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Primary Mathematics Trainee Teacher Confidence and its Relationship to Mathematical Knowledge

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Primary Mathematics Trainee Teacher Confidence and its Relationship to Mathematical Knowledge.

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Abstract: The purpose of this paper is to examine trainee primary school teachers' confidence in their mathematical content knowledge (MCK) and confidence to teach specific primary mathematics concepts (mathematics pedagogical content knowledge –MPCK) which was correlated to their actual MCK on specific tasks. For this correlational study survey and test data were collected from a cohort of 210 trainee teachers. It was found that confidence to do and to teach mathematics was reasonably strongly correlated with competence. Trainee teachers' confidence varied greatly depending on the specific mathematics they were attempting. When presented with specific tasks, trainees were well aware of the link between personal numeracy levels and their potential to teach primary mathematics. A further finding was that the trainee teachers tended to over report their confidence. It is unknown if this is a cultural manifestation or a limitation of the scale. The data also add to the body of knowledge with respect to the MCK of about-to-graduate primary teachers.

Introduction

In recent times public media has reported concern about an apparent slide in mathematics standards of Western students compared to students from East Asian nations including China, Japan, Korea, Singapore, Taiwan and most recently Vietnam. This publicity has focused attention on the processes of teacher preparation, particularly with respect to the preparation of generalist primary teachers. Educational research literature is in agreement that prospective teachers should know the mathematics they are expected to teach deeply, and that this should be accompanied by high levels of confidence and self-efficacy. There is limited empirical research that explores the relationship between these variables, especially in Australian teacher preparation contexts. A cohort of third year undergraduate pre-primary teachers was assessed using a test of mathematics content based on Burghes (2007) International Audit of Primary Teachers Part A. This was accompanied by an author designed survey of pre-service teachers' confidence in their understanding of the mathematics and preparedness to teach it. Descriptive statistics and regression analysis were used to explore the results.

Literature Review

In recent decades there has been increasing interest in the role of affective variables in the learning of mathematics (e.g., Ingram & Linsell, 2014; Leder & Forgasz, 2006). The

importance of a learner's mathematical beliefs and attitudes was articulated by Wilkins and Ma (2003):

A person's mathematical disposition related to her or his beliefs about and attitude towards mathematics may be as important as content knowledge for making informed decisions in terms of willingness to use this knowledge in everyday life. (p. 52)

The same might be said about the relationship between trainee teachers' attitudes and knowledge with respect to the decisions they make in the classroom. In this paper the relationship between the trainee teachers' confidence to do and confidence to teach particular concepts is related to their mathematical content knowledge (MCK) for the same concepts.

There are various models describing the relationships between beliefs, values, attitudes, and emotions or feelings (e.g., Grootenboer, 2008; Grootenboer & Hemmings, 2007). Attitudes are usually seen as more affective and less cognitive than beliefs or values. Attitudes tend to be positive or negative or somewhere in between and are founded in experience (McLeod, 1992). Emotions have cognitive as well as affective roots (Bursal & Paznokas, 2006). It is well accepted that students -- including adult students -- with negative attitudes towards mathematics have performance challenges, in part because emotions such as anxiety impede their cognitive functioning and persistent behaviours (Tapia & Marsh II, 2004). Emotions such as negative feelings associated with mathematics study frequently are called "mathematics anxiety" and have been linked with low self-confidence and fear of failure. Such emotions can extend to the level of debilitating stress that seriously degrades cognitive capacity when engaging with mathematics (Brady & Bowd, 2005). The sources of such negative feelings are generally traced to poor pedagogical practices experienced in primary and secondary school, including assuming mathematical concepts were self-explanatory, insufficient explanation of terminology, student failure to grasp concepts before moving on, and the teaching of mathematics disconnected from students' realities (Cornell, 1999). In short, when students do not understand mathematical concepts it can cause anxiety and they are more inclined to give up on the task. On the other hand, positive emotions, including confidence, are generally accepted to be a student's self-concept of their mathematics performance, which is a belief that they could carry out an action successfully (Henderson & Rodrigues, 2008). Unsurprisingly, there is a negative correlation between anxiety and confidence and the two are frequently seen as opposites (Brady & Bowd, 2005; Bursal & Paznoka, 2006).

Confidence and Teaching Mathematics

The general consensus is that significant portions of trainee teachers at all stages have low levels of mathematical confidence and that, as with anxiety, confidence was related to personal depth of mathematical knowledge as well as prior experiences as a learner (e.g., Battisa, 1986; Bursal & Paznokas, 2006; Cornell, 1999; Grootenboer, 2008; Henderson & Rodrigues, 2008; Schackow, 2005). A relatively recent example of this is the work of Henderson and Rodrigues (2008) who found 68% of their sample of 80 Scottish primary teachers to have little or no confidence in their own mathematical skills. This finding surprised Henderson and Rodrigues since most of the cohort had recently graduated from high school and had completed the necessary qualifications to enrol in primary teacher education. Grootenboer's (2008) case study analysis of pre-service teachers in Australia illustrated that they harboured avoidance and non-engagement attitudes towards mathematics study and consequently, teaching, and at times had feelings of incompetency and anxiety as a future teacher.

Teacher confidence is important not only because of the potential to replicate positive or negative affect in students as noted by Stipek, Givvin, Salmon, and MacGyvers (2001), but also because teacher confidence has been linked to the quality of pedagogy. This manifests in several ways. When confidence is related to confidence to teach or perform a job/task, in this case the enactment of pedagogy, the term “self-efficacy” is frequently used (Bleicher, 2004; Sander & Sanders, 2003). Bleicher drew on the work of Bandura (1977) to note that people are motivated to act if they believe an expected outcome will be favourable and that they have the confidence to perform the necessary action successfully. Perceived self-efficacy was thought to contribute to motivation and performance outcomes of the children being taught, and as noted above, a lack of self-efficacy in the teacher was related to a tendency by the teacher to not take risks and not persevere with tasks. Teachers lacking in confidence may manifest this in a variety of behaviours including avoidance of teaching aspects of mathematics, lack of variation in pedagogy, and relying either upon tightly scripted or very unscripted pedagogy where teacher input is minimal (Ross, 2013; Givvin et al., 2001; Wilkins & Ma, 2003). Both tightly scripted and very unscripted classroom discourse were considered ineffective teaching behaviour (e.g., Hattie, 2009). Unfortunately the teacher’s affect has the potential to be mirrored by students’ affect and students’ learning (Ross, 2013).

Measuring Teachers’ Confidence

The measurement of attitudes and feelings of mathematics learners has a long history with various scales developed over the past half century. Perhaps the most widely used mathematics attitude scale was developed by Fennema and Sherman (1976). These authors produced attitude scales that assessed nine domains including attitude towards success, confidence and anxiety. Most scales, including the Fennema and Sherman scales and those that built upon them, attempt to quantify students’ general feelings of confidence in regard to doing the mathematics appropriate to their level of study. Likert scales of this form ask a dozen or so questions, some positively worded and some negatively worded. Positively worded Likert prompts included “Generally I have felt secure about attempting mathematics”; negatively worded prompts included “I’m not the type who could do well in maths.” More recent scales, for example by Schackow (2005, p. 367), adopt this general stimulus with prompts including “Maths does not scare me at all...I have a lot of confidence when it comes to mathematics...” Similarly, Henderson and Rodrigues (2008) investigated pre-service primary teachers’ confidence and again the questions have tended to be generic in nature such as “How confident are you in your own maths skills?” (p. 101). The unspoken assumption is that, as with earlier studies, the subjects -- and in the case of this study, the pre-service teachers -- will know what the necessary mathematics skills are. Arguably, this may be a reasonable assumption if the trainee teachers have already completed several mathematics curriculum courses and are aware of the level of mathematics expected of them as part of their teaching responsibilities.

As in the case with traditional measures of confidence, scales that measure self-efficacy tend to refer to general capacity with prompts such as “I know the steps necessary to teach science concepts effectively” and “I understand science concepts well enough to be effective in teaching elementary science” (Bleicher, 2004, p. 391). It is usual to link knowing the subject to be taught with knowing how to teach it (Battisa, 1986; Brady & Bowd, 2005). While Bleicher’s scale was targeting science teaching, similar scales are used to gauge mathematics self-efficacy teaching (e.g., Fennema & Sherman, 1976). Of course if the intention is to measure changes in general confidence or self-efficacy across different groups or changes in general confidence over time, the above limitation is less of a concern (Brookstein, Hegedus, Dalton & Moniz, 2011). Scherbaum, Cohen-Charash and Kern (2006)

similarly noted measuring general self-efficacy has merit provided the context of the expressed self-efficacy is kept in mind.

The Relationship between Mathematics Knowledge (MCK) and Confidence

It is widely accepted that if a teacher does not know the mathematics, then they are unlikely to be able to structure lessons to teach it effectively (Ball, Lubienski, & Mewborn, 2001; Graven, 2002; Masters, 2009; Murphy, Neil, & Beggs, 2007; Rowland, Huckstep, & Thwaites, 2005; Stipek et al., 2001; Zhang & Stephens, 2013) not least because they will not be able to manage effective classroom discourse or use meaningful models to assist students to understand the mathematical concepts. Confidence and depth of mathematical knowledge are considered particularly relevant to teachers' practices in "inquiry-orientated" mathematics teaching. Stipek et al. (2001) have used the terms "constructivist" and "social-constructivist" as equivalent to inquiry-oriented learning and report that it is a significant recommendation of the National Council of Teachers of Mathematics (NCTM, 2015) that this form of classroom discourse be strongly recommended. Similar recommendations in curriculum guidelines are found in most Western mathematics curriculum including Australia (Graven, 2002; Hattie, 2009; Meyers, 2012; Muller, 2000). The less-scripted nature of inquiry-oriented classroom discourse is particularly demanding on teachers' capacity to think on their feet in order to provide the appropriate scaffolding. Stipek et al. make the point that high levels of self-confidence need to be supported by teachers' real understandings for them to flexibly scaffold student learning.

The models that describe the relationship between teachers' content knowledge and how this needs to be supported by knowledge of students, learning theories, curriculum intention and specific pedagogy have evolved over the past few decades (e.g., Ball & Bass, 2000; Ball, Hill, & Bass, 2005; Ball, Thames, & Phelps, 2008; Hattie, 2009; Ma, 1999; Shulman, 1987, 1999; Zhang & Stephens, 2013). While the models have evolved and become ever more sophisticated, it is apparent that concerns about the depth of teachers' content knowledge (MCK) remain a relatively constant theme in the Western educational research literature (e.g., Ball et al., 2001; Burghes, 2011; Henderson & Rodrigues, 2008; Ingram & Linsell, 2014; Jensen, 2012; Klein, 2005; Livy & Herbert, 2013; Ma, 1999; Ma & Kishor, 1997; Major & Perger, 2014; Tatto, Rodriguez, & Lu, 2015; Tatto et al., 2008). Not surprisingly this is mirrored by Western government concerns about the extent of teacher knowledge and teacher performance (Graven, 2002; Henderson & Rodrigues, 2008; NSW Smarter Schools National Partnership, 2010; Teacher Education Ministerial Advisory Group [TEMAG], 2014; U.S. Department of Education, 2008) including in the study state (Masters, 2009). Studies into trainee teachers' necessary content suggest widespread cause for concern. Of particular relevance to this study are those that document Australian pre-service teachers' struggles with fractions (e.g., Chinnappan, Forrester, & Thurtell-Hoare, 2012; Marshman & Porter, 2013), and proportional reasoning and number sense in England and New Zealand (e.g., Burghes, 2011; Livy & Herbert, 2013).

The problem of defining what constitutes adequate competency, or real understandings in primary (elementary) teaching, is not simple; nor, despite the citations above, is the relationship between confidence and capacity well researched (Grootenboer, 2008). As has been reported earlier, knowing the content and knowing how to teach it is not the same thing (e.g., Ball & Bass, 2000; Hill, Rowan, & Ball, 2005), but is strongly related, not least through the teacher's sense of self-efficacy (Bleicher, 2004; Ross, 2013). The relationship between confidence and mathematical competency warrants further research.

In summary, a review of the literature indicates concerns with Western primary school teachers' levels of MCK and concerns that while there has been considerable research on the importance of confidence and self-efficacy, there is very little on the link between confidence and MCK on specific relevant mathematics concepts. This paper helps to address this deficit and with this background in mind the key research questions are:

- 1) What is the initial confidence in mathematics content and pedagogy of the trainee teachers?
- 2) What is the initial MCK of the trainee teachers and how is this related to their confidence?

Method

Overview

The method is correlational (Cronbach, 1975) in so much as relationships between confidence to succeed with the content and self-efficacy to teach it was related to the subjects knowledge of mathematics.

Subjects

The subjects were third-year undergraduate primary education students who had successfully completed two prior mathematics curriculum courses. The students were enrolled in Mathematics 3, the purpose of which was to act as a capstone course. The course profile of Mathematics 3 indicated a focus on student error identification and remediation and the teaching of problem solving to primary children. The total cohort across three campuses (n=210) was sampled at the beginning of the course with an instrument designed by the author to assess basic knowledge of mathematics and pre-service teacher levels of confidence to teach the concept tested.

All students had completed two prior mathematics curriculum courses. Students reported on the author constructed survey that between 32% and 37% attained grades of Distinction or High Distinction; when a Credit grade is taken into account these figures were 62% and 70% of the cohort achieving grades of Credit or above. The first mathematics curriculum course (Mathematics 1) aimed to develop the trainee teachers' capability to teach the number and algebra strands. The second (Mathematics 2) aimed to prepare trainee teachers to teach the strands of geometry, measurement, statistics and data. Earlier courses were conducted via blended learning modes of delivery of 3 hours each week over 12 weeks. The student evaluation of the courses (SEC) was very favourable with SEC responses typically from 4 out of 5 to 4.8 out of 5, indicating high levels of student satisfaction. That is, in the main the trainee teachers believed that the mathematics courses prepared them to teach effectively.

Instruments

An overview of the instruments used in this study is documented below.

	Instrument	Comment
Starting content knowledge, established Week 1 first workshop	45-minute author-designed test including items from Burghes (2007) and Australian Curriculum Assessment and Reporting Authority (ACARA, 2014, 2015) (n=168/210)	The test items give a robust assessment of pre-service teachers' MCK

Starting confidence, established Week 1 first workshop	Author-designed survey (n= 168/210)	The Likert survey asked students to rate their confidence in understanding the mathematics and how to teach it via 26 mathematics questions.
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Table 1: Overview of Data-collection Instruments

Measuring Starting MCK

A test of basic content included the Burghes (2007) International Audit of Primary Trainee Teachers Part A. This is a useful test with a range of procedural questions; it enables the reader to carry out cross-referencing with international data on particular questions. Further Year 7 questions from the National Assessment Program Literacy and Numeracy (NAPLAN) (ACARA, 2014, 2015) were adapted. The author also added a few questions related to basic whole-number computation and fractions and proportional reasoning (see Table 4). Concerns with pre-service teachers' basic number sense and in particular concepts associated with proportional reasoning have been reported earlier (e.g., Burghes, 2011; Livy & Herbert, 2013). The test contained content to the level of lower middle years; most of the concepts are likely to be taught in primary school including some fraction computation, an area of mathematics that earlier has been reported to challenge Australian trainee teachers (e.g., Marshman & Porter, 2013). Each question on the content test was mapped to the Australian Curriculum Mathematics (ACARA, 2012). The test was dominated by questions at a level of difficulty equivalent to Year 7 NAPLAN questions (Ministerial Council on Education, Employment, Training and Youth Affairs [MCEETYA], 2008-2014).

The use of calculators and take in notes was not allowed because the students were being trained to teach children who were fluent in basic facts and processes (ACARA, 2012). It was reasoned that one might have similar expectations about their future teachers. In this paper only the results of students' success or otherwise on whole number, fractions and proportional reasoning was considered in detail. Similar patterns emerged with students' understanding and confidence with respect to questions related to algebraic thinking and algebraic processes.

Measuring Trainee Teachers' Confidence to do and to teach Particular Mathematics Concepts

This study asked pre-service teachers to assess their confidence in the content and the teaching of particular concepts. The theoretical justification for linking confidence in doing (MCK) and confidence in teaching or mathematics pedagogical content knowledge (MPCK) is based on the strong link between the two noted in research on teacher knowledge and its relationship to teacher capacity and linked to self-efficacy (e.g., Bleicher, 2004; Sander & Sanders, 2003). Bleicher (2004, p. 384) noted, in regard to science teaching, that "Studies support the development of self-efficacy and conceptual understanding as first principle in an elementary science teaching methods course."

The logic behind using specific rather than generic prompts was twofold: First, trainee or pre-service teachers might not be aware of the level of mathematical knowledge expected of them, thus it was reasoned that the required content ought to be presented since the demands of content to teach primary mathematics are quite diverse. For example, trainee teachers might consider themselves confident to do and to teach addition of whole numbers but might be less confident to understand and to teach fraction division. The literature suggests that, to a point, the correlation between confidence in knowing and in knowing how

to teach is strong, but the author did not find any studies regarding the relationship between confidence in knowing the mathematics and knowing *specifically* how to teach primary school particular mathematics concepts. Hence, the author takes the view that there are two aspects of confidence that need to be assessed: confidence about their personal understanding about *specific concepts* (MCK) and confidence about having the pedagogy to teach these concepts (*specific MPCK*). In teaching the two are inseparably linked, or at least ought to be subsequent to successful completion of two mathematics curriculum courses. So, for each question on the content test, the students were asked to respond on a Likert scale as follows:

- 1 -Not confident at all: You have little idea of the mathematics concept area and consider you would like to do a lot of research before attempting to teach this concept or feel the level of content is above your capacity.
- 2 -Not confident: You are doubtful of the solution/mathematics and have little idea of how to go about teaching the concept without considerable research.
- 3 -Unsure: You are a bit unsure of the solution/mathematics and would like to look up teaching tips.
- 4 -Confident: You consider you understand the structure but would need to look up some teaching tips.
- 5 -Very confident: You feel you could walk in and with very little or no preparation teach questions of this mathematical structure.

Each question probing MCK was marked out of 1. Responses to the Likert prompts were entered into SPSS. SPSS was also used to provide the summary data and carry out the calculations for the regression equation describing the relationship between confidence to do and to teach specific mathematics and actual capacity on each test item.

The breakdown of the percentages of students who responded with respect to their confidence to carry out specific mathematics tasks and to teach the same material is modelled below for Question 1. The actual success rate is provided in brackets following the question identification.

Question 1 (mark): (Actual success on this question --Mean success rate 69%; SD 0.4993).

John needs to save \$40000; so far he has saved \$2379. How much more money does he need to save?

Very confident (5)	Confident (4)	Unsure (3)	Not confident (2)	Very unconfident(1)
35%	51%	11%	3%	0%

Responses to this question indicate that 86% of the trainee teachers considered they were either confident or very confident of their MCK and MPCK, but only 69% successfully carried out the computation. Such a computation is a Year 4 task (ACARA, 2012). In this instance we can see that the success rate on the mathematical task is relatively high (69%) and the reported confidence is similarly high (86%). Unsure does not depict confidence, so 14% expressed a lack of confidence.

The example below is of decimal division, and is at the minimum standard for Year 7 students (ACARA, 2012).

Question 20 (1 mark) (Actual success rate on this question -- 12%; SD =0.3262)

A book is 2.5cm thick. Each page is 0.05mm thick. How many pages are there in the book?

Very confident (5)	Confident (4)	Unsure (3)	Not confident (2)	Very unconfident (1)
4%	14%	57%	17%	8%

As with the example above, confidence is closely mirrored by competency. 18% were confident and 12% were successful. The detailed analysis of trainee teachers' responses for

each item allows a triangulation of the data depicted in summary data and correlational testing.

Results

The overall scores on the content test and mean confidence levels are summarised in Table 2.

	Minimum	Maximum	Mean	Std. Deviation
Total score (possible 35)	5	26	10.893	5.3026
Mean confidence (1 to 5)	1.320	4.520	2.7632	.7307

Table 2: Overall Levels of Confidence and Total Score on Pre-test (n=168)

The average of 2.76 (out of 5) for expressed confidence on all test items indicates that most students expressed low confidence on this scale or were at least unsure.

The relationship between overall confidence and overall mathematical scores on the 26 questions with sub questions totalling 35 marks summarised in Table 2 was assessed via a linear regression which predicted the mathematics test score from the pre-service teachers' overall level of confidence. The regression equation was found to be significant ($F_{91, 168}=74.849, p=.009$), with R^2 of 0.531. The participants' mathematics score is equal to $-5.611+6.270$ (confidence). That is, the mathematics test score increased by 6.270 marks for each unit increase in expressed confidence. The R^2 of 0.531 indicates that over 50% of the students' mathematics scores were accounted for by the model. This moderate correlation between confidence and test score is further explored below.

In order to more deeply explore the extent of the relationship between expressed confidence and mathematical competency as measured by the test, the confidence data were categorized and SPSS was used to facilitate the calculations as well as the ANOVA calculations. Those who had average confidence over all items of 1 to 1.99 were categorised as having *very low confidence* and these students represented approximately 14% of the cohort; those who had average scores of 2 to 2.99 were categorised as having *low confidence* and these students represented approximately 51% of the cohort; those who scored 3 to 3.99 were categorised as *confident* and represented 28% of the cohort; those who averaged 4 to 5 were categorised as *very confident* and represented approximately 7% of the cohort. This method of analysis supports the overall mean for confidence (2.7632 out of 5) in providing evidence that most students reported lacking confidence on doing and teaching the documented mathematics. The one-way ANOVA data below indicate differences among groups with increasing confidence associated with higher scores.

Level of confidence	Mean on test score	Standard deviation (SD)	F	Sig
Very low confidence (1-1.99)	6.266/34	2.814	24.385	.000
Low confidence (2-2.99)	9.511/34	4.152		
Confident (3-3.99)	15.256/34	5.811		
Very confident (4-5)	18.800/34	6.181		

Table 3: Initial Scores of Students with Different Levels of Confidence (n=168)

Mean differences between each category were highly statistically significant, the lowest significance level being $p=0.02$. Very confident students on average scored three times the content marks of students who reported very low confidence levels. As noted above, across all concept areas most students reported lacking in confidence that they understood the mathematics and their capacity to teach it without further study. Unfortunately, many of those

who reported being very confident barely passed the test; this is evidenced in the negative constant in the regression equation. In short, while there was a medium correlation between pre-service teachers’ confidence to do and to teach the mathematics content and measured MCK, there was a tendency for trainee teachers to overestimate their competency in mathematics or to show reluctance to report low levels of confidence.

In order to unpack these trends further and to gain a better understanding of the educational significance of the content test (MCK) data, the relative success on individual questions was examined and this related to the stated confidence for that particular question. Table 4 provides a summary of content and confidence to teach specific concepts of mathematics involving simple whole-number algorithms and computation, with 5 indicative of a very high level of confidence.

Whole-number computation	Pre-test% Success (N=166)	Conf/ Mean SD (out of 5)
Q1. John needs to save \$40000, so far he has saved \$2379. How much more money does he need to save? (Year 4; ACARA, 2012)	69%	4.135/1.064
Q2. Luke earned \$257 for each sale he made. If he succeeded in selling 48 items, what was his total earning? (Year 5; ACARA, 2012)	45%	3.393/1.068
Q3. A syndicate of 27 girls shared \$455 between them. How much was each share to the nearest cent? (Year 6; ACARA, 2012)	12%	2.284/0.918
Q6. What is the value of 4^4 ? (Year 7; ACARA, 2012)	30%	3.161/0.899

Table 4: Results for Whole-number Computation on Pre-test Including Starting Confidence (n=166)

Most students (86%) were either very confident or confident in their knowledge of and capacity to teach subtraction, and 69% were successful in their computation involving subtraction. Similarly, in terms of the multiplication question (Q2) few students were willing to acknowledge a lack of confidence, for this question, preferring to report “unsure” for example 35% were unsure and 15% expressed a lack of confidence. Overall, students were less certain of their knowledge of the concepts associated with multiplication, division and index notation.

Whole-number problem solving and proportion	Pre % Success	Conf/SD
Q9. If the total of 3 tickets is \$4.20, how much will 10 tickets cost? (Year 4; ACARA, 2012)	69%	3.383/1.037
Q10. If \$45 is divided among three friends; Sam, Luke and David in the ratio 3:2:4 how much does each person receive? Sam gets ____: (Year 7; ACARA, 2012)	56%	3.062/1.245
Q22. Chickens have two legs and goats have 4 legs. At the farm there are 56 legs and 18 animals and no amputees. How many chickens and how many goats could there be? (Year 6; ACARA, 2012)	33%	2.906/0.954

Table 5: Results on Questions Involving Whole-number Computation and Proportion Including Starting Confidence (n=166)

Questions 9 and 10 were rare occasions where student success rates exceeded their expressed confidence (Q9: 49% expression confidence [5 or 4], 69% success rate; Q10: confidence [Likert response of 5 or 4] 35% and success rate 56%). Another way of looking at this is that for Question 9, 14% expressed a lack of confidence (Likert response 1 or 2) in their mathematics and capacity to teach it; for Question 10 the statistic was 28%, however the failure rate was 44%.

Fraction computation and problem solving	Pre % Success	Conf
Q5. Write each number as a fraction, decimal and percentage		
(a) $\frac{3}{8}$ (Year 6; ACARA, 2012)	19%	2.780/0.947
(b) 0.6 (Year 6; ACARA, 2012)	69%	
Q19. The small silicon chip has a length 0.2 mm and a width 0.4 mm. What is the area of the chip? (Year 7; ACARA, 2012)	6%	3.124/0.897
Q20. A book is 2.5 cm thick. Each page is 0.05 mm thick. How many pages are there in the book? (Year 7; ACARA, 2012)	12%	2.868/0.912

Table 6: Fraction Computation and Problem Solving Including Starting Confidence (n=166)

The data indicate that trainee teachers struggled with fraction computation and most recognised their limitations. However, as with most of the earlier questions, more were confident than were successful. Nonetheless the level of reported confidence is a reasonable predictor of success provided tendency to overestimate success is taken into account. For example, while 6% could do the decimal multiplication associated with Question 19, 4% were very confident and 28% were confident in their mathematics and capacity to teach it. Only 18% expressed doubt in their solution and considered they would have to do considerable research before teaching this concept area. As with the whole-number analysis, the data indicate that the subjects were reluctant to acknowledge their limitations or were unaware of these.

Discussion and Conclusions

As noted in the literature review the critical relationship between understanding mathematics (MCK) (to a relevant level) and capacity to teach it is almost universally accepted (e.g., Ball & Bass, 2000; Ball et al., 2008; Hill et al., 2005; Ma, 1999; Shulman, 1987; 1999; Zhang & Stephens, 2013). Further, it has been found by earlier authors (e.g., Brady & Bowd, 2005; Henderson & Rodrigues, 2008; Schackow, 2005) that pre-service teacher confidence in understanding mathematics was not robust. In addition the link between confidence and self-efficacy is well documented (e.g., Bleicher, 2004; Sander & Sanders, 2003). This study adds to the above consensus by examining the relationship between confidence and MCK in detail within an Australian context.

The survey developed by the author and used in this study to assess confidence in knowing the mathematics (MCK) and self-efficacy in teaching mathematics (MPCK) did so in one stem. The data from this study indicate that pre-service teachers' confidence in knowing and teaching specific mathematics is a relatively good predictor of MCK as measured in a standard written test, provided the tendency to register overconfidence is taken into account. The trainee teachers tended to over report their capability to carry out mathematics tasks relevant to the level they were expected to teach. On most items, more students could not do mathematics than recognised they would need to do considerable research before teaching and this is seen in the negative constant in the regression equation as well as the more detailed analysis of the relationship between confidence and mathematical capacity documented for levels of confidence and on specific content domains. This could be a result of the 5-point scale not providing sufficient scope for the trainee teachers to represent their levels of confidence and that a fine-grain scale may have yielded more accurate results. Two alternative explanations for this data come to hand. The first is that the trainee teachers were unwilling to report very low levels of confidence on topics with which they were reasonably expected to be fluent. The second is that a significant number of students were genuinely unaware of their limitations: that is, they did not know what they did not know.

Despite the tendency to overrate their confidence, in the main levels of confidence were low, particularly on upper primary concepts.

It is acknowledged that measuring general self-confidence or general self-efficacy has a role to play in educational research in part because of the correlation between general and specific confidence and self-efficacy (eg. Brookstein et al., 2011; Scherbaum et al., 2006). However, the data in this study highlights some of the limitations of asking trainee teachers, indeed teachers and students in general, to respond to generic prompts such as “Generally I have felt secure about attempting mathematics.” In this study it is likely that the overall predictive capacity of confidence with respect to MCK as tested is only valid because a range of questions of varying levels of difficulty were offered. The findings support the assertion of Pajares (2000) and Sander and Sanders (2003) that confidence to achieve a goal is specific to particular situations and greater specificity is likely to result in better predictions. In the case of mathematics teaching this is important since the demands associated with teaching different concepts and levels of mathematics is considerable. The low reported self-confidence with respect to upper primary mathematics concepts in particular are a matter of concern due to the association between confidence/self-efficacy and classroom practice (eg., Ross, 2013; Givvin et al., 2001; Wilkins & Ma, 2003).

A further relevant finding of this study was the rate of success of the students on this test. These rates ought to be a matter of concern since these subjects were about to graduate and had previously successfully completed two curriculum courses in mathematics education. The data indicate that earlier mathematics curriculum courses had been passed mostly with high grades, but seemed to have been ineffective in ensuring the trainee teachers were capable and confident in upper primary mathematics in particular. This suggests that the assessment of these courses is not performing as might be hoped and that high grades could be obtained without corresponding knowledge of mathematics. The majority of educational researchers who consider that knowing mathematics deeply is a key aspect of teaching (e.g., Ball & Bass, 2000; Ball et al., 2008; Hattie, 2009; Ma, 1999; Shulman, 1987; Zhang & Stephens, 2013) would be alarmed. The data on MCK add to the corpus of data related to concern about the levels of mathematics knowledge with which trainee teachers are able to commence study in Western institutions (e.g., Ball et al., 2001; Burghes, 2011; Henderson & Rodrigues, 2008; Jensen, 2012; Klein, 2005; Livy & Herbert, 2013; Ma, 1999; Ma & Kishor, 1997; Major & Perger, 2014; Tatto et al., 2015; Tatto et al., 2008). Prior to 2015 these trainee teachers would have graduated without further opportunity to remediate their levels of content or confidence. For this cohort (2015), there was 32 hours of contact over 8 weeks to address the issues. In this regard the data have relevance to institutional and certification reform recommended by Australian review groups (e.g., TEMAG, 2014).

A further if incidental finding was that despite the short coming of earlier courses to account for student knowledge of their discipline, the students had rated the courses highly. This data suggests that student satisfaction ratings may not be the best metric for effectiveness.

References

- Australian Curriculum Assessment and Reporting Authority (ACARA). (2012). *The Australian curriculum: Mathematics*. Retrieved from <http://www.australiancurriculum.edu.au/Mathematics/Rationale>
- Australian Curriculum Assessment and Reporting Authority (ACARA). (2014). *National Assessment Program Literacy and Numeracy: Year 7 Numeracy Non Calculator*. ACARA.

- Australian Curriculum Assessment and Reporting Authority (ACARA). (2015). *National Assessment Program Literacy and Numeracy: Year 5 Numeracy*. ACARA.
- Ball, D., & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning how to teach. Knowing and using mathematics. In J. Boaler (Ed.), *Multiple perspectives on the teaching and learning of mathematics* (pp. 83-104). Westport, CT: Ablex.
- Ball, D., Hill, H., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator, Fall*. Retrieved from www.aft.org/pubs-reports/american_educator/fall05
- Ball, D., Lubienski, S., & Mewborn, D. (2001). Research on teaching Mathematics: The unsolved problem of teachers' mathematical knowledge. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed.). New York: McMillan.
- Ball, D., Thames, M., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*, 389-407.
<https://doi.org/10.1177/0022487108324554>
- Bandura, A. (1977). Self-efficacy: Towards a unifying theory of behavioural change. *Psychological Review, 84*, 191-215. <https://doi.org/10.1037/0033-295X.84.2.191>
- Battista, M. (1986). The relationship of mathematics anxiety and mathematical knowledge to the learning of mathematical pedagogy by preservice elementary teachers. *School Science and Mathematics, 86*(1), 10-19. <https://doi.org/10.1111/j.1949-8594.1986.tb11580.x>
- Bleicher, R. (2004). Revisiting the STEBI-B: Measuring self-efficacy in preservice elementary teachers. *School Science and Mathematics, 104*(8), 383-392.
<https://doi.org/10.1111/j.1949-8594.2004.tb18004.x>
- Brady, P., & Bowd, A. (2005). Mathematics anxiety, prior experiences and confidence to teach mathematics among pre-service education students. *Teachers and Teaching, 11*(1), 37-46. <https://doi.org/10.1080/1354060042000337084>
- Brookstein, A., Hegedus, S., Dalton, S. & Moniz, R. (2011). Measuring student attitude in mathematics classrooms. Technical Report #4. Retrieved from http://www.kaputcenter.umassd.edu/downloads/products/technical_reports/tr4_student_attitude.pdf
- Burghes, D. (2007). *International comparative study in Mathematics training*. Trainee Teacher Primary Mathematics Audit. (ICSMTT) CfBT Education Trust. Retrieved from <http://www.cimt.plymouth.ac.uk/papers/icsmtt.pdf>
- Burghes, D. (2011). *International comparative study in Mathematics training: Recommendations for initial teacher training in England*. CfBT Education Trust. Retrieved from <https://www.nationalstemcentre.org.uk/res/documents/page/International%20comparative%20study%20in%20mathematics%20teacher%20training.pdf>
- Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 104*(6), 173-179. <https://doi.org/10.1111/j.1949-8594.2006.tb18073.x>
- Chinnappan, M., Forreser, T., & Thurtell-Hoare, E. (2012). Developments in pre-service teachers' mathematics for teaching of fractions. In J. Dindyal, L. P. Cheng & S. F. Ng (Eds.), *Mathematics education: Expanding horizons* (Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia). Singapore: MERGA.
- Cornell, C. (1999). "I hate Math! I could not learn it, and I can't teach it!" *Childhood Education, 75*(4), 225-230. <https://doi.org/10.1080/00094056.1999.10522022>
- Cronbach, L. J. (1975). Beyond the two disciplines of scientific psychology, *American Psychologist, 30*, pp. 116-127. <https://doi.org/10.1037/h0076829>

- Fennema, E., & Sherman, J. (1976). Fennema-Sherman Mathematics Attitude Scales: Instrument designed to measure attitudes towards the learning of mathematics by males and females. *Catalog of Selected Documents in Psychology*, 61(1), 31. <https://doi.org/10.2307/748467>
- Graven, M. (2002). *Mathematics teacher learning, communities of practice and the centrality of confidence*. Thesis submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg.
- Grootenboer, P. (2008). Mathematical belief change in prospective primary teachers. *Journal of Mathematics Teacher Education*, 11, 479-497. <https://doi.org/10.1007/s10857-008-9084-x>
- Grootenboer, P., & Hemmings, B. (2007). Mathematics performance and the role played by affective and background factors. *Mathematics Education Research Journal*, 19(3), 3-20. <https://doi.org/10.1007/BF03217459>
- Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. London: Routledge.
- Henderson, S., & Rodrigues, S. (2008). Scottish student primary teachers' levels of mathematical competence and confidence for teaching mathematics: some implications for national qualifications and initial teacher education. *Journal of Education for Teaching*, 34(2), 93-107. <https://doi.org/10.1080/02607470801979533>
- Hill, H., Rowan, B., & Ball, D. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal*, 42(2), 371-406. <https://doi.org/10.3102/00028312042002371>
- Ingram, N., & Linsell, C. (2014). Foundation content knowledge: Pre-service teacher's attainment and affect. In J. Anderson, M. Cavanagh, & A. Prescott (Eds.), *Proceedings of the 37th annual conference of the Mathematics Education Research Group of Australasia* (pp. 718-721). Sydney: MERGA.
- Jensen, B. (2012). *Catching up: Learning from the best school systems in East Asia*. Melbourne: Grattan Institute. Retrieved from http://grattan.edu.au/static/files/assets/23afab6b/129_report_learning_from_the_best_main.pdf
- Klein, D. (2005). *The state of state Math standards*. Thomas B. Foundation. Retrieved from <http://www.math.jhu.edu/~wsw/papers2/education/02-SOS-Klein-05.pdf>
- Leder, G. C., & Forgasz, H. J. (2006). Affect and mathematics education: PME perspectives. In A. Gutie´rrez & P. Boero (Eds.), *Handbook of research on the psychology of mathematics education: Past, present and future* (pp. 403-427). Rotterdam: Sense.
- Livy, S., & Herbert, S. (2013). Pre-service teachers' responses for ratio and proportion items. In V. Steinle, L. Ball & C. Bardini (Eds.), *Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia* (pp. 450-457). Melbourne: MERGA.
- Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, N.J.: Lawrence Erlbaum Associates, Inc.
- Ma, X., & Kishor, N. (1997). Assessing the relationship between attitude towards mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education*, 28(1), 26-47. <https://doi.org/10.2307/749662>
- Major, K., & Perger, P. (2014). Personal number sense and New Zealand pre-service teachers. In J. Anderson, M. Cavanagh, & A. Prescott (Eds.), *Proceedings of the 37th annual conference of the Mathematics Education Research Group of Australasia* (pp. 710-713). Sydney: MERGA.

- Marshman, M., & Porter, G. (2013). Pre-service teachers' pedagogical content knowledge: Implications for teaching. In V. Steinle, L. Ball, & C. Bardini (Eds.), *Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia* (pp. 474-481). Melbourne: MERGA.
- Masters, G. (2009). *A shared challenge: Improving literacy, numeracy and science learning in Queensland primary schools*. Australian Council for Educational Research. Retrieved from <http://education.qld.gov.au/mastersreview/>
- McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575–596). New York: Macmillan.
- Meyers, D. (2012). *Australian universities: A portrait of decline*. Retrieved from www.australianuniversities.id.au
- Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA). (2008-2014). *National assessment program, literacy and numeracy: Numeracy*. Carlton, Victoria: Curriculum Corporation.
- Muller, J. (2000). *Reclaiming knowledge: Social theory, curriculum and education policy*. London and New York: Routledge Falmer.
- Murphy, C., Neil, P., & Beggs, J. (2007). Primary science teacher confidence revisited: Ten years on. *Educational Research*, 49(4), 415-430. <https://doi.org/10.1080/00131880701717289>
- National Council of Teachers of Mathematics. (2015). *Principles and standards of school Mathematics*. Retrieved from <http://www.nctm.org/Standards-and-Positions/Principles-and-Standards/Principles,-Standards,-and-Expectations/>
- NSW Smarter Schools National Partnerships. (2010). *Smarter schools national partnerships on improving teacher quality*. Retrieved from <http://www.nationalpartnerships.nsw.edu.au/resources/documents/ITQ-HATDETGuidelines.pdf>.
- Pajares, F. (2000). Frank Pajares on nurturing academic confidence. *Emorey Report*, Feb, 14, 52, 21. Retrieved from http://www.emory.edu/EMORY_REPORT/erarchive/2000/February/erfebruary.14/2_14_00pajares.html
- Rowland, T., Huckstep, P., & Thwaites, A. (2005). Elementary teachers' mathematics subject knowledge: The knowledge quartet and the case of Naomi. *Journal of Mathematics Teacher Education* 8(3), 255–81. <https://doi.org/10.1007/s10857-005-0853-5>
- Ross, J. (2013). Teacher Efficacy; In J. Hattie, & E. Anderman (Eds.), *International Guide to Student Achievement*. (pp. 266-267). Routledge: NY.
- Sander, P., & Sanders, L. (2003). Measuring confidence in academic study: A summary report. *Electronic Journal of Research in Educational Psychology and Psychopedagogy*, 1(1), 1-17. Retrieved from <http://www.investigacion-psicopedagogica.org/revista/new/english/index.php?n=1>
- Schackow, J. (2005). *Examining the attitudes towards mathematics of preservice elementary school teachers enrolled in an introductory mathematics methods course and the experiences that have influenced the development of these attitudes*. Graduation Theses and Dissertations. Retrieved from <http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1852&context=etd>
- Shulman, L. (1987). Knowledge and teaching: Foundations of the reform. *Harvard Educational Review*, 57(1), 1-22. <https://doi.org/10.17763/haer.57.1.j463w79r56455411>

- Scherbaum, C., Cohen-Charash, Y. & Kern, M. (2006). Measuring general self-efficacy: A comparison of three measures using item response theory. *Educational and Psychological Measurement*, 66(6), 1047-1063.
<https://doi.org/10.1177/0013164406288171>
- Shulman, L. (1999). Knowledge and teaching: Foundations of the new reform. In J. Leach & B. Moon (Eds.), *Learners and pedagogy* (pp. 61-77). London: Sage.
- Stipek, D., Givvin, K., Salmon, J., & MacGyvers, V. (2001). Teachers' beliefs and practices related to mathematics instruction. *Teacher and Teaching Education*, 17, 213-226.
[https://doi.org/10.1016/S0742-051X\(00\)00052-4](https://doi.org/10.1016/S0742-051X(00)00052-4)
- Tapia, M., & Marsh II, G. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly*, 8(2).
- Tatto, M., Rodriguez, M., & Lu, Y. (2015). The influence of teacher education on mathematics teaching knowledge: Local implementation of global ideas. *International Perspectives on Education and Society*, 27, 279-331. Retrieved from:
<https://doi.org/10.1108/S1479-367920140000027004>
- Tatto, M., Schwille, J., Senk, S., Ingvarason, L., Peck, R., & Rowley, G. (2008). *Teacher Education and Development Study in Mathematics (TEDS-M): Policy, practice, and readiness to teach primary and secondary mathematics. Conceptual framework*. East Lansing, MI: Teacher Education and Development International Study Center, College of Education, Michigan University.
- Teacher Education Ministerial Advisory Group, (2014). *Action now! Classroom ready teachers*. Retrieved from
http://docs.education.gov.au/system/files/doc/other/action_now_classroom_ready_teachers_print.pdf
- US Department of Education. (2008). *Success: The final report of the National Mathematics Advisory Panel*. Retrieved from:
<http://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf>
- Wilkins, J., & Ma, X. (2003). Modeling change in student attitude toward and beliefs about mathematics. *Journal of Educational Research*, 97(1), 52-63.
<https://doi.org/10.1080/00220670309596628>
- Zhang, Q., & Stephens, M. (2013). Utilising a construct of teacher capacity to examine national curriculum reform in mathematics. *Mathematics Education Research Journal*, 25, 481-502. <https://doi.org/10.1007/s13394-013-0072-9>