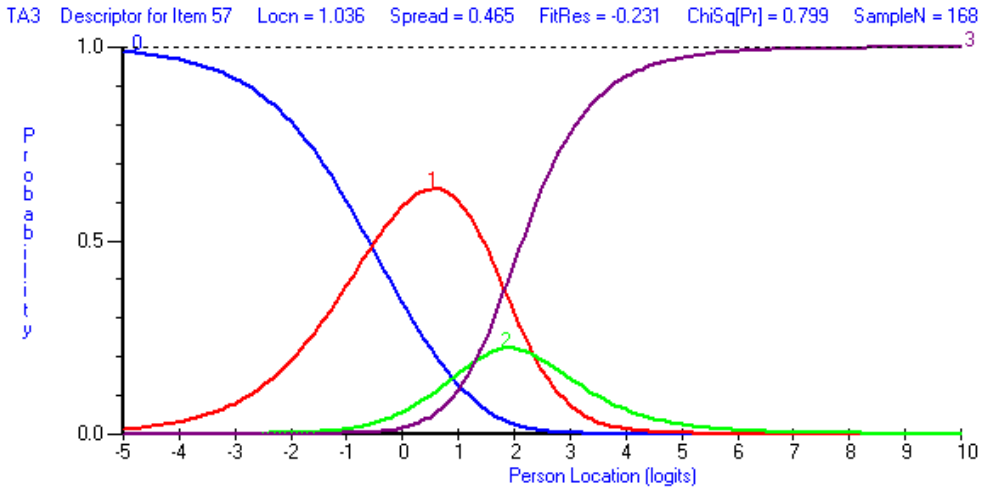

Figure 2. Category probability curves for Item 57 TA3

Table 3 shows the summary test of fit statistics produced by RUMM2030. The item-person interaction measures the degree to which pre-service teachers responded in a logical and consistent manner. The fit residuals for items are within acceptable ranges (that is, mean of close to 0 and standard deviation close to 1). The item-trait interaction indicates the consistency of the item 'difficulties' across the range of different items on the scale. The Chi Square probability value is less than 0.05, indicating the data to model fit could be better and suggesting the scale is measuring a trait that may not be uni-dimensional. The Separation Index indicates the degree to which locations of persons are spread across a continuum, that is, pre-service teachers with higher locations attracted higher scores on the items and those with lower locations attracted lower scores on the items. This index should be close to 1. The separation index of 0.97 in this case indicates high reliability.

Table 3
RUMM summary test-of-fit statistics

Item-Person Interaction - Includes Extreme Persons				
	Items		Persons	
	Location	Fit Residual	Location	Fit Residual
Mean	0.00	0.10	-1.49	-0.51
SD	1.36	1.04	1.35	2.26
Item-Trait Interaction				
Total Item Chi Square		207.87		
Total Degree of Freedom		132.00		
Total Chi Square Prob		0.000029		
Reliability Indices				
Person Separation Index Mathanx				
With Extm:	0.97			
No Extm:	0.97			
Cronbach Alpha [Cronbach alpha not applicable with missing data] Mathanx				
With Extm:	n/a			
No Extm:	n/a			
Power of Analysis of Fit is Excellent				

[Based on Separation Index of: 0.97]

Plotting pre-service teacher locations against item difficulty locations (see Figure 3) showed pre-service teachers were slightly reluctant to affirm the anxiety indicator. The nine hardest to affirm items consisted of the same two instrument items from the Somatic domain in all three situations - *I have difficulty breathing* (CS4, 4.23 logits; TS4,2.66 logits; and AS4, 2.78 logits), *My mouth becomes dry* (CS6, 3.05 logits; AS6, 2.96 logits; and TS62.55 logits). Two more of the hardest to affirm items were the same instrument items from the Somatic domain for the Classroom situation and Teaching situation (CS2, 2.81 logits; and TS2, 2.69 logits). The final item of the nine was from the Cognitive domain - *I feel threatened* in a Teaching situation (TC2, 2.59 logits). The ten easiest to affirm items were all from the Cognitive and Mathematical knowledge/understanding domains, with seven for the Assessment/Test situation, two from the Teaching situation, and one from the Classroom situation. As with the hardest to affirm items, there were similarities in the instrument items over the different situation – *I am aware of previous failures* from the Cognitive domain for all three situations (AC3, -2.04 logits; CC3, -1.96 logits; and TC3, -1.27 logits) and *I am scared I will make a mistake* from the Mathematical knowledge/understanding domain for the Assessment/Test situation and the Teaching situation (AM3, -1.89 logits; and TM3, -1.60 logits). All other items were for the Assessment/Test situation, with three items from the Cognitive domain (*I forget things I normally know*, AC5, -1.23 logits; *I become easily frustrated*, AC6, -1.17 logits; and *I am confused at the start or quickly become confused*, AC8, -1.04 logits) and two from the Mathematical knowledge/understanding domain (*I don't think I know enough about maths*, AM4, -1.24 logits; and *I feel I'll lack the knowledge to do what is required*, AM2, -1.18 logits).

Location	Persons	Items (locations)
5.0		
		CS4
4.0		
3.0		CS6
		CS2 AS6
		TS4 TS2 AS4
	X	TS6 TC2
2.0		
1.0		TA3
	X	AC2 AS2 CC2
	X	
	X	CS5 CS1 TS1
	XXX	AS1 AS5 TC9 CC7 TS5 CC4
0.0	XX	TC7 CC9
	XXXX	AC1 AM1 TM1
	XXXX	AC7 TC6 CC6 CM1 TC1 CA6 CA3
	XXXXX	TC4 TC5 AC9 TA6 TA4 CC1
	XXXXXX	AC4 AA6 CA5 CC8 CM2 CC5
-1.0	XXXXXXXXXXX	CM4 AA4 CM3 TM4 TA5 AA3 TM2 TC8 AA5 CA4
	XXXXXXXX	AM2 AC6 AC8
	XXXXX	TC3 AM4 AC5
	XXX	TM3
	XXXX	
-2.0	XXXXXX	CC3 AM3
	XXXX	AC3
	XXX	
	XX	
	XXX	
-3.0	XXX	
	XX	
	X	
	X	
-4.0		
	XX	
	X	
	X	
-5.0	X	
	X	
-6.0		
-7.0		
-8.0	X	

X = 2 Persons

Figure 3. Item map

2. Is mathematics anxiety manifest in different ways in different situations?

The majority of pre-service teachers reported the highest average anxiety for the Assessment/Test situation (88 pre-service teachers), followed by the Teaching situation (36 pre-service teachers), then followed by the Classroom mathematics learning situation (29 pre-service teachers), though note that this does not include pre-service teachers who had the same average for two or more situations. These results may be influenced by the how prominent each of the situations is in the pre-service teachers' minds and the emphasis that they have placed on them. For example, pre-service teachers had recently been advised that they would need to sit a basic mathematics competency test as part of their course and this could have been at the forefront of their minds when they completed their questionnaires. It will be interesting to see if the results change as subsequent administrations of the instruments get closer to the pre-service teachers' first practical school teaching placement for their current course. Particularly as Brady and Bowd's (2005, p. 43) findings indicated "the existence of a relationship between respondents' levels of mathematics anxiety and the apprehension they experienced when faced with the prospect of teaching the subject during their initial practicum".

3. What are the most difficult to affirm and easiest to affirm aspects of mathematics anxiety?

As can be seen in Table 4, the easiest to affirm item was *awareness of previous failures* in a Test/Assessment situation (logit of -2.04). This was followed by *awareness of failures* in a Classroom learning situation (logit of -1.96), then *being scared of making a mistake* in a Test/Assessment situation (logit of -1.89) and *scared of making a mistake* in a Teaching situation (logit of -1.60).

Table 4.
Items and item difficulty location (logit) for the three situations

Classroom Situation			Assessment/Test Situation			Teaching Situation		
Question Number	Item Identifier	Logit	Question Number	Item Identifier	Logit	Question Number	Item Identifier	Logit
1	CC3	-1.96	23	AC3	-2.04	51	TM3	-1.60
12	CM4	-1.00	29	AM3	-1.89	45	TC3	-1.27
7	CM3	-0.96	34	AM4	-1.24	56	TM4	-0.95
14	CA4	-0.83	39	AC5	-1.23	48	TA5	-0.92
4	CA5	-0.72	28	AM2	-1.18	50	TM2	-0.91
2	CC8	-0.72	25	AC6	-1.17	46	TC8	-0.90
6	CM2	-0.69	24	AC8	-1.04	55	TC4	-0.57

17	CC5	-0.67	36	AA4	-0.99	61	TC5	-0.51
10	CC1	-0.45	35	AA3	-0.91	53	TA6	-0.49
3	CC6	-0.33	26	AA5	-0.83	58	TA4	-0.49
5	CM1	-0.29	33	AC4	-0.74	47	TC6	-0.37
9	CA6	-0.21	31	AA6	-0.72	54	TC1	-0.23
13	CA3	-0.21	43	AC9	-0.50	49	TM1	-0.02
21	CC9	0.03	30	AC7	-0.40	52	TC7	0.00
8	CC7	0.30	32	AC1	-0.20	65	TC9	0.29
11	CC4	0.39	27	AM1	-0.12	64	TS5	0.31
20	CS5	0.46	38	AS1	0.23	60	TS1	0.55
16	CS1	0.50	42	AS5	0.24	57	TA3	1.04
15	CC2	1.00	37	AC2	0.84	66	TS6	2.55
19	CS2	2.81	41	AS2	0.97	59	TC2	2.59
22	CS6	3.05	40	AS4	2.78	62	TS4	2.66
18	CS4	4.23	44	AS6	2.96	63	TS2	2.69
Average		**1.17**	**Average**		**-0.33**	**Average**		**0.16**

The three easiest to affirm items were the same for all situations – *awareness of previous failures* (Cognitive item C3), *scared of making a mistake* (Mathematical knowledge/understanding item M3), and *not knowing enough about maths* (Mathematical knowledge/understanding item M4). Likewise, the four most difficult to affirm items were the same for all situations – *feeling threatened* (Cognitive item C2), *shaking or trembling* (Somatic item S2), *difficulty breathing* (Somatic item S4), and *mouth becoming dry* (Somatic item S6). The final two Somatic items – *feeling uncomfortable* (item S1) and *heart beating more quickly* (item S5) – were within the seven most difficult to affirm items for all situations.

Implications

The modified Cavanagh and Sparrow (2010b) instrument was found to measure pre-service teachers self-reported mathematics anxiety in the three situations – learning mathematics, completing mathematical tests, and teaching mathematics – with the majority of pre-service teachers reporting the highest anxiety for the Assessment/Test situation, followed by the Teaching situation, then the Classroom learning situation.

Research using the instrument will assist in determining the relationship between pre-service teacher mathematics anxiety at university and their anxiety teaching mathematics whilst on their teaching practicums. Gresham's (2008, p. 181) finding "that mathematics anxiety does have a negative relationship with a pre-service teacher's belief in his or her own skills and abilities to be an effective teacher" (p. 181) stressed the importance of pre-service teachers being aware of anxiety towards learning areas. It is, as Malinsky et al. (2006) stated, part of the teacher educators' role to support the pre-service teachers and ensure their pre-service teachers have every opportunity to be aware of and, where possible, address any anxiety they have. Additionally, as Enochs, Smith,

and Huinker (2000) stated, "content knowledge and teacher beliefs are both important in teacher preparation and should be addressed" (p. 197). Huntley (2005) used a process involving teachers "placing themselves on a continuum for various aspects of teaching" (p. 22) to enable those teachers to "reflect on possible implications for their teaching style" (p. 20). Providing pre-service teachers with the opportunity to investigate and reflect on their anxiety regarding mathematics will enable them to reflect also on the potential impact of this on their teaching of mathematics. Furthermore, the process of using an effective measure of anxiety to provide pre-service teachers with information for reflecting has the capacity to be used with other areas of the curriculum where anxiety can occur.

Conclusion

Malinsky et al. (2006) discussed the importance of incorporating research into pre-service teacher education. The research discussed in this paper, and the anticipated use of the instrument, are examples of research that can help shape the approach to pre-service teacher education programs to mathematics anxiety, mathaphobia, and other curriculum areas of pre-service teacher concern. Furthermore, the potential of anxiety to impact on teaching (Gresham, 2008; Malinsky et al., 2006) and the primary aged students of those teachers (Beilock et al., 2009) makes it imperative that strategies are incorporated into programs to increase pre-service teacher awareness of any anxiety they may have towards areas they will teach, raise their awareness of the potential of that anxiety to impact on their teaching and the learning of their primary school students, and to provide avenues to help reduce their anxiety.

References

Andrich, D. (1978a). Application of a psychometric rating model to ordered categories which are scored with successive integers. *Applied Psychological Measurement, 2*(4), 581-594. DOI:10.1177/014662167800200413

Andrich, D. (1978b). Rating formulation for ordered response categories. *Psychometrika, 43*(4), 561-573. DOI:10.1007/BF02293814

Andrich, D. (1978c). Scaling attitude items constructed and scores in the Likert tradition. *Educational and Psychological Measurement, 38*(3), 665-680. DOI:10.4477/001316447803800308

Australian Institute for Teaching and School Leadership [AITSL] (2011). *Accreditation of initial teacher education programs in Australia: Standards and procedures*. Melbourne: Ministerial Council for Education, Early Childhood Development and Youth Affairs (MCEECDYA). Retrieved from http://www.aitsl.edu.au/initial-teacher-education-program-accreditation.html

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2009). *Female teachers' math anxiety affects girls' math achievement.* Proceedings of the National Academy of Sciences of the United States of America [PNAS], 107(5), 1860-1863. http://www.pnas.org/cgi/content/full/0910967107/DCSupplemental

Bond, T. G. & Fox, C. M. (2001). *Applying the Rasch Model: Fundamental measurement in the human sciences*. Mahwah, NJ: Lawrence Erlbaum Associates.

Brady, P. & Bowd, A. (2005). Mathematics anxiety, prior experience and confidence to teach mathematics among pre-service education students. *Teachers and Teaching 11*(1), 37-46. DOI:10.1080/1354060042000337084

Bursal, M. & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*(4), 173-180. Retrieved from http://onlinelibrary.wiley.com

Cavanagh, R. & Sparrow, L. (2010a). Measuring mathematics anxiety: Paper 1 – developing a construct model. *Paper presented at the 2010 AARE International Research in Education Conference, Melbourne, Australia, 28 November-2 December, 2010*.

Cavanagh, R. & Sparrow, L. (2010b). Measuring mathematics anxiety: Paper 2 – Constructing and validating the measure. *Paper presented at the 2010 AARE International Research in Education Conference, Melbourne, Australia, 28 November-2 December, 2010*.

Cavanagh, R. & Sparrow, L. (2011). Mathematics anxiety: Scaffolding a new construct model. *Mathematics: Traditions and [New] Practices*. In Proceedings of the Annual Conference of Mathematics Education Research Group of Australasia, Alice Springs.

Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (3rd ed.). Upper Saddle River, NJ: Pearson Education, Inc.

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics 100*(4), 194-202. Retrieved from http://proquest.umi.com

Gresham, G. (2008). Mathematics anxiety and mathematics teacher efficacy in elementary pre-service teachers. *Teaching Education, 19*(3), 171-184. DOI:10.1080/10476210802250133

Grundy, D. (1985). Writing-anxiety. *The arts in psychotherapy, 12*(3), 151-156. DOI:10.1016/0197-4556(85)90014-0

Huntley, R. (2005). Development of a reflective teaching approach in the primary school. *Education 3-13, 33*(1), 20-25. DOI:10.1080/03004270585200051

Isiksal, M., Curran, J. M., Koc, Y, & Askun, C. S. (2009). Mathematics anxiety and mathematical self-concept: Considerations in preparing elementary-school teachers. *Social Behavior and Personality, 37*(5), 631-644. DOI:10.2224/sbp.209.37.5.631

Kazelskis, R. (1998). Some dimensions of mathematics anxiety: A factor analysis across instruments. *Educational and Psychological Measurement, 58*(4), 623-633. DOI:10.1177/0013164498058004006

Ma, X. & Xu, J. (2004). Determining the causal ordering between attitude towards mathematics and achievement in mathematics. *American Journal of Education, 110(3), 256-280*. DOI:10.1016/j.adolescence.2003.11.003

Malinsky, M., Ross, A., Pannells, T., & McJunkin, M. (2006). Math anxiety in pre-service elementary school teachers. *Education 127*(2), 274-279. Retrieved from http://proquest.umi.com

Rayner, V., Pitsolantis, N., & Osana, H. (2009). Mathematics anxiety in preservice teachers: Its relationship to their conceptual and procedural knowledge of fractions. *Mathematics Education Research Journal, 21*(3), 60-85. Retrieved from http://search.informit.com.au

Schunk, D. H. (2004). Self-efficacy: Educational aspects. *International Encyclopedia of the Social & Behavioral Sciences*, *2004*, 13820-13822. Retrieved from http://www.sciencedirect.com

Swars, S. L. (2005). Examining perceptions of mathematics teaching effectiveness among elementary preservice teachers with differing levels of mathematics teacher efficacy. *Journal of Instructional Psychology, 32*(2), 139-147. Retrieved from http://proquest.umi.com

Swars, S. L., Daane, C. J., & Giesen, J. (2007) Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? *School Science and Mathematics, 106*(7), 306-315. Retrieved from http://onlinelibrary.wiley.com

Tooke, D. J. & Lindstrom, L. C. (1998). Effectiveness of a mathematics methods course in reducing math anxiety of preservice elementary teachers. *School Science and Mathematics, 98*(3), 136-1139. Retrieved from http://proquest.umi.com

Yali, D. (2009). Reflective practices of preservice teachers in a listening skills course in an ELT department. *Procedia Social and Behavioral Sciences 1*, 1820-1824. DOI:10.1016/j.sbspro.2009.01.322