TEACHERS' AND PRE-SERVICE TEACHERS' CONFIDENCE TO TEACH PRIMARY SCHOOL MATHEMATICS

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Abstract

Confidence has been variously defined as a dimension attitude, an outcome of beliefs about one's self-efficacy in a particular situation, and as inherent in the process of learning and linked to identity formation. It is often assumed to be associated with ability and crucial to performance. There is evidence that many primary teachers lack confidence in their ability to teach topics in the mathematics curriculum effectively (Beswick, Watson, & Brown, 2006; Watson, Beswick, Caney, & Skalicky, 2006), and that pre-service teachers have reservations about their preparedness to teach mathematics at the level they will be qualified to teach it. Indeed, mathematics anxiety is commonly reported among pre-service primary teachers (e.g., Uusimaki & Nason, 2004). The pre-service (n = 96) and practising (n = 32) teachers in this study worked together in the pre-service teachers' final mathematics curriculum unit in an approach designed to bridge the perceived theory-practice gap. We were interested in the impact of the unit on the pre-service teachers' confidence.

Confidence data were collected using a paper based questionnaire that included one section related to confidence. The section comprised 21 items to which participants responded on 5-point Likert scales indicating the extent of their confidence from Low confidence to High confidence. This paper presents data on the confidence of practising primary teachers and pre-service teachers to teach various aspects of the primary school mathematics curriculum. Differences between the confidence of the two groups of teachers at the start and end of the project, and changes in the pre-service teachers' confidence from the beginning to the end of the semester long unit are examined using t-tests. Unsurprisingly the practising teachers were more confident to teach most topics than were their novice colleagues at the start of the semester but this was not the case at the end. In general the pre-service teachers' confidence improved from beginning to end of the semester.

Introduction

This paper reports on the confidence of pre-service teachers approaching the end of their initial teacher education and practising primary teachers with whom they worked as part of their final mathematics curriculum unit. The study arose in the context of an approach to delivering the final mathematics curriculum unit for pre-service primary teachers engaged in a 4-year Bachelors degree that involved the pre-service teachers working in school classrooms with students and collaborating with practising teachers who assumed a mentoring role. We anticipated that the approach might reduce the perceived dichotomy between the mathematics pedagogy that pre-service teachers are encouraged to adopt through their university studies, and the practices that they encounter in classrooms through their practical experiences (Taylor, 2002). It is also well established that pre-service teachers regard classroom experience as the best teacher (Richardson, 1996), and that the most

highly valued aspects of their university studies are those perceived as having greatest classroom relevance (Beswick, 2006) and so we hoped that the pre-service teachers would value the opportunity that the approach afforded for them to combine work in classrooms with their university studies. The approach was consistent with Van Es and Conroy's (2009) call for mathematics teacher education to prepare pre-service teachers better to teach mathematics with understanding by integrating theoretical and practical aspects of their preparation.

In relation to pre-service teachers' confidence we were aware that many of our pre-service teachers, like pre-service primary teachers elsewhere, would have commenced their studies with negative feelings about mathematics (Ball, 1990) and with little confidence in their own ability to learn and use the subject (Uusimaki & Nason, 2004). Because confidence to teach mathematics relates to activities that occur in classrooms and involves interactions with students we anticipated that working in classrooms in the role of teacher and documenting the growth of students' understanding in response to their teaching might lead to greater confidence to teach mathematics. Alternatively, encountering firsthand the challenges and complexities of helping students to develop their understanding of mathematics might result in what could be described as a realistic assessment of their ability to influence students' learning and hence result in diminished confidence about their own ability to teach.

Confidence

Burton (2004) drew attention to the common wisdom that links confidence and success in a mutually reinforcing spiral. Such a view is implicit in our hypothesis that witnessing successful learning in response to their teaching efforts would enhance pre-service teachers' confidence whereas awareness that not all teaching interventions are successful might reduce confidence. She also highlighted the differing meanings attached to 'confidence', conflicting findings about its relationship to achievement, and problematic extrapolations of achievement leading to confidence to regarding confidence as an indicator of ability.

Confidence has been considered to be a dimension of attitude often regarded as the opposite of anxiety (Ernest, 1988; Uusimaki & Nason, 2004). For Burton (2004) confidence was "a label for a confluence of feelings relating to beliefs about the self, and about one's efficacy to act within a social setting, in this case the mathematics classroom". Confidence, according to this definition, has a strongly emotional character as well as being related to the specific contexts. Emotions have traditionally been regarded as distinct from cognition (McLeod, 1992; Philipp, 2007) and at the most unstable end of the spectrum of affects encompassing beliefs, attitudes and emotions (McLeod, 1992). Hannula (2002) justified the distinction between emotion and cognition in terms of the physiological differences: cognition involves neural activity whereas emotions are associated with other physiological reactions. Nevertheless, he argued that neither can be understood fully in isolation. Therefore, similarly to Hannula's (2002) categorisation of evaluations that contribute to attitude, the way in which an individual judges his/her confidence to teach a specific mathematical topic on a Likert scale depends upon the emotional response evoked by the mathematical topic itself and the prospect of teaching it, as well cognitive evaluations of his/her ability to teach it. These in turn are influenced by the context in which the evaluation is solicited, where context includes the temporal proximity to relevant experiences (e.g., how recently one has taught or anticipates teaching the topic, images of the general classroom environment in which the anticipated teaching might occur), and broader beliefs about oneself as a teacher and the importance of being able to teach the topic successfully.

Graven (2004) has theorised that confidence is both a result of learning (i.e., successful learning leads to increased confidence), and also a process (i.e., confidence contributes to learning). Graven (2004) argued that confidence was relevant to teachers' ability to access resources, to participate in mathematical activity, and to see themselves as competent

teachers of mathematics but with sufficient confidence to acknowledge that there remained much to learn. The developing confidence of the teachers in Graven's study emerged from interviews over a 2-year period that did not explicitly ask about confidence. The teachers' confidence appeared to grow as they increased their mastery of new ideas and practices and seemed also to be part of the process by which the teachers developed their identities as mathematic teachers. Confidence for Graven (2004) therefore appears to emerge from more stable and centrally held beliefs about one's self efficacy and identity as a mathematics teacher and thus is different from the emotive and highly contextual construct envisioned by Burton (2004).

Despite the centrality of confidence to teacher learning for Graven (2004), other research that used Likert scale responses to measure confidence has suggested that confidence is not necessarily indicative of appropriate knowledge for mathematics teaching (Beswick, Callingham, & Watson, 2011). The explanation of these apparently conflicting findings may lie in the differing constructs, both called confidence, which were accessed by the different methodologies employed. Yet, such a dichotomous view of confidence is also likely to be an oversimplification because even though emotions impact responses to Likert items such responses also involve cognitive evaluations. The relative influence of these aspects would be likely to vary both between individuals and with aspects of context such as those discussed earlier.

The Study

The study was conducted in conjunction with the final mathematics curriculum unit undertaken by fourth year pre-service teachers in a Bachelor of Education (Primary and Early Childhood) program. It involved the pre-service teachers, their university lecturers, primary school mentor teachers, and senior school staff collaborating in a university/school partnership. The partnership was instigated by the principal of one of the schools who saw potential benefits for all of the participants and the school students. The pre-service teachers were given the opportunity to work collaboratively with the classroom teachers in assessing, planning and teaching a small group of students for six consecutive weekly sessions. The pre-service teachers had already completed three half units of mathematics curriculum that each comprised a weekly 1-hour lecture and 1-hour tutorial over 13 weeks. The content covered spanned all of the strands of the primary mathematics curriculum integrated with pedagogy and taught with the aim of modelling appropriate teaching strategies and helping to ameliorate negative attitudes to the subject. The aim of the final unit was to assist the pre-service teachers to bring together the various aspects of knowledge for teaching mathematics that they had developed over the previous units and during practicum experiences. The integration of classroom based experience with university study in the final mathematics curriculum component of the course seemed an ideal context in which pre-service teachers could bring together and apply in a classroom context aspects of knowledge described by Shulman (1987) as knowledge of mathematics content, general pedagogy, mathematics curricula, students as learners of mathematics, and pedagogical content knowledge for mathematics teaching.

Participants

Of the 106 pre-service teachers enrolled in the unit, 96 chose to submit data for the study. Those who did not participate in the study were engaged in the unit in exactly the same way as those who did and care was taken to avoid identifying which were involved until assessment in the unit had been finalised. The 32 mentor teachers with whom the pre-service teachers worked and the leaders of the three primary schools involved in the collaboration also participated in the study.

The Bachelor of Education program was offered on two campuses and hence primary schools in two different cities were involved. The schools had approximate enrolments of

160, 260, and 380. The smallest school was located in a socio-economically disadvantaged city suburb whereas the other schools were in moderately socio-economically disadvantaged areas. The largest school was located in an inner suburb of a small regional city and the other was in an outer suburb of the larger city with an intake from some country areas as well as adjoining suburbs.

Questionnaires
Interview, field notes and classroom observations as well as questionnaires were used to collect data. For the current study only the questionnaire data are relevant.

All participants were invited to complete pre- and post-questionnaires. The initial versions of the questionnaires were identical for all participants and comprised six sections asking about: (1) expectations of the project; (2) confidence to teach mathematics; (3) beliefs about mathematics and numeracy in everyday life; (4) beliefs about mathematics in the classroom; (5) beliefs about mathematics teacher education; and (6) the respondent's role, gender, school or campus. Responses on 5-point Likert scales were required for items in Sections 2, 3, 4, and 5. In each case '5' represented the highest level of agreement or confidence, and '1' the lowest. Section 2 concerned respondents' confidence to teach various topics in the primary mathematics curriculum, all of which had received some attention in the previous units that the pre-service teachers had completed. Four of the items asked pre-service teachers to rate their confidence to develop each of the proficiency strands of the Australian Curriculum: Mathematics (Australian Curriculum Assessment and Reporting Authority, 2011), namely Understanding, Fluency, Reasoning and Problem Solving. The proficiency strands encapsulate aspects of mathematical thinking that had also been covered in the units undertaken prior to that which formed the context of this study, but some the particular language used in relation to them in the Australian Curriculum (e.g., fluency) was likely to have been relatively new to the pre-service teachers. The section comprised 21 items and is the focus of the current study.

Sections 2, 3, 4, and 5 were repeated on the final questionnaire for pre-service teachers but for mentor teachers and school leaders only Section 5 (dealing with beliefs about mathematics teacher education) was repeated. Both versions of the final questionnaire included a section comprising open-response items focussed on evaluating the approach used in the unit. All responses were anonymous with respondent devised codes used to match responses across the two questionnaires.

Procedure
Before the start of the semester the pre-service teachers were randomly divided into groups of approximately four and assigned to one of the participating mentor teachers. The random assignment to groups meant that the pre-service teachers were not necessarily assigned to a grade level that fell within their chosen specialisation: early childhood (Grades K-2) or primary (Grades 3-6). This was appropriate because all would be qualified to teach K-6 and it mirrored the realities of working in a real school with unfamiliar colleagues.

The initial questionnaires were distributed and completed in meetings on each campus that involved pre-service teachers, university lecturers, and school leaders. These meetings provided an opportunity for the university lecturers to explain the project, for school leaders to explain their expectations of both the project and the pre-service teachers, and for the groups of pre-service teachers to meet with their mentor teachers.

The mentor teachers identified the small groups of students with whom the pre-service teachers would work. In some cases these were students whom the mentor teachers believed would benefit from additional support and in other cases they were considered in need of extension. During the first six weeks of the semester the pre-service teachers attended weekly 2-hour on campus workshops/tutorials as well as meeting with their

colleague teachers at negotiated times. The focus of the pre-service teachers' activity during these weeks was planning and preparation for the subsequent six weekly teaching sessions. Their tasks included designing and administering agreed pre-assessment tasks to the groups of students and becoming familiar with the classroom environment and particular students with whom they would be working. University lecturers maintained contact with the schools and were available to the pre-service teachers for additional guidance on content and pedagogy as they planned for teaching and analysed student responses to the pre-assessment tasks.

During the weeks in which the pre-service teachers worked in the schools with the student groups they continued to meet regularly with their mentor teachers. University lecturers visited the pre-service teachers and mentor teachers at the school and remained available to both groups for advice and support. The semester ended with celebratory afternoon teas on each campus. The final questionnaires were administered at these events.

Pre- and post-project comparisons of questionnaire responses were made using *t*-tests and effect sizes (Cohen's *d*) were calculated by dividing the difference in means by the pooled standard deviation of the two groups as described by Becker (2000).

Results and Discussion

Table 1 shows the topics in relation to which there were significant differences in the mean reported confidence levels of mentor and pre-service teachers at the start of the project. Both groups were, on average, least confident to develop measurement formulae (Item 14) and to teach metric unit conversions (Item 15).

Table 1. Items eliciting significantly different responses from teachers and pre-service teachers

Item	Mean (teachers) N=30	Mean (pre-service teachers) N=96	Mean diff.(teacher-pre-service teacher)	Pooled Std dev.	Sig. (2-tailed)	Effect size, *d*
2. Mental computation with whole numbers	4.33	3.70	0.64	0.685	0.000*	0.93
7. Properties of 2D shapes	4.60	3.84	0.76	0.764	0.000*	0.99
9. Generalising number patterns	4.13	3.55	0.58	0.847	0.003*	0.69
10. Language of probability	4.16	3.51	0.66	0.834	0.000*	0.79
11. Drawing inferences from data	4.00	3.36	0.64	1.026	0.002*	0.62
14. Developing measurement formulae	2.13	3.22	-1.10	1.317	0.001*	-0.83
15. Converting metric units	2.47	3.24	-0.77	1.394	0.024*	-0.55
16. Summary statistics (mean, median, mode, range)	2.23	3.71	-1.48	1.510	0.000*	-0.98
17. Developing students' understanding	4.13	3.63	0.51	0.696	0.001*	0.73
19. Developing students' mathematical reasoning	3.80	3.28	0.52	0.824	0.004*	0.63

20. Developing students' mathematical fluency	3.67	3.26	0.41	0.756	0.014*	0.54

*p<0.05 ** p<0.01

The mentor teachers were, on average, more confident than the pre-service teachers to teach mental computation with whole numbers (Item 2), properties of two dimensional shapes (Item 7), generalising number patterns (item 9), the language of probability (Item 10), drawing inferences from data (Item 11), and developing students' mathematical understanding (Item 17), reasoning (Item 19), and fluency (Item 20). However, the pre-service teachers began the semester more confident than their mentor teachers in their ability to develop measurement formulae (Item 14), and to teach conversion of metric units (Item 15), and summary statistics (item 16). The effect sizes were medium for Items 9, 10, 11, 15, 17, 19 and 20, and large for Items 2, 7, 14, and 16.

The pre-service teachers finished the semester with mean confidence levels higher than at the start in relation to all of the aspects of the curriculum listed in Table 2. Effect sizes were small for Items 7, 14, 16 and 18, medium for Items 2, 3, 4, 5, 15, 20 and 21, and large for Items 12 and 19. The number of students completing the second questionnaire was much lower than the number who completed it initially and reflected the relatively low attendance by pre-service teachers at the final meeting.

Table 2. Items eliciting significantly different responses from pre-service teachers at the start and end of the semester

Item	Mean (initial) N=96	Mean (final) N=27	Mean diff.(final-initial)	Pooled Std. dev.	Sig. (2-tailed)	Effect size
2. Mental computation with whole numbers	3.67	4.15	0.45	0.763	0.007**	0.59
3. Equivalent fractions	3.14	3.93	0.79	1.067	0.001**	0.74
4. Decimal place value	3.32	4.00	0.68	1.023	0.004**	0.66
5. Percent increase and decrease	2.88	3.44	0.57	1.026	0.013	0.56
7. Properties of 2D shapes	3.84	4.26	0.42	0.869	0.036	0.48
12. Mental computation with rational numbers (fractions, decimals, percent)	2.85	3.70	0.85	1.052	0.000**	0.81
14. Developing measurement formulae	3.23	3.85	0.62	0.786	0.003**	0.44
15. Converting metric units	3.24	3.70	0.46	0.896	0.029	0.69
16. Summary statistics (mean, median, mode, range)	3.70	4.11	0.40	0.962	0.047	0.48
18. Developing students' problem solving abilities	3.48	4.11	0.63	0.863	0.000**	0.47
19. Developing students' mathematical reasoning	3.28	3.81	0.53	0.780	0.004**	0.81

20. Developing students' mathematical fluency	3.26	3.78	0.52	0.838	0.004**	0.64
21. Integrating ICTs in mathematics teaching	3.47	4.00	0.53	0.799	0.016*	0.65

*p<0.05 ** p<0.01

Items for which there were significant differences between the mean confidence of pre-service teachers at the end of the project and mentor teachers (measured at the start of the semester) are shown in Table 3. The mean confidence levels of the pre-service teachers were higher than for their mentor teachers in relation to teaching decimal place value (Item 4), percent increases and decreases (Item 5), mental computation with rational numbers (Item 12), developing measurement formulae (Item 14), teaching conversions among metric units (Item 15), and summary statistics (Item 16), and integrating ICTs in mathematics teaching (Item 21). Effect sizes were moderate for Items 5, 12 and 21, and large for Items 4, 14, 15, and 16.

Table 3. Items eliciting significantly different responses from teachers at the start of the semester and the pre-service teachers at the end of the semester

Item	Mean (teachers) N=30	Mean (pre-service teachers) N=27	Mean diff. (pre-service teacher-teacher)	Pooled Std dev.	Sig. (2-tailed)	Effect size, *d*
4. Decimal place value	2.80	4.00	1.20	1.349	0.001**	0.89
5. Percent increase and decrease	2.37	3.44	1.08	1.382	0.005**	0.78
12. Mental computation with rational numbers (fractions, decimals, percent)	2.73	3.70	0.97	1.370	0.011*	0.71
14. Developing measurement formulae	2.13	3.85	1.72	1.265	0.000**	1.36
15. Converting metric units	2.47	3.70	1.24	1.389	0.001**	0.89
16. Summary statistics (mean, median, mode, range)	2.23	4.11	1.88	1.449	0.000**	1.30
21. Integrating ICTs in mathematics teaching	3.34	4.00	0.66	0.930	0.011*	0.70

*p<0.05 ** p<0.01

There were four items for which there were no significant differences between the groups at either, the start and end of the project, or from the beginning to the end of the unit for the pre-service teachers. These were confidence to teach early number (Item 1), scaling up and down (Item 6), visualisation (Item 8), and length measurement (Item 13).

If we accept that improving pre-service teachers' confidence is a desirable outcome then the approach used in the unit appears to have been successful. There are, however, other

factors that may have influenced the results and that should be considered. Firstly, the extent of the positive impact of the semester on the pre-service teachers' confidence could be explained in part by the different numbers attending the initial and final meetings and hence completing the respective iterations of the questionnaire. It could be argued that more conscientious pre-service teachers may have been over-represented on the second occasion but even if this was the case there is no clear rationale for arguing that these pre-service teachers would be more confident than their peers.

Another possible explanation relates to the context in which the two questionnaires were administered. Although the physical spaces were the same the first questionnaire was administered in a session in which the novel approach to the unit was explained, expectations made clear and the pre-service teacher groups met together for the first time and were introduced to their mentor teachers. It is reasonable to assume that this occasion may have elicited feeling of nervousness and uncertainty for some pre-service and mentor teachers. Given the emotional character of confidence as defined by Burton (2004) the inherent stressfulness of the situation may have resulted in lower feelings of confidence on that occasion. In contrast, the final session was a celebratory event conducted when the required activities of the semester were complete and a holiday was imminent for all of the teachers. Any contribution of the respondents' emotional state to their ratings of their confidence would likely have been positive. Only the pre-service teachers completed the confidence section on this occasion and the comparisons between their mean confidence levels on this occasion and those of the mentor teachers at the start of the project may have been exaggerated by the differing emotional tenor of the two occasions.

To the extent that the confidence measures used in this study were accessing more cognitive evaluations of self-efficacy and hence a conceptualisation of confidence more aligned with that described by Graven (2004), the extent to which the results are positive depends upon the accuracy of the respondents' assessments of their abilities. Caution seems warranted, however. Beswick et al. (2011) found, using a similar instrument to that used in this study, that for practising teachers expressing confidence in their ability to teach topics was much easier than demonstrating even basic general pedagogical knowledge or pedagogical content knowledge for teaching mathematics. The fact that individual pre-service teachers were likely to have focussed on just one aspect of the curriculum content during the weeks that they worked with school students but there were significant increases in confidence across all content strands and most proficiency strands suggests that the improved confidence levels were not only indicative of improved mastery of knowledge and practices relevant to teaching the topics listed. However, if the pre-service teachers' confidence is, as Graven's (2004) study suggests, indicative of a change in their identities towards viewing themselves as capable teachers of mathematics in a way that influence not only their competence at the time but also their ability to recognise the need to continue to learn and indeed to continue learning then it can be seen as a positive development. The experience of working with students on a particular aspect of mathematics may have helped pre-service teachers to see themselves as able to learn and develop their expertise in relation to particular topic and hence improved their confidence that they could do the same in relation to other topics as required.

Conclusion

The data collected in this study showed significant improvements in the confidence ratings of pre-service teachers from the start to the finish of their final mathematics curriculum unit that was taught using a novel approach involving learning in both school and university contexts. Consideration of the nature of the emotional and cognitive nature of confidence as well as research that calls into question the connection between confidence and competence suggest caution in interpreting the improved confidence of pre-service teachers as a successful outcome. Further studies exploring the nature of the construct of confidence

evoked in various circumstances would be worthwhile. In particular, it would be useful to explore the extent to which increased confidence resulting from interventions such as this are reflective of pre-service teachers' evolving identities as competent teachers of mathematics. Improving pre-service teachers' confidence in this sense, rather than simply providing experiences that help them to feel better about teaching mathematics without necessarily addressing their competence or their capacity and inclination to continue to develop their competence, appears to be a goal of pre-service teacher education that promises lasting impact. The inclusion of qualitative data such as from interviews has potential to provide further insights into these issues.

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