Preparing for the Numeracy Skills Test: Developing a Self-Perception for Success

Leni Brown
University of South Australia
Leni.Brown@unisa.edu.au

Lisa O'Keeffe
University of South Australia
Lisa O'Keeffe@unisa.edu.au

Numeracy Skills testing was brought to the forefront following the Action Now: Classroom Ready Teachers report in 2015. The announcement was met with much concern by many pre-service teachers (PSTs). Given the body of research associated with mathematics anxiety and assessment, which suggests that students' self-efficacy and confidence in their mathematical abilities can be counterproductive, this paper explores the impact of positive reinforcement and affirmation on the knowledge and mathematical ability of a cohort of PSTs facing the *Numeracy Test for Initial Teacher Education Students*.

A Federal Government review panel has decided that from 2017 graduating student teachers will need to pass a national literacy and numeracy test (Australian Government, Dept. of Education and Training, 2015). As a result of this report*,* the Australian Council of Education Research (ACER) has been tasked with creating and implementing these national tests. In mid-2015, a sample of ten literacy and ten numeracy questions were released by ACER and free access was offered for the 2015 trial assessments. It was initially anticipated that students enrolled in Bachelor of Education Programs from 2016 and beyond, would be required to pass the numeracy and literacy tests to successfully attain their teaching qualification. While this benchmark was recently moved to come into effect from 2017 onwards it has still caused angst amongst some of the present cohort of education students who feel 'pressured' to complete these tests. This paper presents a case study of a sample of students from a cohort of PSTs; it tracks their self-perception (self-efficacy) of their own mathematical abilities throughout a two month period of preparation for the aforementioned numeracy skills test.

Background

The term self-efficacy stems from Bandura's social learning theory (Bandura, 1977) and refers to an individual's belief and confidence to complete specified tasks (Lui & Koirala 2009). According to Bandura, one's self-efficacy affects choices of both activity and behaviour, including how much effort and persistence one applies (Bandura, 1977). This is reinforced by Pajares (1996, p. 326) who states that those "with a high sense of efficacy are more likely to show greater interest in, and attention to, working the problems, increased effort, greater perseverance in the face of adversity, and a heightened sense of optimism that they can ultimately succeed". This is further supported by Hoffmann (2010) who found that pre-service teacher's efficiency in problem solving is related to high self-efficacy, suggesting that improving pre-service teacher's self-efficacy will enhance their own abilities to solve problems. Further to this, Pajares and Miller (1994) identified that self-efficacy beliefs about problem solving are a strong predictive indicator of performance, stronger than variables such as gender, maths background or math anxiety for example.

Bandura identifies that self-efficacy is derived from four key principles. The first of these, mastery experience, refers to one's own previous attainment. This is cited by Bandura (1977) as being most influential in forming one's self-efficacy. The second principle is the vicarious experience of observing others that is how one rates oneself in comparison to

2016. In White, B., Chinnappan, M. & Trenholm, S. (Eds.). Opening up mathematics education research (Proceedings of the 39th annual conference of the Mathematics Education Research Group of Australasia), pp. 158–165. Adelaide: MERGA.

peer's performances. For example, watching a peer succeed at a task may convince them that they can be successful (Usher & Pajares, 2009). The third principle, social persuasions, is often referred to as verbal persuasions as it refers to the encouragement and feedback received from others, supportive feedback can boost confidence hence lead to success. Bandura (1977) makes note of the fact that it is easier for social persuasions to decrease rather than increase one's self-efficacy, particularly in younger students. The final principle, which impacts on self-efficacy, is emotional and physiological states including anxiety, stress and fatigue (Usher & Pajares, 2009).

Self-efficacy beliefs can also influence the stress and anxiety levels that a person experiences when undertaking an activity or task (Pajares & Schunk, 2001). Confidence and self-efficacy in a particular performance situation can be based on personal familiarity with the type of task and previous experience. Prior success in a familiar circumstance will lead to a higher level of self-efficacy and an increased confidence to attempt and complete the undertaking (Pajares & Schunk, 2001). However, being confronted with a situation where there is uncertainty of the skills required to successfully complete the task, can lead to a much lower level of self-efficacy as there is no bench mark to base personal confidence on (Pajares & Schunk, 2001). As a consequence, a person's self-efficacy beliefs can have a significant influence on the degree of success and achievement that they ultimately accomplish (Pajares & Schunk, 2001). Kvedere (2014) discusses how a negative form of self-efficacy and self-concept can be highly related to anxiety. Also, Uusimaki and Nason (2004) indicate that negative self-beliefs about mathematics can also become evident in the phenomenon known as maths-anxiety. Hembree (cited in Uusimaki & Nason, 2004) asserts that maths-anxiety manifests itself as intense frustration or powerlessness about one's capacity to do mathematics, and can be depicted as a learned emotional response. Elevated anxiety levels are most prevalent in situations where a person needs to communicate their mathematical knowledge, such as in a test situation or working through mathematical problems. This is consistent with Tooke and Lindstrom's (1998) view; they suggest that maths-anxiety surfaces most dramatically when the subject is seen to be under evaluation, as would be the case with this numeracy skills testing.

Brady and Bowd (2005) suggest that to some extent, mathematics anxiety can be the result of how mathematics is taught in school, from as early as elementary level. This view is supported by Rayner, Pitsolantis and Osana, (2009), who found that different methods of mathematics instruction impacted on PST's perceived mathematics anxiety and by Vinson (2001), who noted a significant reduction in the anxiety levels of a group of pre-service teachers when they used manipulate materials in a mathematics methods course to enhance their conceptual understanding. According to Rayner et al. (2009) instruction that does not support students' conceptual understanding of mathematics, can reduce their confidence in their mathematical ability and then lead to anxiety in situations where this knowledge is being assessed. Although there appears to be no studies that have directly researched the relationship between mathematics anxiety and conceptual understanding in PSTs (Rayner et al., 2009), it would be logical to predict that levels of mathematics anxiety should decrease as the conceptual understanding of mathematical topics increases. Hence, this paper explores how increasing one's confidence in their conceptual understanding of mathematics may impact on their perceived levels of mathematics anxiety.

Methodology

This pilot study was conducted with a sample of self-selected third year PST's who wished to avail themselves of additional support in mathematics. The aim of the study was to identify the impact, on self-efficacy and confidence, of an intervention focused on building the PSTs confidence in their mathematical abilities. This study was guided by the following research questions:

- What are the initial self-efficacy and confidence levels of this self-nominated cohort of students?
- How highly do these students value procedure over conceptual understanding and is there any correlation to their self-efficacy?
- Can an intervention focused on building confidence rather than teaching mathematical skills/concepts impact on an individual's self-efficacy in regard to their mathematical ability?

The Sample

Following the announcement of the numeracy skills testing in the summer of 2015, the researchers emailed their cohort of third year PSTs seeking to identify those who intended to apply to sit the initial trial tests in August/September 2015 and wished to avail of some additional support. Of the cohort of approximately 100 students, 14 (two males and twelve females) replied indicating that they intended to apply and would be interested in participating. All of these students were in their third year of their undergraduate Bachelor of Education (Primary and Middle) degree. Of the 14 students who originally indicated interest, a consistent group of five students (all female) participated throughout the 8 week study. Three of the five participants had completed some mathematics to Year 12, one had taken mathematics to year 11 and one to year 10. Not surprisingly, the participant with year 10 mathematics presented with the lowest pre-test score for procedural mathematics (as presented in Table 2). Three of the participants have opted to take additional mathematics courses at University level, but the participant with the highest pre-test mathematical knowledge and highest self-efficacy, is not one of these.

The Fortnightly Sessions; Structure and Data Collection

We met the group initially in June 2015 to discuss their needs and expectations and then from July we met the group for two hours every fortnight until their numeracy skills test (end August). We also met one final time, the week after the numeracy skills test, to debrief. The focus of each fortnightly session was collectively decided by the group but typically centred on fractions, percentages and statistics. Each session was kept as informal as possible to ensure the participants felt comfortable in the environment - to encourage them to be open and honest about the tasks at hand. Both researchers were present at all sessions but the sessions did not include any formal teaching. The fortnightly sessions were focused strongly on principle two and three of Bandura's (1977) four principles; working together as a supportive group of peers and building on each other's experiences of success and positive reinforcement and affirmation to boost their confidence.

In order to establish the levels of confidence and the perceptions of mathematics among the PSTs, they were asked to complete a survey instrument which combined the *Perceptions of Mathematics* survey (POM) (Kajander, 2005) and an extract from *The Mathematics Self-efficacy Scale* (Betz & Hackett, 1993). This combined test instrument was utilised in Pre- and Post- capacity, with the group completing the pre-test in the first session in June 2015, and the post-test in late August. Mid-way through the intervention the participants were also asked to reflect on and answer four questions relating to how they felt (from a confidence perspective) in regard to the numeracy skills test and their preparations for it. The participants were given the option to orally answer these or to return them later in the week in written form – all participants chose to return them later in hardcopy.

Data Collection Instrument

According to Kajander (2010) the POM survey is designed to identify mathematical knowledge (both procedural and conceptual) while also identifying value perceptions. The POM survey consists of "separate sets of (open-response) knowledge items that separated the provision of procedures leading to correct answers (procedural knowledge or PK) from the ability to provide alternative solutions, explanations, justifications, or models (conceptual knowledge or CK)" (Kajander, 2010, p. 236). The POM survey also seeks to identify participant beliefs about the importance of procedural and conceptual learning in mathematics by means of the mathematical values statements. Alongside this we also included Part 1 of the Mathematics Self-efficacy Scale, which according to Betz and Hackett (1993) is intended to measure beliefs regarding one's ability to perform various mathematics related activities. Part 1: Comprises questions relating to the solving of mathematics problems and mathematics behaviours used in everyday life such as balancing accounts. According to Betz and Hackett (1993) the problems presented are similar to those found in standardized tests of mathematical aptitude and achievement (i.e. Dowling's Mathematics Confidence Scale) and the everyday life activities are similar to those included in the Math Anxiety Rating Scale (MARS; Richardson & Suinn, 1972).

The Role of the Researchers in the Sessions

Our role throughout the fortnightly sessions was two-fold; to prepare and provide material that would be appropriate to tease out their understanding of the chosen concepts and to provide guided feedback to further support this. In conjunction with this, the researcher's deliberate focus was to show each individual how much they knew – trying to build their self-perception and to encourage the group to knowledge-share and support. Hence, the purpose of this pilot study was to build participants' self-perception of their mathematical knowledge and abilities as a means of supporting their preparation for the numeracy skills test.

Findings and Discussion

Belief in regard to mathematical value

According to Table 1, all participants appear to have relatively strong belief in the importance of both aspects of mathematics. Four of the five of the participants indicate a decline in regard to procedural value of mathematics between testing, with no participants demonstrating a decline in regard to conceptual value. The overall mean scores for the group are 7.5 (pre) to 7.4 (post) for the PV and 8.5 (pre) to 8.7 (post) for the CV. These figures indicate small 'positive' changes, rather than statistically significant changes. This is of relevance as the nature of the numeracy skills testing is to assess competence in applying mathematical procedures. Yet, as the participants worked through their preparation their view on the importance of procedural values of mathematics appears to decrease.

Table 1: Procedural and Conceptual value of Mathematics

	Procedural Value (PV)			**Conceptual Value (CV)**		
	PRE	POST	*Difference*	PRE	POST	*Difference*
Gwyn	7.3	6.6	-0.7	7.6	8.0	+0.4
Tal	8	7.7	-0.3	8.0	9.3	+1.3
Jane	8.7	6.3	-2.4	9.0	9.0	0
Hazel	8	7.3	-0.7	9.3	9.3	0
Eve	5.7	7.7	+2	7.7	8.0	+0.3

Procedural and conceptual knowledge

Table 2 presents the raw scores for the mathematics context questions as part of the POM survey. The survey included a total of seven questions, of which five questions or part questions (questions 1a, 2a, 3a, 4 and 5) are all defined by Kanjander (2005) as procedural questions. A total mark of 2 is given for the correct answer and one mark for partially correct responses. Hence, the maximum score attainable in this section is 10. The above data again indicates a positive change for all participants, with the scores for procedural knowledge increases ranging from +2 to +4. The remaining five question or part questions (1b, 2b, 3b, 6 and 7) were also marked out of two. Kajnader's (2005) scoring model indicates that one be awarded for the beginnings of what might be a correct response for questions 1 – 3 and two marks for a full explanation. For question 6, she suggests that one mark be given for the first two responses and two marks be awarded if there are three correct answers as required. Finally, for question 7, one mark is suggested for an incomplete but correct response and two marks for the full correct response.

Table 2: Procedural and Conceptual Knowledge

	Procedural Knowledge (PK)			**Conceptual Knowledge (CK)**		
	PRE	*POST*	*Difference*	*PRE*	*POST*	*Difference*
Gwyn	6.6	10.0	+3.4	1.0	2.0	+1
Tal	6.0	8.0	+2	0	1.0	+1
Jane	2.0	6.0	+4	0	1.0	+1
Hazel	4.0	7.0	+3	0	1.0	+1
Eve	4	6.0	+2	0	3.5	+3.5

As evident in table 2 the scores for conceptual knowledge increase from +1 to +3.5. The most significance change evident in the conceptual knowledge was that the participants were willing to offer a possible response in the post test rather than just leave it blank as they did in the pre-test (which they indicated as for fear of getting it wrong). However, most responses were outlines of the rule or procedure associated with the question rather than elaborating on the concept as required. The overall mean scores for the group are 4.5 (pre) to 7.4 (post) for the PK and 0.6 (pre) to 1.1 (post) for the CK. What is of note is that all participants demonstrated positive increases which could be linked to Usher and Pajares (2009) view on the positive impact of peer group success.

Participant self-efficacy

This data is intended to measure one's beliefs regarding one's ability to perform various mathematics related activities. Participants responded, hypothetically, to how they would feel if tasked with completing a series of everyday mathematics tasks. They indicate their responses on a scale from 0-9, ranging from no confidence (0) to complete confidence (9). As evident in Table 3 above, and as with previous data, there is a positive shift in regard to pre to post scores. The mean score went from was 5.67 in pre-testing 7.34 on post-testing.

Table 3: Mathematics Self-Efficacy

	Gwyn	Tal	Jane	Hazel	Eve
Pre	6.2	5.6	3.1	6.1	7.4
Post	7.3	7.4	6.1	7.9	7.9
Difference	+1.1	+1.8	+3	+1.8	+0.5

These findings are further supported by the data collected from the participant reflections (raw data in Table 4 below). Question one of the reflections asked the participants to indicate (on a scale from 1, not at all confident, to 10, very confident) and identify: *how confident did you feel in your ability to do mathematics (as appropriate for primary middle teacher) before there was any mention of numeracy skills testing?* In response to question one, four of the five participants indicated that they had good (one participant: 6 out of 10) to very good confidence (three participants: 8). The participant who only had mathematics up to year ten scored herself at 2 and indicated that she was confident in everyday mathematics only. The second of these questions asked the participants: *Upon getting confirmation that you would be required to sit a numeracy skills test, how do you feel about your ability to complete this?* Table 4 gives an indication of the change in participant self-perceived confidence in light of the prospect of having to complete the numeracy skills Test (Q1 V Q2). The biggest changes in confidence are demonstrated by Tal and Hazel, who both drop from 8 to 4. Tal explained that completing this under test conditions would be daunting while Hazel said the idea of completing this test makes her 'anxious' and 'worried' and made her start to doubt her ability.

The third of these questions asked the participants: *Now that you are being proactive about preparing for the numeracy skills test, how do you feel about your ability to complete this? (In comparison to when you initially heard)?* All participants recorded a minor increase in their perceived confidence however most were hesitant and noted things such as "*the amount of secrecy and lack of information about the test*" (Hazel), "*feel more prepared but only slightly more confident*" (Tal). The final of these questions (Q4) was administered after the participants had completed the ten sample questions that were made available in mid-August. The participants were asked *Now that you are have attempted the sample questions for the numeracy skills test, how do you feel about your ability to complete the test? (In comparison to when you initially heard)*. The key concerns noted by the participants appear to be related to circumstance rather than personal confidence, they included issues such as whether the actual questions will be significantly harder than the sample questions and having to complete the questions on a computer. Only one participant indicated a personal concern, this was Jane who indicated that while she was still worried she might fail she is keen to give it a go.

Table 4: Self-Perceived Mathematics Confidence

	Gwyn	Tal	Jane	Hazel	Eve
Q1	*8*	*8*	*2*	*8*	*6*
Q2	*7*	*4*	*1*	*4*	*7*
Q3	*9*	*6*	*4/5*	*5*	*9*
Q4	*9*	*6*	*4/5*	*7*	*9*

Further analysis of the raw data in Table 4 indicates that all participants presented a mean increase of 2.1 in their self-recorded confidence from Q2 to Q3. This suggests, unsurprisingly, that once students began to prepare for the numeracy skills test their perceived confidence increased by at least 2 points. Also, the data shows a mean difference of 2.5 between Q2 and Q4, which indicates that their self-confidence increased further once they had attempted the sample questions. This data is of particular importance as according to Pajares and Miller (1994) students are more likely to be successful when they have a higher self-efficacy as students with higher self-efficacies are more likely to apply themselves with increased effort and perseverance (Pajares,1994); both of which combine to suggest a favourable outcome for the participants.

Finally, and of particular importance to the participants, all five individuals passed the numeracy skills test and were very grateful for their involvement in the sessions, indicating that the sessions helped them to build their confidence and feel more prepared . Of the nine individuals, who originally indicated that they intended to sit the numeracy skills test in August/September of 2015 but did not/could not regularly attend the support sessions, three did not apply to sit the test, four passed the test and two sat the test but were not successful.

Summary and Conclusion

Given the sudden introduction of Skills Testing in 2015, which for some PSTs is three years into their degree programmes, and in light of the UK research on Skills Testing (such as Morris, 1993 and McNamara et al., 2002), which raises the issues of mathematics anxiety and stress, it is important to ensure that PSTs are supported throughout this process. Many educators and researchers alike support initiatives that ensure the quality of all PSTs. The issue of PST, as well as in-service teacher, content knowledge is a serious one which researchers such as Ball, Hill and Bass (2005) draw our attention to. However, it is also worth remembering the body of research (for example Pajares (1996), Pajares & Schunk (2001), Uusimaki & Nason (2004) and Hoffmann (2010)) around maths anxiety and self-efficacy, and that for some it is the anxiety and stress that comes from the testing procedure which hinders their path rather than their mathematical content knowledge. This was particularly evident in the final phase of data collection where the participants made direct reference to the ‘secrecy’ surrounding the testing and how nervous they felt about the test in general.

This pilot case-study suggests that building effective support, in this case around principle 2 and 3 of Bandura’s (1997) four principals of self-efficacy, could potentially be productive in terms of ensuring that students who are likely to feel anxiety or pressure in such testing environments build strategies to help themselves succeed. As evident in the pre and post testing of both self-efficacy and confidence, participants demonstrated an increase across both and also an increase in their PK as assessed by the POM survey. The participants also noted that while they felt more confident and prepared, they still had elements of anxiety due to the nature and importance of the test itself which was not tied to their mathematical abilities, as assessed by the researchers. However, the results of this study need to be interpreted in the context of the small sample size. Looking forward, the next phase of research needs to consider upscaling this programme in a sustainable manner as irrespective of Skills Testing or any other means of testing it is important that PSTs have confidence in their mathematical abilities and as such all have the opportunity to undergo confidence building interventions such as this.

References

Australian Government, Dept. of Education and Training. (2015). Action Now, Classroom Ready Teachers. Report of the TEMAG Group. Retrieved from https://www.studentsfirst.gov.au/teacher-quality.

Ball, D. L., Hill, H.C, & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator*, 29 (1), 14-46.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioural change. *Psychological Review*, 84, 191–215.

Betz, N.E. & Hackett, G. (1993). *Mathematics Self-Efficacy Scale Manual, Instrument and Scoring Guide*. Redwood City, CA: Mind Garden.

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

Hoffman, B. (2010). "I think I can, but I'm afraid to try": The role of self-efficacy beliefs and mathematics anxiety in mathematics problem-solving efficiency. *Learning and Individual Differences*, 20, 276 -283.

Kajander, A. (2005). Moving towards conceptual understanding in the pre-service classroom: A study of evolving knowledge and values. *Proceedings of the 27thth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education,* Roanoke, Virginia.

Kajander, A. (2010). Elementary mathematics teacher preparation in an era of reform: The assessment and development of mathematics for teaching. *Canadian Journal of Education*, 33(1), 228–255.

Kvedere, L. (2014). Mathematics Self-Efficacy, Self-Concept and Anxiety among 9th Grade Students in Latvia. *Procedia - Social and behavioural sciences*, 116, 2687-2690.

Liu, X., & Koirala, H. (2009). The effect of mathematics self-efficacy on mathematics achievement of high School students. *Proceedings of the 2009 Northeastern Educational Research Association (NERA)* Annual Conference, University of Connecticut.

Pajares F. (1996) Self-Efficacy Beliefs and Mathematical Problem-Solving of Gifted Students. *Contemporary Educational Psychology*, 21, 325-344.

Pajares, F., & Schunk, D.H. (2001). Self-Beliefs and School Success: Self-Efficacy, Self-Concept, and School Achievement. In R. Riding & S. Rayner (Eds), *Perception* (pp 239-266). London: Ablex Publishing.

Pajares, F., & Miller, M.D. (1994). The role of self-efficacy and self-concept beliefs in mathematical problem-solving: A path analysis. *Journal of Educational Psychology,* 86, 193-203.

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.

Richardson, F., & Suin, R. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology*, 19, 551-554.

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), 136-140.

Usher, E. L., & Pajares, F. (2009). Sources of self-efficacy in mathematics: A validation study. *Contemporary Educational Psychology*, 34, 89-101.

Uusimaki, L., & Nason, R. (2004). Causes Underlying Pre-Service Teachers' Negative Beliefs and Anxieties about Mathematics, *Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education*, 4, 369–376.

Vinson, B. (2001). A comparison of preservice teachers' mathematics anxiety before and after a methods class emphasizing manipulatives. *Early Childhood Education Journal*, 29(2), 89-94.