PRE-SERVICE TEACHERS' NUMERACY VIEWS AND CAPABILITIES: A COMPARISON OF STUDENTS WITH STEM AND NON-STEM SPECIALISMS

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ABSTRACT

Strong numeracy skills are crucial in order for teachers to successfully integrate science, technology, engineering, and mathematics (STEM) in their teaching. In this study, we explored pre-service teachers' views of and capabilities in numeracy. Students in a Master of Teaching program at a prestigious Australian university who were enrolled in a unit about numeracy teaching and learning completed questionnaires before and after completing the unit about their views of and capabilities in numeracy. Here, we focus on the pre-unit questionnaire data from 2017 and 2018, drawing comparisons between the responses of secondary pre-service teachers with STEM (n = 18) and non-STEM (n = 25) subject area specialisms. We analysed two calculation questions (including the linked questions about the participants' confidence in their responses) and three questions about participants' views of numeracy and mathematics, to see if there were differences in the response patterns of the two groups. While the differences between the STEM and non-STEM groups were generally not statistically significant, there was a consistent pattern of the STEM students being more knowledgeable about numeracy and confident in their numeracy capabilities. These findings point to the importance of numeracy units in preparing all pre-service teachers to incorporate both numeracy and STEM in their teaching.

Keywords: *Numeracy, pre-service teachers, STEM vs. non-STEM specialisms*

INTRODUCTION

As argued by the STEM Partnerships Forum (2017), which is led by Australia's Chief Scientist, Alan Finkel, primary and secondary schools are not providing adequate STEM education, and students are not participating in – or achieving in – these subjects sufficiently well. To address these issues, the STEM Partnerships Forum (2017) suggested that these subjects need to be made "so compelling, so stimulating and so exciting that the student cannot help but be inspired to take up these subjects. This will require teachers who are confident in their discipline" (p. 5). The STEM Partnerships Forum further asserted that "An increasing focus on STEM skills should build on strong foundations in literacy and numeracy and be a part of a rich school education" (p. 6).

The importance of numeracy for teachers and students has also been recognised by several key educational bodies in Australia in recent years. Numeracy is one of seven general capabilities in the Australian Curriculum (Australian Curriculum, Assessment and Reporting Authority [ACARA], n.d.), which means that it is the responsibility of all teachers to develop students' numeracy capabilities. Numeracy is also a requirement in the Australian Professional Standards for Teachers (Australian Institute for Teaching and School Leadership [AITSL], 2017), with Standard 2.5 relating to developing numeracy capabilities in students and Standard 5.4 relating to interpreting student data. To assess whether pre-service teachers have adequate literacy and numeracy skills, the Australian Council for Education Research (ACER) introduced the Literacy and Numeracy Test for Initial Teacher Education (LANTITE) in 2016. All pre-service teachers must pass the LANTITE test – with passing indicating that they are in the top 30% of the Australian adult population with regard to personal literacy and numeracy skills – prior to graduation (ACER, n.d., 2018).

Here, we focus on pre-service teachers' numeracy views and capabilities. If teachers are prepared in such a manner that they are capable, confident, and knowledgeable about numeracy, it will serve them well in all of their teaching responsibilities, particularly those related to STEM, as STEM teaching is strongly predicated on numeracy capabilities and confidence. To explore these topics, we conducted research in which pre-service teachers at a prestigious Australian university completed questionnaires about their numeracy capabilities, confidence, and understandings, prior to and after completing a unit about numeracy teaching and learning.

GOALS AND OBJECTIVES

The goal of this paper is to investigate whether there are differences between secondary pre-service teachers with STEM and non-STEM subject area specialisms, in terms of their views of, confidence in, and capabilities in numeracy.

THEORETICAL FRAMEWORK

The present study was informed by the Australian Curriculum's expectations (ACARA, n.d.) that teachers of all subject areas develop their students' numeracy capabilities, as well as by the AITSL (2017) requirements related to graduating teachers' personal numeracy capabilities. Guiding the development of the unit of teaching that the participants were about to commence, and hence the study reported here, was the 21st Century Numeracy Model (Goos, Geiger, & Dole, 2014), a model that centres on using mathematics in context. The model is broadly aligned with a social constructivist theoretical stance on learning.

REVIEW OF LITERATURE

Steen (2007), a ground-breaking U.S. author on numeracy, clearly distinguished between mathematics (abstract) and numeracy (concrete and tangible) and claimed that "the need to understand and be able to use mathematics in daily life and work has never been greater" (p. 17). Current Australian Curriculum expectations are consistent with Steen's view. As noted above, all teachers are charged with the responsibility of developing students' numeracy skills. Together with the mandated pre-graduation personal numeracy test now in place, ongoing concerns about prospective teachers' numeracy understandings and capabilities are being enacted.

While internationally there is a large body of research on teachers' and prospective teachers' mathematical content knowledge, research on their numeracy capabilities is quite limited.

Via an online survey, an international dataset of practicing teachers' views of numeracy, mathematics, and the relationship between the two was gathered by Forgasz, Leder, and Hall (2017). Participants were teachers from all grade levels teaching across all subject areas. Focusing on responses from teachers in Australia, the U.S., and Canada, it was found that many from each country could not articulate what numeracy was, nor did they appear to appreciate contemporary perspectives on the relationship between mathematics and numeracy.

Forgasz, Leder, Geiger, and Kalkhoven (2015) conducted an exploratory study with 151 prospective teachers and found that, despite being generally capable of answering a series of numeracy items suitable for 15-year-olds correctly, about 50% of the participants did not believe they had studied sufficient mathematics to be competent teachers. In an earlier study, Watson and Moritz (2002) required prospective teachers to select a newspaper article that included numerical data and develop a lesson idea based on the content. They concluded that such tasks were likely to assist teachers to help their students "become quantitatively literate citizens" (p. 55).

No studies were found in which the views and/or capabilities of sub-groups of prospective or practicing secondary teachers about numeracy were compared. The present study addresses this issue.

METHODOLOGY

This project, now in its fourth year, involves pre-service teachers enrolled in a required unit about the teaching and learning of numeracy in the Master of Teaching (MTeach) program at a prestigious Australian university, herein referred to as University X. At the start and end of the semester, students were asked to complete online questionnaires about numeracy. In this paper, we focus on the pre-unit questionnaires completed by students in 2017 and 2018. It is only in the pre-unit questionnaire that students were required to answer questions gauging their numeracy capabilities.

Data Collection Instrument

The pre-unit questionnaire, a modification of a questionnaire created by Forgasz et al. (2015), contained both closed and open-ended questions. The questionnaire began with demographic questions (e.g., age, gender). Next, there was a section about participants' views of numeracy, mathematics, and teaching (e.g., relationship between mathematics and numeracy). The third section was comprised of six calculation questions, of which five were drawn from large-scale assessments of numeracy: the 2010 Year 9 NAPLAN test and the 2012 PISA test. After the participants completed each calculation question, they were asked to state their level of confidence in the accuracy of their response (i.e., right, wrong, unsure).

Here, we discuss the results from five items, of which three focused on the participants' views. Specifically, we considered (1) whether the participants thought that there was a difference between mathematics and numeracy, (2) the participants' views of their own mathematical ability, and (3) whether the participants thought that it is important for teachers to be good at mathematics. These three questions were all multiple-choice, with the response options "yes", "no", and "unsure" for the first and third questions. The second question had the following five response options: "weak", "below average", "average", "good", and "excellent".

Additionally, two calculation questions (with associated confidence questions) were analysed for this paper. The first question ("Code Question") required participants to calculate the total possible number of four-digit codes possible using a 10-digit (0-9) keypad. One example, 0051, was provided, as well as an image of a keypad. Participants typed their answers into a textbox. This question was selected because it had been previously found to have been answered poorly (Forgasz et al., 2017; Hall & Forgasz, 2017), and thus could be considered a difficult question. The second question ("Distance Question") was selected because it was considered to be of medium difficulty, based on previous analyses. This question required participants to select which distance (0.1203 km, 123 m, 1,230 cm, or 12,030 mm) was the longest, requiring an understanding of unit conversions.

Participants

There were 43 participants (2017: 33; 2018: 10) who identified themselves as secondary pre-service teachers and who answered questions beyond the demographic portion of the questionnaire. Most participants were women (67%) and students aged 25 and older (67%); this profile was reflective of the student population in the MTeach program generally. The students' subject area specialisms were classified into STEM (e.g., chemistry, mathematics) and non-STEM (e.g., business, visual art) groups: 18 STEM (42%) and 25 non-STEM (58%) students. The STEM students were evenly divided by gender, while the non-STEM students were mostly women (80%). Unsurprisingly, the majority (78%) of the STEM students had studied tertiary level mathematics, compared to only 16% of the non-STEM students.

Analyses

The questionnaire data were analysed several ways. The three "views" questions were all multiple-choice questions, and the findings were initially analysed through descriptive statistics. The responses to the Achievement Level Question were quantified (1 = weak to 5 = excellent) so that quantitative analyses could be conducted. The responses to these questions were analysed through two-way ANOVAs to compare the mean scores of the STEM students and non-STEM students.

The Code Question was coded as right (answer of 10,000), wrong (incorrect numerical answer or a response like "lots"), or blank (no response or a response like "I literally have no idea"). The wrong answers were also analysed for any trends (e.g., multiples of 10). The Traffic Light Question was multiple-choice, so the responses were analysed similarly to those for the "views" questions. The responses to the associated questions about the participants' confidence in their responses were analysed via cross-tabulations.

RESULTS AND DISCUSSION

In the following sections, we discuss the findings from our analysis of the three questions about the participants' views of mathematics, numeracy, and teaching, as well as the two calculation questions (both the accuracy and confidence of the responses).

Differences between Mathematics and Numeracy

The majority of students (33: 77%) believed that there was a difference between mathematics and numeracy, compared to three (7.1%) who did not believe that there was a difference and six (14.2%) who were unsure. Of those who believed there was a difference, there was a higher proportion of STEM (88%: 15) than non-STEM (72%: 18) STEM students. Only non-STEM students did not believe that there was a difference. A slightly higher proportion of non-STEM (16%: 4) than STEM (11.8%: 2) was unsure. The differences in the distributions of responses were not statistically significant.

Perceptions of Mathematical Ability

The mean score for the question "How good are you at mathematics?" was 3.53 (1 = weak to 5 = excellent), indicating that, on average, the participants saw themselves as being between "average" and "good" at mathematics. There were no statistically significant differences in the mean scores of STEM and non-STEM students. However, the mean score of STEM students was higher than that of non-STEM students (3.71 compared to 3.39).

Perceptions of the Importance of Teachers Being Good at Mathematics

The participants were asked whether it was important for teachers to be good at mathematics. The results are shown in Table 1.

Table 1. Participants' Perceptions of the Importance of Teachers Being Good at Mathematics

Is it important for teachers to be good at mathematics?	Yes	No	Unsure			
	26 (63%)	4 (10%)	11 (27%)			
	STEM (n = 17)			**Non-STEM (n = 24)**		
	Yes	***No***	***Unsure***	***Yes***	***No***	***Unsure***
	12 (71%)	2 (12%)	3 (17%)	14 (58%)	2 (8%)	8 (33%)

While a majority of the participants agreed that it was important for teachers to be good at mathematics (63%), more STEM students (71%) than non-STEM students (58%) agreed. The reverse pattern held true for "unsure" responses, with more non-STEM students (33%) than STEM students (17%) indicating uncertainty. However, the differences in the response patterns for the two groups were not statistically significant.

Numeracy Capabilities and Confidence

The STEM students' and non-STEM students' correct and incorrect responses to the two calculation questions and levels of confidence by subgroup who answered correctly and incorrectly are shown in Table 2.

Table 2. Comparisons between STEM and non-STEM Students on Two Calculation Questions

Distance Question	STEM (n = 16)						Non-STEM (n = 23)					
	Correct			***Incorrect***			***Correct***			***Incorrect***		
	13 (81%)			3(19%)			19 (83%)			4 (17%)		
Confident correct?	***Y***	***N***	***U***	***Y***	***N***	***U***	***Y***	***N***	***U***	***Y***	***N***	***U***
	13	0	0	1	0	2	15	3	1	2	0	2
	100%			33%		67%	79%	16%	5%	50%		50%
Code Question	**STEM (n = 15)**						**Non-STEM (n = 19)**					
	Correct			***Incorrect***			***Correct***			***Incorrect***		
	10 (67%)			5 (33%)			7 (37%)			12 (63%)		
Confident correct?	***Y***	***N***	***U***	***Y***	***N***	***U***	***Y***	***N***	***U***	***Y***	***N***	***U***
	8	0	2	1	1	3	7	0	0	1	4	7
	80%		20%	20%	20%	60%	100%			8%	33%	58%

For the Distance Question, similarly high proportions of STEM (81%) and non-STEM students (83%) were correct. However, of those who answered correctly, a higher proportion of STEM than non-STEM students was confident that their answers were correct (100% compared to 79%).

A higher proportion of non-STEM students (24.0%) than STEM students (16.7%) left the Code Question blank. The fact that this was not a multiple-choice question arguably contributed to this high rate of blank responses, as participants (a) may not have wanted to take the time to type a response or (b) may not have had any idea how to respond and could not simply randomly select from the provided responses. Of the participants who provided a response, nearly twice the proportion of STEM students (67%) than non-STEM students (37%) was correct. Interestingly, of those who were correct, all the non-STEM students, but only 80% of the STEM students, were confident that their answers were correct. This is the reverse pattern of confidence to the Distance Question. It may be the case that only the non-STEM students who were very confident about this topic attempted this question. For those whose answers were incorrect, there was a similar pattern of the levels of confidence of answers provided for the STEM and non-STEM students. There were no patterns in the incorrect answers to the Code Question. Incorrect answers ranged from 8 to 40,000,000, and many seemed like complete guesses (e.g., "11107", "1048576").

CONCLUSIONS AND SIGNIFICANCE

In this paper, we compared the responses of two groups of secondary pre-service teachers – those with STEM specialisms and those with non-STEM specialisms – on a questionnaire about numeracy views, capabilities, and confidence. Compared to the non-STEM students, the STEM students tended to be more knowledgeable about numeracy, have more confidence in their own numeracy capabilities, and perform better on calculation questions; however, the differences between the groups were not statistically significant.

Nonetheless, it is important to pay heed to these differences, as they may be practically significant. The mandatory numeracy teaching and learning unit at University X plays an important role in assisting all pre-service teachers to develop a better understanding of numeracy, particularly its role in teaching. Recall that the findings presented here are from pre-unit questionnaires and, as such, reflect students' views, confidence, and capabilities before engaging with unit materials. From our prior research (Authors, 2016, 2017), we know that the unit plays an important role in helping pre-service teachers to become more confident about their own numeracy capabilities and about incorporating numeracy in their teaching, as well as to be more knowledgeable about numeracy. Having increased confidence and understandings about numeracy will support teachers to address the requirements of the Australian Curriculum (ACARA, n.d.) and the Australian Professional Standards for Teachers (AITSL, 2017). An increase in confidence and knowledge about numeracy will support teachers to address the demands of an increasingly STEM-focused education.

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