

2019

Learning about Numeracy: The Impact of a Compulsory Unit on Pre-service Teachers' Understandings and Beliefs

Helen J. Forgasz

Monash University, helen.forgasz@monash.edu

Jennifer Hall

Monash University, jennifer.hall@monash.edu

Recommended Citation

Forgasz, H. J., & Hall, J. (2019). Learning about Numeracy: The Impact of a Compulsory Unit on Pre-service Teachers' Understandings and Beliefs. *Australian Journal of Teacher Education*, 44(2).
<http://dx.doi.org/10.14221/ajte.2018v44n2.2>

This Journal Article is posted at Research Online.
<https://ro.ecu.edu.au/ajte/vol44/iss2/2>

Learning about Numeracy: The Impact of a Compulsory Unit on Pre-Service Teachers' Understandings and Beliefs

Helen J. Forgasz
Jennifer Hall
Monash University

Abstract: In 2015, a new Master of Teaching coursework unit, Numeracy for Learners and Teachers, was introduced at Monash University in Melbourne, Australia. The drivers for the establishment of the unit were the Australian Institute for Teaching and School Leadership numeracy standards for graduate teachers and the inclusion of numeracy as a general capability in the Australian Curriculum. In this article, we describe the content and organisation of the unit. An evaluation was conducted with students in each of the years 2015-2017. Data included pre- and post-unit surveys and interviews. Findings indicated that students had fairly good numeracy skills on entry to the unit, and that as a consequence of studying the unit, their understanding of the relationship between numeracy and mathematics improved, as did their confidence to incorporate numeracy into their teaching across the curriculum.

Introduction

The concept of numeracy (i.e., mathematical literacy) has a long history. More than a half-century ago, numeracy was defined as the mirror image of literacy (Crowther, 1959). Cockcroft (1982) maintained that it was “the responsibility of teachers of mathematics and other subjects to equip children with the skills of numeracy” (p. ix). In the Australian Association of Mathematics Teachers’ (1997) policy on numeracy, a definition of what it is to be numerate was provided: “to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life” (p. 2).

There were two main drivers for the introduction of a new unit, Numeracy for Learners and Teachers (NLT), which was introduced into the Master of Teaching program at Monash University in Melbourne, Australia in 2015: (1) The graduate expectations of the Australian Institute for Teaching and School Leadership (AITSL, 2014) and (2) The curriculum expectations and pedagogy associated with numeracy, one of seven general capabilities in the Australian Curriculum (Australian Curriculum, Assessment and Reporting Authority [ACARA], n.d.).

The AITSL standards for teachers include a Literacy and Numeracy Strategies standard (2.5): Graduates are expected to “know and understand literacy and numeracy teaching strategies and their application in teaching areas” (AITSL, 2014). Additionally, according to Standard 5.4, they are expected to be able to demonstrate the capacity “to interpret student assessment data to evaluate student learning and modify teaching practice” (AITSL, 2014). According to AITSL (2015), the accreditation of any pre-service teacher education course across Australia is founded in ensuring “that all graduates of initial teacher education meet the Australian Professional Standards for Teachers at the Graduate career stage” (p. 2).

All Australian teachers are also charged with developing students' numeracy capabilities, per the Australian Curriculum (ACARA, n.d.). Numeracy is one of seven general capabilities in the Australian Curriculum. According to ACARA (n.d.), "The general capabilities play a significant role in the Australian Curriculum in equipping young Australians to live and work successfully in the twenty-first century." In the Australian Curriculum, numeracy is defined as encompassing:

the knowledge, skills, behaviours and dispositions that students need to use mathematics in a wide range of situations. It involves students recognising and understanding the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully. (ACARA, n.d.)

Although "preservice teachers are expected to teach their students for numerate participation in a global world... they themselves oftentimes lack the necessary mathematical foundations and strategic and critical skills" (Klein, 2008, p. 321). It should be noted that the focus of the unit (NLT) was not on teaching these foundational mathematical skills but on teaching pre-service teachers how they can seize opportunities within the full range of disciplines encompassed by the curriculum to develop students' numeracy capabilities, as well as to develop the numeracy capabilities that they themselves need outside the classroom for the teaching profession. For pre-service teachers who felt that their mathematical skills were lacking or needing revision, opportunities to revise and sharpen their mathematical knowledge and skills were provided through online "Mathematics Self-Help Kiosks," a bank of mathematics learning resources that they could access and work through independently. The kiosks covered a range of mathematical topics that were particularly relevant to the unit, such as proportional reasoning, basic algebra, and collecting and analysing data.

Content of Numeracy for Learners and Teachers (NLT)

The guiding principles underpinning the development of the unit were that our teacher education students (1) develop an understanding of what numeracy is and how it relates to mathematics, (2) learn to recognise numeracy opportunities across the curriculum, and (3) identify ways to engage their future students in relevant and critically challenging curriculum-based activities that would build numeracy skills. The 21st Century Numeracy Model (Goos, Geiger, & Dole, 2014) was central to the pedagogy and the numeracy lesson ideas with which the Master of Teaching students engaged during the unit, and also learned to plan, devise, and implement. The model is illustrated in Figure 1.

As can be seen in Figure 1, context is central to the 21st Century Numeracy Model. Contexts can be work-related, personal/social, or related to citizenship. Within the Australian Curriculum framework, numeracy tasks span all curricular disciplines, and in teachers' workplaces (schools), numeracy demands are broad (e.g., assessment, budgeting). To undertake and complete a numeracy task, mathematical knowledge is drawn upon, positive dispositions are needed, and tools may be required. The critical orientation dimension of the model involves using mathematical information to make decisions, support arguments, and challenge positions.

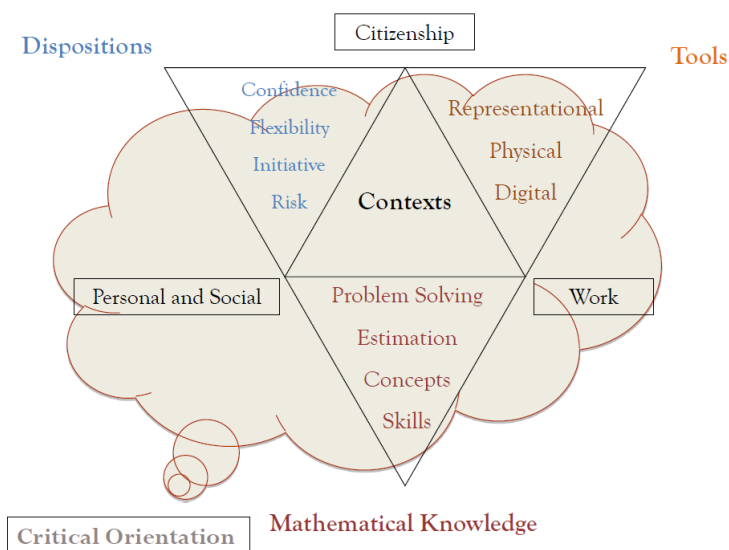


Figure 1: 21st Century Numeracy Model (Goos et al., 2014)

The Master of Teaching (MTeach) program at Monash University has five pre-service teacher education streams, preparing teachers to teach children in Early Years (birth to 8 years of age), Early Years/Primary (birth to Year 6), Primary (Foundation to Year 6), Primary/Secondary (Foundation to Year 12), and Secondary (Years 7 to 12). NLT is a core unit studied by students enrolled in all streams except Early Years, and is delivered face-to-face for on-campus students and online to off-campus students. The unit was divided into nine modules, as the teaching semester of 12 weeks also includes three weeks of professional experience (teaching placement). All teaching materials were uploaded to Moodle (an online learning platform) for off-campus students to work through and for on-campus students to draw upon. In response to students’ and lecturers’ feedback, slight changes were made each year to the topics and the order in which they were scheduled. In Table 1, an overview of the topics by year is provided.

Week	2015	2016	2017
1	Introduction: What is numeracy?	Introduction: What is numeracy?	Introduction: What is numeracy?
2	Persuasive writing/literacy*	Persuasive writing/literacy	Persuasive writing/literacy
3	Health, well-being, and body image	Health, well-being, and physical education	Health, well-being, and physical education
4	Sustainability	Science and geography	Science and geography
5	Visual, graphic, and performing arts	Statistical literacy for teaching and assessment	Statistical literacy for teaching and assessment
6	Critical orientation and statistical literacy	Financial literacy	Financial literacy
7	History	History	History
8	Technology	The arts	The arts
9	Financial literacy	Technology	Technology

Note: Other than Weeks 1, 6, and 9 in 2015 (and similar topics in 2016 and 2017), the weekly topics were titled ‘Numeracy and [topic]’.

Table 1: Schedule of topics: Numeracy for Learners and Teachers unit, 2015-2017

On-campus students were expected to engage with the weekly online lecture (30 minutes long) prior to attending tutorial classes, which were 1.5 hours long in 2015 and two hours long in 2016 and 2017. Students were also expected to spend additional time (approximately 30 minutes per week) engaging with additional (provided) resources on the

weekly topics (readings, video clips, and websites). For off-campus students, the online lecture and tutorial materials (similar to those engaged in face-to-face by on-campus students) were posted on Moodle.

There were two assignments for the unit. The first involved four short tasks based on the work covered in Weeks 1-4; the second included responses (posted to online discussion forums) to provocative statements or questions (“Conversation Starters”) related to the work covered in four later weeks of the unit. In 2015 and 2016, students completed two written tasks in the second assignment: a lesson idea founded in Australian Curriculum content to build students’ numeracy capabilities, and the interpretation of National Assessment Program for Literacy and Numeracy¹ (NAPLAN; for details, see National Assessment Program, 2016) data to exemplify the numeracy demands in their future work as teachers. In 2017, additional weight/length was given to the Conversation Starter and NAPLAN tasks, while the lesson task was eliminated.

As noted earlier, all students had access to the online Mathematics Self-Help Kiosks, where various resources were provided for those wishing to refresh their skills in a range of mathematics content areas. Students could also complete quizzes to check their understanding. Using the Mathematics Self-Help Kiosks was not an integral component of the unit, but in providing this opportunity for students, there was the potential to address the deficiency in teacher education programs identified by Klein (2008).

Pertinent research that guided the design of the unit and foregrounded the research undertaken is discussed next.

Literature Review

In the 1990s and into the 21st century in Australia, the definition of numeracy and its place in Australian schooling evolved into what is now encompassed in the Australian Curriculum. An overview of this work, the people involved, and the ensuing government policies are provided by the Queensland Board of Teacher Registration (2005). Recognising that there was much research on pre-service teachers’ mathematical capabilities, it was claimed that “There appears to be no research on the numeracy skills of preservice teachers on graduation” (Queensland Board of Teacher Registration, 2005, p. 42). Since that time, research on numeracy and Australian pre-service teacher education students has remained limited. Hence, the literature review includes what is known about pre-service and practicing teachers’ views of numeracy and their experiences incorporating numeracy into their pedagogical approaches, as well as the inclusion of numeracy into pre-service education programs. Australian literature is presented first, followed by reports from international contexts.

Australian Research

Watson and Moritz (2002) reported on a quantitative literacy (i.e., numeracy) component of a mathematics unit in a Bachelor of Teaching program at the University of Tasmania. A website focussing on chance and data in the news (drawn from the *Hobart Mercury* newspaper) had been developed earlier. Students were required to select one article and complete four tasks, including the development of a lesson idea to be implemented while

¹ NAPLAN is the Australian national testing program. Each year, school students in Years 3, 5, 7, and 9 complete tests in reading, writing, spelling, grammar and punctuation, and numeracy.

on practicum. Watson and Moritz (2002) concluded that “projects like this quantitative literacy project will assist teachers to help high school graduates become quantitatively literate citizens in society” (p. 54).

Leder, Forgasz, Kalkhoven, and Geiger (2015) completed a pilot study with teacher education students enrolled at an Australian university. The instrument used was a pre-cursor to the one adopted in the present study. The majority of the participants recognised the importance of mathematics and its applications in everyday life (i.e., numeracy), but fewer than 50% believed that there were mathematical demands on teachers beyond their classrooms. Leder et al. (2015) claimed that this finding was likely to have particular relevance to teacher education students for whom mathematics was not a teaching specialism, as these students were considered less likely to be able to deal adequately with the full range of potential numeracy demands.

Geiger, Forgasz, and Goos (2015) reported findings from an Australian study in which practicing teachers (not all of whom taught mathematics) were involved in a professional development program focussing on the incorporation of numeracy activities in all school subjects. The program was based on the 21st Century Numeracy Model (Goos et al., 2014). The critical dimension of the model, involving decision-making and justification, proved more challenging than the other dimensions of the model to incorporate into lesson ideas. Geiger et al. (2015) concluded that “the professional learning program based on the numeracy model provided sufficient support for teachers to design and implement numeracy activities in subjects other than mathematics” (p. 622).

There has been some research on teachers’ views of numeracy. Forgasz, Leder, and Hall (2017) reported on an international sample of practicing teachers’ views of numeracy, mathematics, and the relationship between the two. The data were gathered via an online survey using Facebook advertising to recruit respondents. Participants were teachers from all grade levels who taught across all subject disciplines. Forgasz et al. (2017) focused on findings from teachers in three countries (Australia, USA, and Canada). It was found that “Many in each group could not articulate what numeracy is, nor did they seem to appreciate contemporary understandings of the relationship between mathematics and numeracy” (Forgasz et al., 2017, p. 17).

International Research

Internationally, terminology other than “numeracy” is often used, the most common being quantitative literacy, mathematical literacy (e.g., in the Programme for International Student Assessment [PISA]), and critical mathematics (which focuses on social justice contexts).

There has been some research reported on practicing teachers’ numeracy skills, and on pre-service teacher education students’ self-efficacy beliefs about numeracy. Using data from each of 15 countries that had participated in the Programme for the International Assessment of Adult Competencies (PIAAC) and the Adult Literacy and Life Skills Survey (ALL), Golsteyn, Vermeulen, and de Wolf (2016) compared the performance of teachers with that of the other adults in the samples. The researchers found that in virtually all countries, teachers were more highly skilled in both literacy and numeracy than the average respondent. For all respondents, strong correlations were reported between literacy and the numeracy scores.

Arslan and Yavuz (2012) gathered survey data on the self-efficacy beliefs about mathematical literacy of pre-service mathematics and physics teachers in Turkey. The researchers found no statistically significant differences in the belief measures for the

mathematics and physics pre-service teachers, nor were there any gender differences. However, the mean scores for the pre-service physics teachers and the males were higher than for their respective counterparts.

Unlike in Australia, where numeracy is a general capability to be developed in all subject areas by teachers at all grade levels, in South Africa, Mathematical Literacy (ML) is a school subject offered as an alternative for students who do not study traditional mathematics subjects in Grades 10-12 (Bansilal, Webb, & James, 2015). The perceptions of this subject have been fairly negative. Botha (2011), for example, claimed that ML had been considered as “the dumping ground for mathematics underperformers” (n.d.) by some people both within and beyond the classroom, and that some principals believed that teachers of subjects other than mathematics can teach ML. Based on a study of two teacher education programs for ML teachers, Bansilal et al. (2015) suggested the content and emphases of pre-service programs that are required to best prepare teachers of ML: ML knowledge for teaching and cognisance of the contextual attribute demands in line with policy, as well as rigorous content knowledge with an emphasis on reflective practices.

The Study

As mentioned, NLT was introduced in 2015. From the outset, we decided that more information about the outcomes of students’ experiences in the unit was desirable than would be provided by the Monash University official unit evaluation process. This research was conducted with the permission of the Dean of the Faculty of Education and the Monash University Ethics Committee.

Aims

We had several aims in this study:

- to gauge students’ views of numeracy, mathematics, the relationship between numeracy and mathematics, and the role of numeracy in teaching
- to investigate students’ numeracy skills and confidence in their numeracy capabilities
- to determine whether their perspectives following participation in the unit were different from their prior held views

Research Design

As with the conception and implementation of the unit itself, our research was framed by the 21st Century Numeracy Model (Goos et al., 2014), which is consistent with a social constructivist theoretical stance. To investigate students’ views of and experiences with numeracy and the unit, we employed a mixed-methods design. Namely, data were collected through online surveys, before and after the unit was taught. Additionally, in 2015 and 2016, semi-structured interviews were held after the unit had finished. Interviews were not conducted in 2017 as they had not been found to substantially add to the survey datasets.

In this article, we focus on the pre- and post-unit surveys completed by the students in the Numeracy for Learners and Teachers (NLT) unit. The surveys were completed anonymously by participants; this meant that pre- and post-unit responses could only be considered in aggregate. In the following sections, we discuss the pre- and post-unit survey design, participants, and methods of data analysis.

Survey Design

The online surveys were developed in Qualtrics and featured a mix of open-ended (e.g., definitions, explanations) and closed items (e.g., yes/no/unsure responses, Likert-type response formats). The first two sections of the survey were identical in both iterations. The first section was comprised of a few demographic questions (e.g., age range, educational background), while the next section featured open-ended questions regarding the participants' definitions of "numeracy" and "mathematics," as well as the connection between these two concepts. In this section, participants were also asked about their perceptions of their own mathematics abilities (in general and for teaching) and about the numeracy demands on teachers.

The third section of the pre-unit survey featured six mathematical skills questions set in context (that is, numeracy questions), two of which had multiple parts. Three of the questions were drawn from the 2010 (publicly available) Year 9 NAPLAN test and two from the released 2012 PISA items (used with permission); the sixth question (interpretation of NAPLAN data) was developed by the researchers and their colleagues and is not discussed in this article. The five questions discussed in this article addressed mathematical topics such as basic arithmetic, unit conversions, combinatorics, and interpreting data from a table. For each of the numeracy questions, participants were asked to indicate the level of confidence in their responses, that is, whether they believed their answer to be correct ("yes"), incorrect ("no"), or if they were uncertain about their answer ("unsure"). In the final section of the pre-unit survey, volunteers for the interview portion of the research were sought (in 2015 and 2016), and participants were given an opportunity to provide feedback on the survey. In the final section of the post-unit survey, students were asked to indicate their pre-unit and post-unit levels of confidence in incorporating numeracy into their teaching, provide feedback on the unit, and share their "take-away" message from the unit. As with the pre-unit iteration, participants could also provide feedback on the survey in this section.

In this article, we report on the participants' numeracy skills evident on entry to the unit and their confidence in their answers. To do so, we assessed their responses to the five numeracy questions described previously. Additionally, by comparing pre- and post-unit survey responses, we report on the students' changing views of the relationship between numeracy and mathematics, as well as their perceptions of the numeracy demands on teachers. Finally, based on responses to the post-unit survey, we examine their perceptions of the pre- and post-unit confidence to incorporate numeracy into their teaching, and discuss their feedback on the unit.

Participants

All students who were enrolled in NLT were invited to complete the surveys via discussion forum posts on the unit's Moodle site. In each case, the survey was open for approximately one week, at the start and end of the semester, respectively. The students in 2015 were in the second semester of the first year of their two-year MTeach teacher education program, while in 2016 and 2017, the students were in the first semester of the second year of their program. In 2015, the majority of the students enrolled in NLT were from the Primary/Secondary (P/S) and Secondary streams; in 2016, most were from the Early Years/Primary (EY/P) and Primary MTeach streams. In 2017, due to a scheduling change for NLT, students from all four MTeach streams were simultaneously enrolled in the unit. Herein, P/S and Secondary students are referred to as "Secondary" students, while EY/P and

Primary students are referred to as “Primary” students. Additional information about the cohorts is provided in Table 2.

	2015	2016	2017
Number of students	300	140	450
Prevalent course stream	Secondary (67%)	Primary (67%)	Secondary (70%)

Table 2: Cohort information for NLT students (2015-2017)

The Secondary students had a wide range of subject area specialisms (e.g., geography, visual arts, chemistry), and only a small number were preparing to become mathematics teachers. The Primary students were preparing to be generalist teachers; that is, they did not have subject area specialisms.

The demographic make-up of the participants in both the pre- and post-unit surveys was broadly representative of the cohorts of the MTeach program as a whole. Specific details about the pre- and post-unit survey participants are shown in Table 3.

	2015	2016	2017
Pre-unit survey			
Participants	53 began; 48 finished	46 began; 33 finished	75 began; 56 finished
Gender	81% female	90% female	76% female
Age	77% aged 25-34	80% aged 25-34	72% aged 25-34
Stream	Secondary (74%)	Primary (79%)	Secondary (69%)
Studied university mathematics?	No (66%)	No (78%)	No (70%)
Post-unit survey			
Participants	35 began; 21 finished	21 began; 13 finished	28 began; 17 finished
Gender	74% female	81% female	71% female
Age	74% ages 25-34	86% ages 25-34	79% ages 25-34
Stream	Secondary (80%)	Primary (90%)	Secondary (61%)
Studied university mathematics?	No (63%)	No (70%)	No (67%)

Table 3: Demographic information about pre- and post-unit survey participants

The lower response rate for the post-unit compared to the pre-unit surveys in each year was likely due to the timing of the data collection – the end of the semester, when students were busy completing assignments. Varying numbers of participants completed each question on each survey. The demographic profile of the post-unit respondents was similar to pre-unit respondents. In all three years, most participants were female, aged 25-34, and had not studied university-level mathematics. In 2015 and 2017, most of the participants were in the Secondary stream, while in 2016, most of the participants were in the Primary stream.

Data Analyses

The survey data were analysed in multiple ways. For the purposes of this paper, descriptive statistics (e.g., frequencies, percentages) were calculated for responses to the closed questions (e.g., multiple-choice numeracy and confidence level questions). Additionally, cross-tabulations were completed to compare the participants’ confidence and accuracy in their answers to the numeracy (calculation) questions. The responses to the open-ended questions were analysed through a process of emergent coding (Bogdan & Biklen, 2007; Creswell, 2014); that is, the responses were read multiple times and grouped into categories by response type. Two researchers coded the open-ended responses separately.

Consensus was reached on the categorisation of responses for which there were differences in the assigned codes (fewer than 5% of all responses).

Results

In the following sections, we discuss findings from our analysis of the pre- and post-unit survey data. To begin, we discuss the participants' accuracy and confidence in completing numeracy (calculation) questions on the pre-unit survey. Next, we focus on the participants' views of numeracy, mathematics, and their relationship, as well as numeracy's role in teaching more broadly. Then, we compare the pre-unit and post-unit survey data. Finally, we address the participants' views of the unit, as reported in the post-unit survey.

Numeracy (Calculation) Questions

The derivations of the five numeracy questions analysed in this study were described earlier. Of the five questions analysed, only the fifth question had multiple parts. After answering each question/part, respondents had to indicate their level of confidence in their answer by responding to the question, "Do you think your answer is correct?", and selecting from the "yes", "no", or "unsure" response options.

In the next section, the five questions are described first, followed by a discussion of the accuracy and confidence of the participants' responses.

The Five Questions

1. The Box Question focused on subtraction. Participants were shown two images of a box with a removable lid (lid on, lid off). They were informed that the box and lid had a total mass of 232 grams, while the box by itself had a mass of 186 grams. Participants were asked to calculate the mass of the lid and to select a response from the following options: 46 grams, 56 grams, 144 grams, or 54 grams.
2. The Traffic Light Question focused on fractions. Participants were told that "A set of traffic lights is red for half the time, orange for $\frac{1}{10}$ of the time, and green for the rest of the time." They were asked to determine what fraction of the time the lights are green. Participants had to select one of the following listed answers: $\frac{1}{3}$, $\frac{2}{5}$, $\frac{6}{10}$, and $\frac{10}{12}$.
3. The Distance Question focused on length unit conversions. Participants were asked to identify which distance was the longest of the following options: 0.1203 km, 123 m, 1,230 cm, and 12,030 mm.
4. The Code Question focused on combinatorics. Participants were asked how many four-digit codes were possible for a door with a keypad lock (0051 was provided as one possible combination). An image of a keypad with the numerals 0-9 as well as the asterisk (*) and hash (#) keys accompanied the question. Participants were required to type their answers into a text box.
5. The Car Question had three parts. A table with information about four cars was provided (year, price, etc.), and participants had to respond to questions based on this information. Part A focused on interpreting the data in the table, and participants had to select which car met certain conditions (e.g., made in the year 2000 or later). Part B focused on place value, and participants had to determine which car had the smallest

engine capacity by selecting from 1.79, 1.796, 1.82, or 1.783 litres. Part C focused on percentages, and participants had to calculate the value of 2.5% tax on one of the cars (selling price of \$4,800) and type their answers into a text box.

The participants' responses to the five questions and the levels of confidence in their answers are shown in Table 4.

	2015	2016	2017
Box Question			
	(n = 42)	(n = 29)	(n = 51)
Correct response (46 grams) selected	41 (98%)	29 (100%)	48 (94%)
Thought they were correct	37 (88%)	25 (86%)	47 (92%)
Traffic Light Question			
	(n = 44)	(n = 29)	(n = 51)
Correct response (2/5) selected	42 (95%)	27 (93%)	42 (82%)
Thought they were correct	40 (91%)	25 (86%)	42 (82%)
Distance Question			
	(n = 43)	(n = 29)	(n = 50)
Correct response (123 m) selected	37 (86%)	22 (76%)	41 (82%)
Thought they were correct	34 (79%)	21 (72%)	38 (76%)
Code Question			
	(n = 38)	(n = 24)	(n = 50)
Correct response (10,000) provided	22 (58%)	10 (42%)	21 (42%)
Thought they were correct	17 (45%)	9 (38%)	24 (48%)
Car Question			
Part A			
	(n = 42)	(n = 27)	(n = 48)
Correct response (Bolte car) selected	42 (100%)	26 (96%)	45 (94%)
Thought they were correct	42 (100%)	27 (100%)	45 (94%)
Part B			
	(n = 41)	(n = 27)	(n = 48)
Correct response (1.783 litres) selected	41 (100%)	26 (96%)	42 (88%)
Thought they were correct	41 (100%)	25 (93%)	45 (94%)
Part C			
	(n = 38)	(n = 24)	(n = 45)
Correct response (\$120 tax)*	30 (79%)	20 (83%)	38 (84%)
Thought they were correct	31 (82%)	21 (88%)	39 (87%)

Note: For this question, some participants misread the question and included the cost of the car plus the correct tax calculation in their answer (i.e., \$4,800 + \$120 tax = \$4,920); we counted this answer as correct.

Table 4: 2015-2017 participants' accuracy and confidence on the five numeracy questions

As can be seen in Table 4, the Box Question was completed by the participants with high rates of accuracy and confidence; this was unsurprising given its basic mathematical content (subtraction involving three-digit numbers). However, for each cohort, the participants were not as confident in their responses as they were accurate. The Traffic Light Question was completed by the participants with similarly high rates of accuracy and confidence. The Distance Question was completed with less accuracy and confidence than the previous two questions.

The Code Question was completed with the lowest rates of accuracy and confidence of the five questions considered. The participants in all three years provided responses that indicated their lack of understanding of this question/concept, such as "Literally I have no idea", "Lots", and "Not sure", as well as responses that seemed to just be guesses of large numbers (e.g., 40 million). Whilst these findings may indicate that combinatorics is poorly understood, that the question was open-ended may also have contributed to the low accuracy rates.

With respect to the Car Question, the first two parts (A and B) focused on reading data, including place value concepts, from a table and were completed with the highest levels of accuracy and confidence of all the questions considered. Nearly all participants in the three cohorts selected the correct answers and indicated that they were confident in their choices. A lower percentage of participants answered Part C (the tax calculation) correctly, compared to the percentages of participants who were correct for Parts A and B. In 2015, only 68% of the respondents ($n = 38$) provided the correct response of \$120 tax for Part C, but there was a further 11% who misread the question and provided the total price for the car of \$4,920 (i.e., \$4,800 + \$120 tax). Since it was clear that these students were able to correctly calculate the tax component, we categorised this response as correct. Thus, overall, 79% of respondents appeared to have completed the calculation correctly; similarly, in 2016 and 2017, 83% and 84%, respectively, appeared to have completed the required tax calculation correctly. As with the Code Question, the poorer outcome on Part C, compared to Parts A and B, may be partially attributable to the fact that it was also an open-ended item.

It was interesting to note that, with the exceptions of Parts A and C of the Car Question, the 2016 cohort (predominantly prospective Primary teachers) was less confident than the other two cohorts (predominantly prospective Secondary teachers) that their answers were correct, although the actual accuracy of their responses was not much different from those provided by the 2015 and 2017 cohorts. This finding for the MTeach primary students at Monash University does not support previous findings (e.g., Ball, Hill, & Bass, 2005; Ma, 1999) that primary teachers in general have weak mathematical skills.

General Views on Numeracy

Through a series of related open-ended and closed questions, participants' views of numeracy, mathematics, and the relationship between the two, as well as the role of numeracy in the profession of teaching more broadly, were investigated. Here, we report on responses to questions regarding the links between numeracy and mathematics, as well as participants' views of numeracy demands on teachers beyond what is taught in the classroom.

The responses of the participants to the two questions – “Do you believe there are differences between mathematics and numeracy?” (Yes/No/Unsure) and “Are there mathematical demands on teachers in schools apart from what is taught to students?” (Yes/No/Unsure) – on the pre-unit and post-unit surveys by cohort are shown in Table 5.

As shown by the data in Table 5, for both items, there was a higher “yes” response rate in the post-survey than in the pre-survey for each cohort of participants (figures in bold). This finding also serves as a positive outcome for the unit as, based on the theoretical and pedagogical underpinnings of the unit, “yes” was the expected response to both items. Although quite low, the post-survey “no” and “unsure” response rates to both items remain a challenge to those of us teaching the unit.

	2015		2016		2017	
	Do you believe there are differences between mathematics and numeracy?					
	Pre- ($n = 45$)	Post- ($n = 21$)	Pre- ($n = 29$)	Post- ($n = 13$)	Pre- ($n = 55$)	Post- ($n = 15$)
Yes	34 (76%)	20 (95%)	26 (90%)	12 (92%)	42 (76%)	14 (93%)
No	2 (4%)	0 (0%)	0 (0%)	1 (8%)	4 (7%)	0 (0%)

	9 (20%)	1 (5%)	3 (10%)	0 (0%)	9 (16%)	1 (7%)
Are there mathematical demands on teachers in schools apart from what is taught to students?						
	Pre- (n = 44)	Post- (n = 21)	Pre- (n = 28)	Post- (n = 13)	Pre- (n = 51)	Post- (n = 16)
Yes	28 (64%)	19 (90%)	21 (75%)	11 (85%)	30 (59%)	15 (94%)
No	3 (7%)	0 (0%)	0 (0%)	0 (0%)	2 (4%)	1 (6%)
Unsure	13 (30%)	2 (10%)	7 (25%)	2 (15%)	19 (37%)	0 (0%)

Note: Bolded figures represent the higher of the pre-unit and post-unit response rates for the two items for each cohort.

Table 5: Pre-unit and post-unit survey responses to two items, by cohort

The analyses of the “no” and “unsure” explanations provided for the participants’ responses to the item “Do you believe there are differences between mathematics and numeracy?” on the pre-unit survey were particularly revealing. Typical “no” and “unsure” responses included:

- No: The concept of the two being interrelated never really occurred to me until this subject. (2015)
- No: I genuinely have no idea. I would guess that numeracy is the language that allows us to engage in mathematics. (2015)
- Unsure: I had never really thought of Numeracy as separate to Mathematics. (2017)
- Unsure: Even the basic counting is adding which is a mathematical theory. So maths and numeracy there is little if any difference, except terminology, and where it is used. (2015)
- Unsure: I have heard numeracy and maths being referred to as the same thing in the past. For example, in primary school I remember the subject being called numeracy and in high school it changed to maths, even though we would work on the same concepts. Maths I relate to be more with direct numbers and problem solving whereas numeracy I consider it to be more broad and involves applying maths concepts to the world. (2017)

Amongst those who responded “yes” on the pre-unit survey, some demonstrated a good appreciation of the difference between mathematics and numeracy; the views of others were inconsistent with contemporary understandings. Typical examples included:

- Yes: They are similar but still has differences between each other. Numeracy is the ability to use maths into people's daily lives, for example, people use numeracy skill to solve the problem like reading the bus timetable etc. On the other hand, Maths is an exact study of calculus, equations and statistical analysis. (2017)
- Yes: While mathematics attempts to understand and study the use of numbers, numeracy is the actual use of it in everyday life and across all disciplines. (2017)
- Yes: One looks at what numbers are and the other looks at how numbers are used. (2016)
- Yes: Numeracy is an important aspect of mathematics, you cannot have mathematics without numeracy. (2017)
- Yes: Numeracy is the application of maths. (2017)

For the item “Are there mathematical demands on teachers in schools apart from what is taught to students?” on the pre-unit survey, some respondents were very perceptive, while others revealed that they had no idea:

- Yes: Teachers are involved in a lot of responsibilities in addition to teaching such as preparing a budget proposal, measuring the dimensions of a space, placing an order, making inferences from statistical data such as

students results' etc. all of which place a significant demand on the mathematical ability of teachers. (2017)

Yes: Teachers are required to keep to budgets, divide the class into smaller groups, calculate remaining class time and other schedules, create marked tests and calculate percentages, even tell time etc. which all require some level of numeracy and mathematical skill. (2017)

Yes: You need to calculate art materials when ordering, also your wage, hehe. (2017)

Unsure: I don't know. Probably. I haven't really thought about it before. (2015)

No: The demands aren't mathematical in nature, technically. The demands on teachers are really more about pedagogy and instruction. (2017)

Influence of Unit

In the last section of the post-unit survey, participants were asked specific questions about their experiences in the unit and the ways that their participation in it may have influenced their views about numeracy. Specifically, the questions were:

- Before commencing NLT, how confident were you about incorporating numeracy into the teaching of your subject areas(s)?
- After completing NLT, how confident are you about incorporating numeracy into the teaching of your subject area(s)?

Hence, at the end of the semester, the participants were reflecting on their confidence levels at the start of the semester as well as at the time that they completed the survey.

In Figures 2 to 4, the 2015 to 2017 participants' reported pre-unit and post-unit levels of confidence to incorporate numeracy into their teaching are shown.

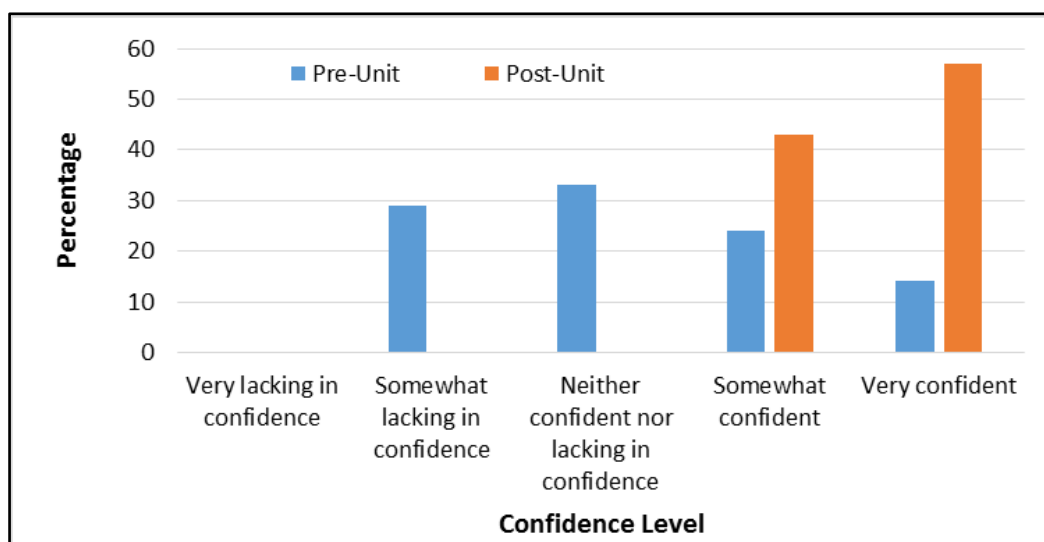


Figure 2: 2015 participants' reported pre- and post-unit confidence levels

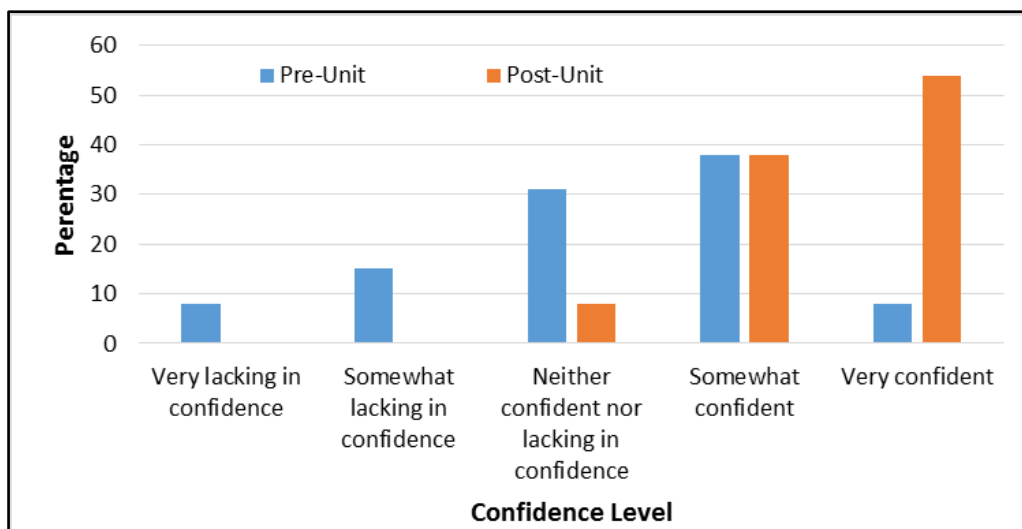


Figure 3: 2016 participants' reported pre- and post-unit confidence levels

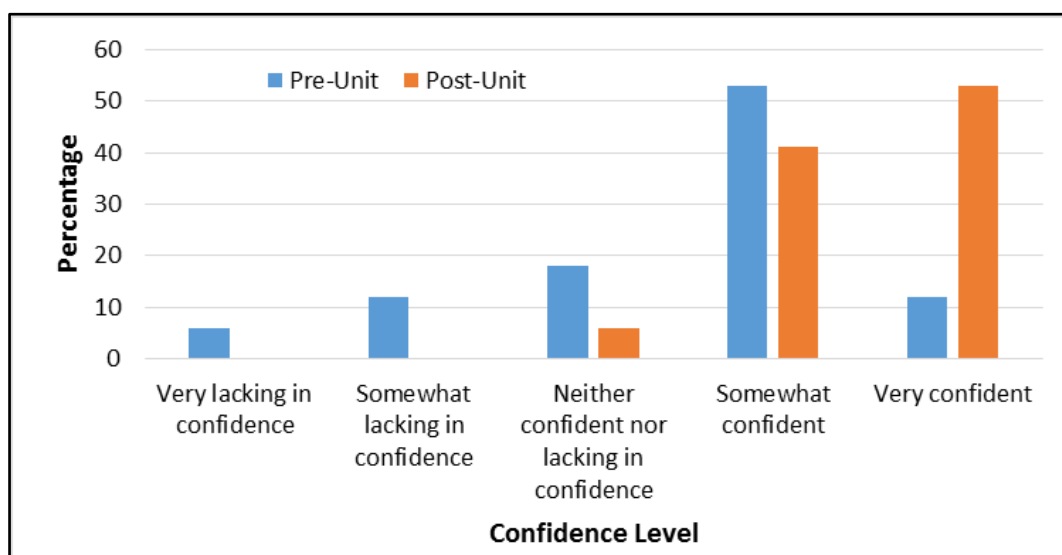


Figure 4: 2017 participants' reported pre- and post-unit confidence levels

As is clearly evident in Figures 2 to 4, the students' experiences in the unit impacted their reported levels of confidence. On the post-unit survey, large proportions of the participants (62% in 2015, 54% in 2016, and 36% in 2017) reported being less than "somewhat confident" before beginning the unit. In contrast, more than half of the participants (57% in 2015, 54% in 2016, and 53% in 2017) reported being very confident after completing the unit. Encouragingly, all but two participants (49 of 51 = 96%) over the three years reported being at least somewhat confident in their abilities to incorporate numeracy into their teaching after completing the unit.

Participants typically explained their changes in confidence levels as follows:

I have a clearer understanding of what numeracy entails, have been provided examples with how it would work in my method curriculum areas, and feel confident that I have adequate mathematical reasoning and numeracy skills to be able to handle this in my teaching. (2015)

I feel empowered and reassured that my 'average' knowledge of mathematics is enough to address it across the board of Primary school subjects. Through topic-based teaching I hope to engage in a variety of angles of approach, thus covering a number of curriculum demands at once. The demands of the

mathematics curriculum can definitely be incorporated alongside those of other subjects such as humanities, literacy, PE and Health, science and so on. (2016)
Being exposed to how numeracy can be incorporated in the teaching of different disciplines has made me be open to and aware of how I can utilise this in my future teaching as well. (2017)

Participants were also asked more generally if the unit had made an impact on their views of numeracy. In 2015, 21 participants responded to this question, compared to 13 in 2016 and 17 in 2017. Perhaps unsurprisingly, nearly all of the respondents (45 of 51, 88%) reported that their views had changed. Some representative responses included:

I did not know the word before this unit. (2015)

I now understand there is a difference between numeracy and mathematics. (2015)

I feel much more comfortable now to acknowledge its presence and make reference to it. I realise that I will have to teach specific mathematics lessons and address formulae and systems for working out problems, while numeracy will emerge as part of other subjects and the link with the specific mathematics concept can be made. For example, in a history and geography lesson we were talking about certain dates in history, which we then put into a timeline - this involved sequencing - then we decided to calculate how many years ago a specific date was. We therefore discussed first which mathematical formula we would need to use to calculate this. It also involved four digit numbers. So, in effect, I guided the children to momentarily 'step out' of the topic of history and we had a mini revision lesson on how to subtract large numbers. (2016)

I now understand how much numerical skills need to be explicitly taught in my subject areas and understand it is my responsibility to teach this - AITSL and curriculum requires it. (2016)

I can see math as being important now. I always thought it was somewhat boring and non-engaging but it actually is pretty fun. (2017)

I have realized that Numeracy is more accessible, and is easier to include in lessons than I had originally thought. (2017)

Fewer participants (17 in 2015, 12 in 2016, and 14 in 2017) responded to the question about their overall impressions of the unit, but the responses were quite informative, as well as being encouraging. Specifically, 33 (77%) of the 43 participants who responded to the question provided comments that were positive, with comments such as:

Brilliant course [unit]. My favourite. (2015)

Well taught, engaging and encouraging. Absolutely a necessary subject for MTeach. (2016)

I have really enjoyed it. The course content was very relevant and the essays were straightforward and appropriate to the unit and teaching. (2017)

It was an interesting unit, with lots of practical application. (2017)

There were also a few participants whose responses regarding overall impressions about the unit were mixed or negative. Specifically, there were four negative responses (9%) and six mixed responses (14%) across the three years of data. Examples of mixed and negative responses are provided below.

Interesting subject. Except the second assessment to interpret the NAPLAN wasn't fun! (mixed, 2017)

It seemed like a bit of a waste of time. The initial seminars seemed relevant to all teachers, but the majority of the following seminars were too specialised towards specific methods. To be honest I think this class could be taught in two weeks and should probably be grouped together with the Literacy subject (which

also doesn't need 12 weeks), and be called Teaching the General Capabilities. (negative, 2015)

Finally, when asked about the overall message that they would take away from the unit, the 39 participants who responded (15 in 2015, 13 in 2016, and 11 in 2017) tended to discuss the ubiquitous nature of numeracy/mathematics/numbers and the importance of numeracy for all teachers. These ideas are illustrated by the following comments:

Opportunities for numeracy can be found in many lessons/disciplines. Take advantage of them. (2015)

That my mathematical knowledge is not as 'average' as I initially thought and that the application of maths is what matters most. Furthermore, that I can incorporate mathematics and numeracy in a fun way into other subjects and that I can make children feel that it is not an intimidating subject to be feared, but one that is useful in understanding a variety of topics. (2016)

If I want my students to become informed decision makers, I need to create an environment where my students feel safe to explore what numeracy means not only in the subjects that they are learning but also in their everyday lives. (2016)

Mathematics should be useful in everyday life and can be engaging. Cross curricular activities should also be promoted and maths should not only be seen as an unmoving body of knowledge. (2017)

Anyone can teach numeracy in the class - dance teachers, musicians, health teachers - we all have the skills, just need to build our confidence. (2017)

Concluding Remarks

The expectation of a numerate citizenry primarily came to the fore in the late 20th century (Steen, 1999). However, the translation of this general expectation into educational systems took longer. In the Australian context, the expectation of students and teachers being numerate is explicit in the statement on the numeracy general capability in the Australian Curriculum (ACARA, n.d.), and in AITSL's (2014) professional standards for teachers.

The teacher education students, both Primary and Secondary, who participated in the study demonstrated relatively good background mathematical skills. With the exception of the Code Question, a question based on skills in combinatorics, for which approximately 50% provided the right answer, approximately 80% to 100% of the participants correctly answered each of the other questions. Since completion of an undergraduate bachelor's degree is the minimum pre-requisite for entry into the MTeach program, it was not surprising that the basic mathematical skill level of participants was generally good. However, it seems that mathematical combinatorics is a weakness for many. There may be other mathematics content areas, not tapped in the present study, that challenge some students. Even those who took advantage of the Mathematics Self-Help Kiosks provided alongside the NLT unit may still require additional support if they are to pass the Literacy and Numeracy Test for Initial Teacher Education Students (LANTITE), now a pre-requisite for graduation (See Australian Council for Educational Research, 2017, for details).

As demonstrated from our findings, participation in a numeracy-focused MTeach unit, Numeracy for Learners and Teachers (NLT), impacted participants' views and self-perceptions. In particular, the teacher education students became more confident about incorporating numeracy into their teaching within all subjects that they might teach, and garnered a much greater awareness of the differences between numeracy and mathematics. Additionally, participants became more aware of the potential out-of-classroom numeracy demands on teachers. When considering the participants' self-confidence in incorporating

numeracy in their teaching, it was most encouraging to see such an increase in confidence after the students had experienced the unit.

Since the participants in our study will soon be teaching in primary and secondary classrooms across a wide variety of subject areas, it is vital that they are not only aware of ways in which numeracy can be incorporated in their teaching, but also that they are confident in their ability to do so. This confidence includes not only their own abilities and understandings, but also their willingness to seek assistance from colleagues, provide support as required, and network with other teachers. So doing has the potential to lead to cross-curricular educational explorations, enriching the learning experiences of the students in their classrooms. In turn, their students' understandings of mathematical concepts may be strengthened and motivate them to venture into stimulating engagement with challenging mathematics both inside and outside the mathematics classroom. Some teacher education students may have already decided that they are not "maths people." Yet, if they are teaching a subject area in which they feel confident, they may be more willing to engage their future students in numeracy-based activities. Indeed, we witnessed this very phenomenon in our NLT classes. Students with performing and visual arts specialisms, for example, even those who identified themselves as weak at mathematics and anxious about incorporating numeracy into their teaching, were particularly engaged during the Arts week of the unit, and supported their peers from non-arts specialisms.

Arguably, some of the changes in the teacher education students' views were initiated in the first module of the unit, where various conceptions of numeracy, as well as the differences between numeracy and mathematics, were explored. As the unit progressed, students encountered classroom-based examples highlighting numeracy opportunities across a range of subject areas. Since confidence plays a role in the implementation of any new topic and/or pedagogy, the participants' increased confidence to incorporate numeracy into their teaching augurs well for the future of the next generation's numeracy capabilities.

References

- Arslan, C., & Yavuz, G. (2012). A study on mathematical literacy self-efficacy beliefs of prospective teachers. *Procedia - Social and Behavioral Sciences*, 46, 5622–5625. doi:10.1016/j.sbspro.2012.06.484 <https://doi.org/10.1016/j.sbspro.2012.06.484>
- Australian Association of Mathematics Teachers. (1997). *Policy on numeracy in schools*. Adelaide, Australia: Author. Retrieved from www.aamt.edu.au/content/download/724/19518/file/numpol.pdf
- Australian Council for Educational Research. (2017). *Literacy and numeracy test for initial teacher education students*. Retrieved from <https://teacheredtest.acer.edu.au/>
- Australian Curriculum, Assessment, and Reporting Authority. (n.d.). *General capabilities*. Retrieved from <http://www.australiancurriculum.edu.au/generalcapabilities/overview/introduction>
- Australian Curriculum, Assessment and Reporting Authority. (2016). *National assessment program*. Retrieved from <http://www.nap.edu.au/>
- Australian Institute for Teaching and School Leadership. (2014). *Australian professional standards for teachers*. Retrieved from <http://www.aitsl.edu.au/australian-professional-standards-for-teachers/standards/list>

- Australian Institute for Teaching and School Leadership. (2015). *Accreditation of initial teacher education programs in Australia: Standards and procedures*. Melbourne, Australia: Author. Retrieved from https://www.aitsl.edu.au/docs/default-source/default-document-library/accreditation-of-ite-programs-in-australiace118891b1e86477b58fff00006709da.pdf?sfvrsn=86f9ec3c_2
- Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator*, 29(1), 14-17, 20-22, 43-46. Retrieved from <http://www.aft.org/our-news/periodicals/american-educator>
- Bansilal, S., Webb, L., & James, A. (2015). Teacher training for mathematical literacy: A case study taking the past into the future. *South African Journal of Education*, 35(1), 1-10. <https://doi.org/10.15700/201503062356>
- Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research for education: An introduction to theories and methods* (2nd ed.). Boston, MA: Pearson/Allyn and Bacon.
- Botha, J. J. (2011). *Exploring mathematical literacy: The relationship between teachers' knowledge and beliefs and their instructional practices* (Unpublished doctoral dissertation). University of Pretoria, South Africa. Retrieved from <https://repository.up.ac.za/bitstream/handle/2263/28984/Complete.pdf?sequence=8>
- Cockcroft, W. H. (1982). *Mathematics counts: Report of the committee of inquiry into the teaching of mathematics in schools*. London, England: Her Majesty's Stationery Office. Retrieved from <http://www.educationengland.org.uk/documents/cockcroft/cockcroft1982.html>
- Creswell, J. W. (2014). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Sydney, Australia: Pearson.
- Crowther, G. (1959). *The Crowther Report. 15 to 18. A report of the Central Advisory Council for Education (England)*. London, England: Her Majesty's Stationery Office. Retrieved from <http://www.educationengland.org.uk/documents/crowther/>
- Forgasz, H. J., Leder, G., & Hall, J. (2017). Numeracy across the curriculum in Australian schools: Teacher education students' and practicing teachers' views and understandings of numeracy. *Numeracy*, 10(2), 1-20. <https://doi.org/10.5038/1936-4660.10.2.2>
- Geiger, V., Forgasz, H., & Goos, M. (2015). A critical orientation to numeracy across the curriculum. *ZDM: Mathematics Education*, 47(4), 611-624. <https://doi.org/10.1007/s11858-014-0648-1>
- Golsteyn, B. H. H., Vermeulen, S., & de Wolf, I. (2016). *Teacher literacy and numeracy skills: International evidence from PIAAC and ALL*. Retrieved from <http://ftp.iza.org/dp10252.pdf> <https://doi.org/10.1007/s10645-016-9284-1>
- Goos, M., Geiger, V., & Dole, S. (2014). Transforming professional practice in numeracy teaching. In Y. Li, E. Silver, & S. Li (Eds.), *Transforming mathematics instruction: Multiple approaches and practices* (pp. 81-102). New York, NY: Springer. https://doi.org/10.1007/978-3-319-04993-9_6
- Klein, M. (2008). Preservice teachers and numeracy education: Can poststructuralism contribute? In M. Goos, R. Brown, & K. Makar (Eds.), *Proceedings of the 31st Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 317-322). Freemantle, Australia: MERGA.
- Leder, G. C., Forgasz, H. J., Kalkhoven, N., & Geiger, V. S. (2015). Pre-service teachers and numeracy in and beyond the classroom. In M. Marshman, V. Geiger, & A. Bennison (Eds.), *Mathematics education in the margins: Proceedings of the 38th Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 349-356). Adelaide, Australia: MERGA

- Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of the fundamental mathematics in China and the United States*. Mahwah, NJ: Erlbaum.
- Queensland Board of Teacher Registration. (2006). *Numeracy in teacher education: The way forward in the 21st century. A report of the Numeracy in Preservice Teacher Education Working Party*. Brisbane, Australia: Author. Retrieved from https://www.qct.edu.au/pdf/Archive/BTR_NumeracyReport2005.pdf
- Steen, L. A. (1999). Numeracy: The new literacy for a data-drenched society. *Educational Leadership*, 57(2), 8-13. Retrieved from <http://www.ascd.org/publications/educational-leadership.aspx>
- Watson, J., & Moritz, J. (2002). Quantitative literacy for pre-service teachers via the internet. *Mathematics Teacher Education and Development*, 4(2002), 42-55. Retrieved from <http://www.merga.net.au/publications/mted.php>