Numeracy
Advancing Education in Quantitative Literacy

Volume 10 | Issue 2 Article 2

2017

Numeracy Across the Curriculum in Australian Schools: Teacher Education Students’ and Practicing Teachers’ Views and Understandings of Numeracy

Helen J. Forgasz
Monash University, helen.forgasz@monash.edu
Gilah Leder
Monash University, Gilah.Leder@monash.edu
Jennifer Hall
Monash University, jennifer.hall@monash.edu

Recommended Citation
Forgasz, Helen J., Gilah Leder, and Jennifer Hall. "Numeracy Across the Curriculum in Australian Schools: Teacher Education Students’ and Practicing Teachers’ Views and Understandings of Numeracy." *Numeracy* 10, Iss. 2 (2017): Article 2. DOI: http://doi.org/10.5038/1936-4660.10.2.2

Numeracy Across the Curriculum in Australian Schools: Teacher Education Students' and Practicing Teachers' Views and Understandings of Numeracy

Abstract

In this article, we confront the challenges to teacher education students and practicing teachers raised by the concept of numeracy and its place in the curriculum. In the Australian Curriculum, there is an expectation that teachers at all grade levels and in all subject areas develop students' numeracy capabilities. At Monash University, a public, research-intensive university, the largest university in Australia, graduate level teacher education students are now required to complete a course entitled *Numeracy for Learners and Teachers*. We describe the content of this course and, from an online survey, report findings of the impact on students' understandings of the relationship between numeracy and mathematics, their confidence and numeracy performance, and their readiness to incorporate numeracy in their teaching. Using a similar online survey, we also examine practicing teachers' confidence about their numeracy proficiency, their views on how numeracy and mathematics are related, and provide a snapshot of the teachers' actual numeracy capabilities. We discuss the implications of our findings.

Keywords

numeracy teachers, teacher education, numeracy education, numeracy vs. mathematics, Australian Curriculum, Monash University

Cover Page Footnote

Helen Forgasz is a Professor of Education at Monash University (Australia). Her research centres on equity issues in mathematics education, gender in particular. Her research has encompassed: grouping practices for learning (e.g., single-sex versus co-education); achievement and enrolment patterns in STEM subjects; technology in mathematics classrooms; and numeracy learning for all. Helen serves on the editorial boards of journals and book series, and is actively involved in scholarly associations. She has secured many large research grants, and has published widely in books, journals, and public media outlets. In 2017, she was a member of the team awarded the Mathematics Education Research Group of Australasia's 2017 Research Award (for recent contributions to numeracy research).

Gilah Leder is an Adjunct Professor at Monash University (Australia) and Professor Emerita at La Trobe University (Australia). Her research has focussed particularly on gender issues in mathematics education, on assessment, on exceptionality – predominantly high achievement, and on affective factors. Gilah is a Past President of the Mathematics Education Research Group of Australasia (MERGA) and of the International Group for the Psychology of Mathematics Education, a Fellow of the Academy of the Social Sciences in Australia, the recipient of the Felix Klein medal awarded for outstanding lifetime achievement in mathematics education research and development, and of the 2013 MERGA Career Research Medal.

Jennifer Hall is a Lecturer in Early Years/Primary Numeracy at Monash University (Australia). Her research focuses on the relationships that students form with mathematics, investigating how their in- and out-of-school experiences influence their views. She has a particular interest in exploring students' gendered relationships with mathematics and the ways in which gender-related research in mathematics education is conducted. Jennifer's research also focuses on pre-service teachers' experiences with and views of numeracy.

Introduction

The Australian Curriculum F-10 and Numeracy

Under the Commonwealth Constitution of Australia, responsibility for school educational provisions falls under the purview of each of the eight states/territories in the country (Australian Bureau of Statistics [ABS] 2012) (see Table 1 for guide to abbreviations). This responsibility is financial as well as to determine the curricula. As noted by the ABS (2012), the Council of Australian Governments [COAG][1] committed to a comprehensive education reform agenda in 2008. The Australian Curriculum evolved as a result of all Australian education ministers agreeing to a set of common educational goals for all young Australians, described in the *Melbourne Declaration on Educational Goals for Young Australians* (Ministerial Council on Education, Employment, Training and Youth Affairs [MCEETYA] 2008). In negotiating the parameters of this important document the Australian Curriculum, Assessment and Reporting Authority (ACARA 2016) adopted a "collaborative curriculum development process to produce the Australian Curriculum". Each state/territory subsequently developed its own F-10 [2] curriculum founded on the Australian Curriculum. In Victoria, for example, the Victorian F-10 curriculum "incorporates the Australian Curriculum and reflects Victorian priorities and standards" (Victorian Curriculum and Assessment Authority [VCAA] n.d.)

Table 1.
Abbreviations and Acronyms

ABS	Australian Bureau of Statistics
ACARA	Australian Curriculum, Assessment and Reporting Authority
ACER	Australian Council for Educational Research
AITSL	The Australian Institute for Teaching and School Leadership
COAG	Council of Australian Governments
MCEETYA	Ministerial Council for Education, Early Childhood Development and Youth Affairs
NAP	National Assessment Program
NAPLAN	National Assessment Program Literacy and Numeracy
OECD	Organisation for Economic Co-operation and Development
PIAAC	Programme for the International Assessment of Adult Competencies
PISA	Programme for International Student Assessment
VCAA	Victorian Curriculum and Assessment Authority

The Australian Curriculum for Grades F-10 (compulsory years of schooling) includes eight content learning areas (e.g., mathematics, languages, humanities and social sciences), three cross-curriculum priorities (e.g., Asia

[1] An organisation consisting of the federal government (the Prime Minister), the governments of the six states (the Premiers) and two mainland territories (the Chief Ministers) and the Australian Local Government Association (its President). (https://en.wikipedia.org/wiki/Council_of_Australian_Governments)

[2] F-10 includes one year of schooling prior to Grade 1 (the Foundation year).

and Australia's engagement with Asia), and seven general capabilities. Numeracy is one of these general capabilities, alongside the other broad skills of literacy, information and communication technology capability, ethical understanding, personal and social capability, critical and creative thinking, and intercultural understanding (ACARA n.d.-a). Teachers at all grade levels, and of all subject areas, are responsible for developing students' numeracy capabilities as well as the other six general capabilities.

According to ACARA (n.d.-b), numeracy and its place in the curriculum are described as:

> In the Australian Curriculum, students become numerate as they develop the knowledge and skills to use mathematics confidently across other learning areas at school and in their lives more broadly. Numeracy encompasses 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.
>
> When teachers identify numeracy demands across the curriculum, students have opportunities to transfer their mathematical knowledge and skills to contexts outside the mathematics classroom. These opportunities help students recognise the interconnected nature of mathematical knowledge, other learning areas and the wider world, and encourage them to use their mathematical skills broadly.

In the F-10 Australian Curriculum, numeracy comprises six "interrelated elements": (1) using spatial reasoning, (2) interpreting statistical information, (3) using measurement, (4) estimating and calculating with whole numbers, (5) recognizing and using patterns and relationships, and (6) using fractions, decimals, percentages, ratios, and rates (ACARA n.d.-c). Opportunities for teachers to incorporate numeracy development across the content learning areas are found on the searchable Australian Curriculum website (via the Resources and support page[3]) by selecting the "numeracy symbol" (i.e., a graphic depicting the four basic operations) together with grade level and learning content area. The curriculum descriptions that result inform teachers that, when teaching these dimensions of the curriculum, there are opportunities to develop learning activities that promote numeracy development.[4]

Accreditation of Teacher Education Programs and Professional Standards for Teachers

The Australian Institute for Teaching and School Leadership (AITSL) has oversight of the accreditation of *initial teacher education programs* (see AITSL 2015), which is considered "an essential means of ensuring that all

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[3] http://www.australiancurriculum.edu.au/resources-and-support/curriculum-filter

[4] Examples of numeracy opportunities within the history learning area in Grade 9 are found at http://www.australiancurriculum.edu.au/Browse?a=H&y=9&c=2&layout=2&browseLayout=2

teachers are prepared to a high standard, and gain the knowledge, skills and experiences to make a positive impact on student learning" (AITSL 2014b). The teacher regulatory authority in each state/territory accredits programs in line with AITSL standards and procedures (see AITSL 2015). As noted in the preamble, these standards and procedures "are designed to ensure that all graduates of initial teacher education meet the Australian Professional Standards for Teachers at the Graduate career stage. This is the foundation of the accreditation process" (AITSL 2015, p. 2).

Among the AITSL *Professional Standards for Teachers* (2014a) at the graduate level are two standards that relate directly to numeracy skills. One is consistent with the expectations of the Australian Curriculum (Standard 2.5), while the other relates to teachers' workplace-related numeracy capabilities (Standard 5.4):

> Standard 2.5 (Literacy and numeracy strategies): Know and understand literacy and numeracy teaching strategies and their application in teaching areas.
>
> Standard 5.4 (Interpret student data): Demonstrate the capacity to interpret student assessment data to evaluate student learning and modify teaching practice.

Underpinning the development of a compulsory pre-service teacher education course, *Numeracy for Learners and Teachers*, which was delivered to graduate pre-service teacher education students at a prestigious university in Australia, were: the expectations of the Australian Curriculum, the AITSL professional standards, and theoretical considerations derived from research literature. In this article, we report on the impact that this numeracy course had on two cohorts of pre-service teacher education students who completed the course in 2015 and 2016. We also provide evidence of the contemporary understandings of teachers from Australia, Canada, and the United States, about the relationship between mathematics and numeracy as well as their numeracy capabilities, and reflect on the implications of our findings for the teaching profession and on future research directions.

Before providing details of the research undertaken, we discuss how the concept of numeracy, as defined and envisioned in the Australian context, fits with the confusion of terminology used around the world. We also consider the relevance of numeracy in the wider context of national and international testing regimes in which Australian school students participate.

Numeracy: Contested and Confusing Terminology, and the Contemporary Australian Educational Context

The term *numeracy* is used, and has been defined, in the Australian Curriculum as quoted above. The history of the use of the term numeracy in the Australian context (e.g., Kemp and Hogan, 2000) is closely aligned with the overview provided by Karaali et al. (2016). The Australian definition of numeracy also appears to fit comfortably with Vacher's (2014) vocabulary matrix associated with numeracy, and with the set of definitions of numeracy provided by Karaali et al. (2016). It is also consistent with the definition of *mathematical literacy* adopted in the Organisation for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA). This international testing regime attracts worldwide attention as one measure of the health of the education systems in participating countries. According to the OECD (2013):

> Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognise the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens. (p. 25)

By including the words, "reasoning mathematically", however, the PISA definition of mathematical literacy carries with it connotations associated with Vacher's (2014) vocabulary matrix for *quantitative reasoning.*

Another international testing regime that is taken seriously as a gauge of the educational level of a nation's citizenry is the OECD's Programme for the International Assessment of Adult Competencies (PIAAC). Numeracy is one component of the PIACC testing regime. In the PIAAC, numeracy is defined as "the ability to access, use, interpret and communicate mathematical information and ideas in order to engage in and manage the mathematical demands of a range of situations in adult life" (OECD 2012, p. 33). More specifically, numerate behavior is defined as "managing a situation or solving a problem in a real context, by responding to mathematical content/ information/ideas represented in multiple ways" (p. 34).[5] Again, this definition of numeracy appears to accord well with Vacher's (2014) vocabulary matrix.

In Australia, the term numeracy has also been misused. Nationally, all Australian students in Grades 3, 5, 7, and 9 are mandated to complete the National Assessment Program Literacy and Numeracy (NAPLAN) tests. No definition of numeracy is provided (see National Assessment Program [NAP], 2016). It is claimed, however, that the *Australian Curriculum: Mathematics* is used as the base reference for the numeracy tests which

> "assess the proficiency strands of understanding, fluency, problem-solving and reasoning across the three content strands of mathematics: number and algebra; measurement and geometry; and statistics and probability" (NAP 2016).

It is our view that the use of the term numeracy in the NAPLAN context is inappropriate, adding to confusion in the community. NAPLAN numeracy is effectively a measure of students' mathematics achievement and the implementation of the mathematics curriculum.

It is a sad reflection on politicians, some educational leaders, and many popular media outlets that they mistakenly equate the PISA results of

[5] It is interesting to note that Australian teachers ranked 12th among 31 nations in PIACC numeracy scores, Canadian teachers ranked 18th, and U.S. teachers ranked 23rd (see Hanushek et al. 2014).

mathematical literacy to measures of students' mathematical achievements; they also seem to believe that the results reflect the relative success of each nation's mathematics curriculum. Drawing on the PISA data, Australia is said to be slipping down the ranking ladder since performance levels have declined significantly between 2003 and 2012 (Thomson et al., 2013). Teachers, particularly teachers of mathematics, are often scapegoated if a country's PISA rank is lower than desired. Arguably, in Australia, this situation, together with a perceived lack of improvement in NAPLAN "numeracy" outcomes, have led to the more stringent standards for the accreditation of teacher education programs described above, and the requirement that all teacher education students pass tests of personal numeracy and literacy prior to graduation (see Australian Council for Educational Research [ACER] 2017).

The recently implemented Australian Curriculum and numeracy general capability, together with the AITSL program standards for accreditation of teacher education programs and the mandated literacy and numeracy testing of teacher education students prior to graduation, have provided challenges to practicing teachers and to teacher education course providers. The research studies we report in this paper were undertaken to highlight aspects of the challenges that need to be addressed.

The Studies

In the next sections of the paper, we present findings from a study based on the experiences of primary (elementary) and secondary (high school) teacher education students enrolled at one Australian university where they completed a compulsory course entitled *Numeracy for Learners and Teachers*, as well as from a study of the views of practicing teachers in Australia, Canada, and the United States about numeracy, its relationship to mathematics, and of their personal numeracy capabilities.

1. The Impact of a Numeracy-Based Course for Teacher Education Students at Monash University

The teacher education student data discussed here were gathered from students enrolled in *Numeracy for Learners and Teachers* (EDF5017), which was introduced in 2015 as a compulsory course for primary and secondary teacher education students in the graduate level Masters of Teaching program at Monash University. [6] EDF5017 was designed to meet the numeracy

[6] The largest university in Australia with ca. 65,000 students in 2017 (see https://www.monash.edu/__data/assets/pdf_file/0012/765687/campus-profiles-2017-prelim-feb17.pdf), Monash University is a prestigious, globally ranked university (see http://www.australianuniversities.com.au/ranking/monash-rankings.html), a member of the Group of Eight coalition of research-intensive Australian universities. Five of its campuses are in the state of Victoria; the others are scattered around the world, starting in Malaysia (see http://www.monash.edu/about/our-locations). The main campus, with over 33,000 students in 2017, is in Clayton, a suburb of Melbourne.

requirements encompassed by the AITSL (2014a) standards for graduate teachers discussed earlier, and to prepare these future teachers to develop the numeracy capabilities of the students they will teach in future, that is, to meet the expectations of the numeracy general capability dimension of the Australian Curriculum.

Our aim in this study was to gauge the impact that taking this course had on the students' conceptions of mathematics and numeracy. To do so, we gathered data from them prior to commencing, and on completion of, the course.

Content of Numeracy for Learners and Teachers (EDF5017)

The goals underpinning the development of *Numeracy for Learners and Teachers* were that students:

- develop an understanding of what numeracy is and how it relates to mathematics;
- learn to recognise numeracy opportunities across all learning areas of the curriculum; and
- identify ways to engage their future students in relevant, critically challenging, curriculum-based activities that would build numeracy skills.

The 21st Century Numeracy Model (Goos et al. 2014) was central to the pedagogy of the course and the numeracy lesson ideas that the students learned to devise. The model includes elements encompassed by the definitions of numeracy discussed earlier: context, mathematical knowledge, tools, and dispositions. These dimensions are all rooted in a critical orientation, the capacity to argue for, or justify the result of, applying mathematics in real world content. The realms in which numeracy skills are required are highlighted: citizenship, work, and personal and social life.

At Monash University, the 12-week semester for teacher education students includes three weeks of fieldwork in schools (professional experience/practicum). EDF5017 was divided into nine weekly teaching modules representing a range of content teaching areas (or themes) aligned with the Australian Curriculum that the students might be expected to teach in their professional futures. In 2016, minor modifications were made to the order and content of the weekly topics that were based on student feedback and the timing of the three-week professional experience period. Summaries of the topics taught in the nine teaching weeks in 2015 and 2016 are shown in Table 2.

All teaching materials were uploaded to the online teaching platform, Moodle, as the course was also taught to students enrolled online (off-campus students). Also provided on the Moodle site were Self-Help Kiosks – resources we prepared for those who lacked confidence in their mathematical capabilities and wished to refresh their skills in a range of mathematics content areas. The Self-Help Kiosks provided the potential to address an identified deficiency in teacher education programs to prepare teacher education students

https://scholarcommons.usf.edu/numeracy/vol10/iss2/art2
DOI: http://doi.org/10.5038/1936-4660.10.2.2

adequately to teach for "numerate participation in a global world" (Klein 2008, p. 321).

Table 2
Weekly Topics in EDF5017 in 2015 and 2016

Week	2015	2016
1	Introduction: What is numeracy?	Introduction: What is numeracy?
2	Numeracy and persuasive writing/literacy	Numeracy and persuasive writing/literacy
3	Numeracy and health, well-being, and body image	Numeracy and health, well-being, and physical education
4	Numeracy and sustainability	Numeracy and science and geography
5	Numeracy and visual, graphic, and performing arts	Statistical literacy for teaching and assessment
6	Numeracy and critical orientation and statistical literacy	Financial literacy
7	Numeracy and history	Numeracy and history
8	Numeracy and technology	Numeracy and the arts
9	Financial literacy	Numeracy and technology

Research Design and Survey Instruments

An online survey instrument was used to gauge the teacher education students' views on numeracy and mathematics, as well as their confidence to recognise and seize opportunities to develop students' numeracy capabilities across all learning areas in the Australian Curriculum. The instrument was administered twice: prior to the commencement of EDF5017 (pre-course survey), and again on completion of the course (post-course survey); on each occasion, participation was voluntary. Changes in students' views of the relationship between numeracy and mathematics, and their confidence in being ready to teach numeracy across the curriculum, were of particular interest. The two data sets enabled any changes to be identified.

The survey instruments. In both iterations of the survey, participants responded to closed (e.g., multiple-choice) and open-ended questions about numeracy, mathematics, and teaching. The surveys were modified versions of the one administered by Forgasz et al. (2015).

The pre- and post-survey instruments included biographical items (e.g., gender, whether studying to be a primary or secondary teacher), items exploring understandings about numeracy and mathematics, views on the utility of numeracy skills for teaching, as well as confidence with mathematics. In the pre-course questionnaire only, participants completed six numeracy questions, two of which had multiple parts. Five of these questions were derived from national and international large-scale assessments of numeracy/quantitative literacy: the Australian Grade 9 numeracy NAPLAN test (three publicly available items) and PISA for 15-year-olds (two items, used with permission). The sixth question was an open task with multiple solutions that was devised by the researchers. When responding to these numeracy questions, participants were asked to gauge how likely it was that their answer was correct (another indicator of confidence in their mathematical skills).

Participants

The composition of the 2015 and 2016 cohorts of teacher education students in the course differed. In 2015, about 300 students were enrolled in EDF5017, the majority of whom were preparing to be secondary teachers (in subject areas other than mathematics). In contrast, of the 140 students enrolled in 2016, most were studying to be primary teachers. In both years, more students completed the pre-course survey than the post-course survey, most likely due to the timing of the data collection; the post-course survey took place when students had many assignments due. Demographic information about the pre-course survey participants is shown in Table 3.

Table 3.
Participants in the Pre-Course Survey, 2015 and 2016

	2015	2016
Number of participants	53 began; 40 finished	46 began; 22 finished
Gender	Female (81%)	Female (90%)
Age	Ages 25-34 (77%)	Ages 25-34 (80%)
Study stream	Secondary (74%)	Primary (79%)
Studied university mathematics?	No (66%)	No (78%)

As shown in Table 3, the participant profiles were very similar in 2015 and 2016 with regard to gender, age, and in whether university-level mathematics had been studied. The study stream (primary/secondary) and number of completed surveys were representative of the entire enrolled cohort in each year. The post-course survey participants were very similar to the pre-course participants in terms of the aforementioned characteristics. However, as noted earlier, in each year fewer participants completed the post-course than the pre-course surveys. Specifically, in 2015, 35 students began the post-course survey, while 20 completed it, compared to 21 and 13 students, respectively, in 2016.

Aims of the Study

We wanted to know how pre-service teacher education students conceived of the relationship between mathematics and numeracy and whether they thought there were numeracy demands on teachers in their workplace, the school. Students' confidence about incorporating numeracy into their teaching was of particular interest in evaluating the effect that completing the course, *Numeracy for Learners and Teachers*, might have had.

Findings

We begin by discussing the participants' perceived confidence in their mathematics and numeracy capabilities, followed by their responses to numeracy questions (numerical questions, set in context, drawing on mathematical skills). As noted above, for each of the numeracy questions, the students also had to report how confident they felt that their answers were correct.

Participants' perceived confidence in their mathematics and numeracy capabilities. Participants were asked "How good are you at mathematics?" and were required to select a response from five options (weak, below average, average, good, and excellent). In both years (2015: n = 44, 2016: n = 28), the vast majority of participants reported that they were either "average" or "good" at mathematics.

In 2015, 39% of participants reported that they were "average" at mathematics and 46% reported that they were "good", compared to 54% and 36%, respectively, in 2016. Essentially, the pattern for these two categories was reversed in 2016 compared to 2015. As evidenced by these data, as well as by the fact that 14% of the 2015 sample, compared to 4% of the 2016 sample, considered themselves to be "excellent" at mathematics, the 2015 participants were more confident than the 2016 participants. Recalling that the 2016 cohort was composed mainly of those preparing to be primary teachers, this lower level of confidence was unsurprising. Primary teachers have been found to have low levels of confidence in their mathematical capabilities and weak mathematical skills (e.g., Ballet al. 2005; Bursal and Paznokas 2006). Among the 2015 and 2016 cohorts completing the survey, only three students (representing 4% of participants across the two years) reported that they were lower than "average" at mathematics. This result may be indicative of a self-selection participation bias; that is, those who lacked confidence in their mathematical capabilities may have chosen not to volunteer to participate in the study.

Using a series of questions specific to real-world scenarios, participants were also asked about their confidence in their numeracy skills. For the first item, participants were asked to indicate their level of agreement (strongly disagree, disagree, unsure, agree, or strongly agree) with the following statement: "Given the price per square metre, I could estimate the cost of the new carpet I need for my lounge room". In both years, participants reported being quite confident about completing such a task, with nearly all the participants (96% in 2015; 93% in 2016) agreeing or strongly agreeing with the statement. Another statement related to reading data: "I can easily extract information from tables, plans, and graphs". Again, participants reported high levels of confidence, with nearly all participants (91% in 2015; 89% in 2016) agreeing or strongly agreeing with the statement. These levels of confidence were not unfounded, as the participants generally did very well on the numeracy questions involving these skills.

Participants' numeracy capabilities. Participants were asked to complete six numerical questions set in real world contexts, and to report on their confidence in the accuracy of their answers. All of the questions were approximately at a Grade 9 level; as noted earlier, five items were drawn from NAPLAN Grade 9 and PISA tests. The questions incorporated a wide range of mathematical topics, including basic operations, fractions, and data analysis. Generally, the questions were completed to a high standard with a high degree of confidence (typically 80-100% accuracy and confidence), save for the question regarding combinatorics.

For the combinatorics question, participants were asked how many four-digit codes were possible for a door with a keypad lock (0051 was provided as an example). An image of a keypad with the numerals 0-9, an asterisk (*), and a hash symbol (#) accompanied the question. Participants had to insert their answers into a text box. That this was an open-ended question, rather than a multiple-choice question, may have partially contributed to the lower accuracy of responses. In 2015, of the 38 who answered this question, 58% completed the question correctly, and 44% thought that they were correct. Only 20% of the participants thought that they were incorrect, while 37% were unsure. In 2016, the question was answered by 24 students. Of these, only 41% (a lower proportion than in 2015) provided the correct answer, and only 40% thought they had answered correctly. The teacher education students in both cohorts appear to have underestimated their numeracy capability with this question, but the secondary cohort (2015) was more accurate than the primary cohort (2016). The spread of "confidence" responses in 2016 was very similar to that of the 2015 cohort, with 40% of the 2016 participants feeling unsure and 20% assuming that they were incorrect.

What is the relationship between mathematics and numeracy.[7] Summaries of the 2015 and 2016 participants' responses to the question, "Is there a difference between mathematics and numeracy?", on the pre-course and post-course surveys are shown in Table 4. It was encouraging to see that after completing the course, higher proportions of the teacher education students believed that there was a difference between mathematics and numeracy. This change in views was particularly pronounced in 2015, with an increase of 19 percentage points from the pre- to the post-course survey.

Table 4.
Participants' Views of Whether there is a Difference between Mathematics and Numeracy

	2015		2016	
Is there a difference between mathematics and numeracy?	Pre-course survey (*n* = 45)	Post-course survey (*n* = 21)	Pre-course survey (*n* = 29)	Post-course survey (*n* = 13)
Yes	76%	95%	90%	92%
No	4%	0%	0%	8%
Unsure	20%	5%	10%	0%

[7] It should be noted that there were varying numbers of responses to each item discussed in this section.

https://scholarcommons.usf.edu/numeracy/vol10/iss2/art2
DOI: http://doi.org/10.5038/1936-4660.10.2.2

Representative explanations from those who believed there was a difference included:

- I think that numeracy is a broader concept than mathematics, because otherwise we wouldn't have pure maths.
- Numeracy is the application of mathematics in real life contexts.
- Mathematics is to numeracy what language is to literacy – only part of the whole.

It was disappointing to see that there was a higher proportion of students in the 2016 post-course survey, compared to the pre-course survey, who believed there was no difference between numeracy and mathematics. As noted earlier, the 2016 students were predominantly studying to be primary teachers. Unfortunately, "numeracy" has been the word used for "mathematics" at the primary level in the state of Victoria for many years. In the students' other courses focusing on the primary level curriculum in general or on how to teach primary level mathematics, or while on field experience, they may have come across lecturers or classroom teachers who used the words "numeracy" and "mathematics" synonymously; quite possibly this would have created some confusion. Interestingly, the same effect was not seen among the 2015 cohort, predominantly studying to be secondary level teachers; at the secondary level, mathematics and numeracy are not confused in relation to the teaching discipline of mathematics.

Representative explanations from those who did not believe there was a difference included:

- Both are the use of numbers.
- There is little, if any, difference, except terminology and where it is used.
- Numeracy and mathematics are closely related and impact on one another.

Representative examples of "unsure" responses included:

- I'd never really given it much thought before now. Both scare me!!!
- I genuinely have no idea. I would guess that numeracy is the language that allows us to engage in mathematics.

Are there numeracy demands on teachers in schools apart from what is taught to students? We explored students' understandings of numeracy demands on teachers in schools beyond the classroom. Summary data in response to the question, "Are there numeracy demands on teachers in schools apart from what is taught to students?" from participants in 2015 and 2016 are shown in Table 5.

Table 5.
Participants' Views on whether there are Numeracy Demands on Teachers Beyond the Classroom

Are there numeracy demands on teachers beyond the classroom?	2015		2016	
	Pre-course survey (*n* = 44)	Post-course survey (*n* = 21)	Pre-course survey (*n* = 28)	Post-course survey (*n* = 13)
Yes	64%	90%	75%	85%
No	7%	0%	0%	0%
Unsure	30%	10%	25%	15%

As with the previous question, the completion of studies in EDF5017 led to a greater awareness of the role of numeracy. In both years and both iterations of the survey, the majority of students agreed that there were numeracy demands on teachers apart from what is taught to students. Those who agreed provided examples such as assessment, planning excursions, budgeting, and salaries. For instance, one student wrote that "Teachers are required to assess student outcomes and a good level of numeracy will enable teachers to accurately dissect their data to create change in the curriculum to benefit their students". Notably, no participants in either year's post-course survey indicated they believed there were no numeracy demands on teachers outside the classroom, although some remained unsure (10% in 2015; 15% in 2016) after completing the course.

Confidence to incorporate numeracy development in teaching. In the post-course survey, participants were asked specific questions about their experiences in EDF5017, and the ways that their views about numeracy had been influenced as a consequence. In one question, they were asked to reflect on and rate their levels of confidence in "incorporating numeracy into the teaching of [their] subject area(s)" before experiencing EDF5017, and also after completing the course. The pre-course and post-course responses are shown in Figures 1 (2015 data) and 2 (2016 data).

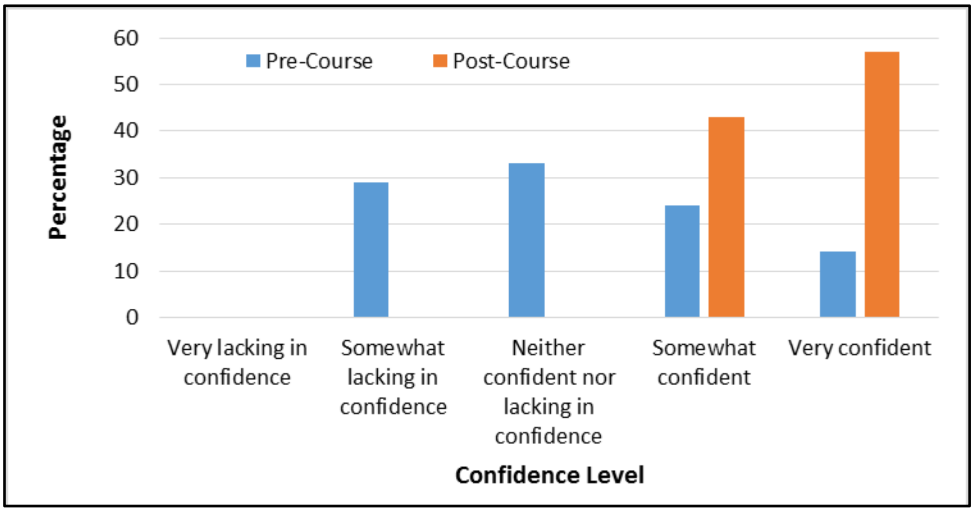

Figure 1. 2015 participants' reported pre- and post-course confidence to incorporate numeracy into their teaching.

https://scholarcommons.usf.edu/numeracy/vol10/iss2/art2
DOI: http://doi.org/10.5038/1936-4660.10.2.2

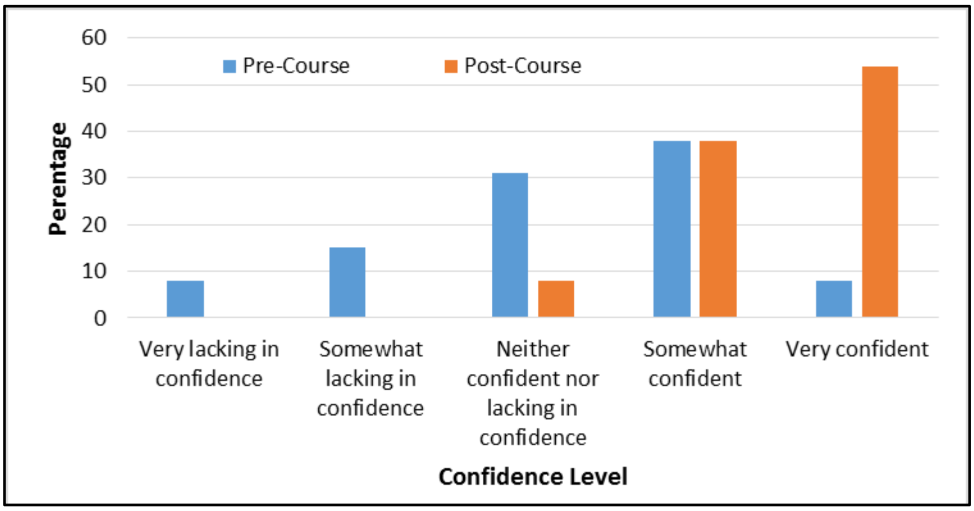

Figure 2. 2016 participants' reported pre- and post-course confidence to incorporate numeracy into their teaching.

It is very clear from Figures 1 and 2 that the students' experiences in the course impacted their reported levels of confidence to incorporate numeracy into their teaching. Pre-course, approximately half of the participants in both years reported being less than somewhat confident. Encouragingly, in comparison, nearly all participants in both years indicated being somewhat or very confident after completing EDF5017. In explanation of the participants' post-course levels of confidence, one student wrote:

> 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.

Participants were also asked how EDF5017 had impacted their views of numeracy. Perhaps unsurprisingly, the majority of respondents in both years (86% in 2015; 85% in 2016) reported that their views had changed. Some representative responses included:

- I did not know the word before this unit [course].
- I now understand there is a difference between numeracy and mathematics.
- I understand that it is my responsibility to teach this [numeracy] – AITSL and the curriculum require it.

When asked about their overall impressions of EDF5017, most responses (76% in 2015; 75% in 2016) were positive. Comments included: "good", "brilliant course. My favourite.", and "made me more comfortable".

Participants were also asked about the message they would take from EDF5017. Those who responded discussed issues such as the pervasive nature of numeracy, mathematics, or numbers in the world, and the importance of numeracy for all teachers. One participant noted that: "Opportunities for numeracy can be found in many lessons/disciplines. Take advantage of them."

In summary, the experience of studying EDF5017, *Numeracy for Learners and Teachers*, positively influenced the teacher education students':

- understanding of the relationship between mathematics and numeracy;
- confidence to incorporate numeracy into their teaching;
- appreciation of teachers' responsibilities to develop their students' numeracy capabilities, and of opportunities to do so across the curriculum; and
- awareness of numeracy demands in teachers' workplaces both in, and beyond, the classroom.

2. Teachers and Numeracy: Views and Confidence

The data reported above were gathered from a specific group: teacher education students enrolled at Monash University. To provide a baseline context for these findings, we investigated practicing teachers' views about numeracy and used the survey previously described, with minor modifications to ensure its suitability for the new target audience. To reach, and attract, a geographically diverse set of participants, we placed an advertisement on Facebook, inviting potential participants to complete a short survey on the "Numeracy capabilities of teachers". Like us, Kosinski et al. (2015) found that "Facebook… can be used to inexpensively recruit large and diverse samples" (p. 543).

Those who clicked on the advertisement were directed to the online survey. Our intended (and targeted) sample for the online survey included all teachers, whether or not mathematics was among the subjects they taught.

Respondents to our survey comprised 100 Australian teachers as well as almost 300 from the United States and just under 100 from Canada. These groups enabled us to compare (1) the responses of the Australian preservice teachers with Australian teachers already in the work force, and (2) to see whether or not there was agreement between the respondents from these three countries.

Some Sample Details

In each country, more females than males participated. Considering respondents from the three countries collectively, 399 (84%) were female and 76 (16%) were male. Thus, the teacher education sample and the group of practicing teachers were comparable with respect to gender composition. As expected, however, the two groups differed in terms of age profile, with a much higher proportion of the practicing teacher group aged 40 years or older.

Overall, 305 (65%) participants indicated that they taught at the primary level, 106 (23%) at the secondary level, and 60 (13%) did not fit into either of these groupings. Over 80% of the respondents from each country indicated that mathematics was among the subjects they taught.

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DOI: http://doi.org/10.5038/1936-4660.10.2.2

Selected Results

Confidence about mathematical proficiency. When asked "How good are you at mathematics?", very few respondents considered themselves to be weak or below average. Overall, at least 60% of the respondents from each country believed that they were above average (good or excellent) at mathematics, with under 10% from each country considering themselves to be weak. In summary, the respondents, like the pre-service teacher education students, were generally confident about their personal mathematics capabilities.

Further confidence indicators. Responses to several other items on the survey further highlighted the teachers' confidence in their capacity to use mathematics in everyday life (numeracy skills). As on the survey administered to the teacher education sample, there was a cluster of items requiring responses on 5-point Likert type response formats, SA (strongly agree) to SD (strongly disagree). The responses from two such items are reported below.

Item A: *Given the price per square metre, I could estimate the cost of the new carpet I need for my lounge room.*

> Respondents overwhelmingly agreed that they could do this: 96% of the participants from the United States agreed or strongly agreed with this statement, as did 98% and 99% of the Canadian and Australian teachers, respectively. The teacher education students also expressed a high level of confidence in their ability to do this estimation: 96% in 2015 and 93% in 2016.

Item B: *I can easily extract information from tables, plans, and graphs.*

> Respondents again overwhelmingly thought they could do this: 99% of the respondents from the United States agreed or strongly agreed with this statement, as did 94% of the Canadians and 99% of the Australians. The vast majority of teacher education students (around 90% in both years) similarly indicated that they could readily extract the relevant information.

Participants' actual numeracy proficiency. The teacher education students' performance on the combinatorics question was reported earlier in the article. Just over half of the 2015 group, but a little under half of the 2016 group, were able to answer this question correctly. For the practicing teacher group, this same question (shown below) also proved challenging.

> Helen's office has a security alarm. To turn it off Helen has to type her 4-digit security code into this keypad. [A diagram of a 10-digit keypad was included.] Helen's code is 0051. Including Helen's code, how many different 4-digit codes are possible?

In each country, approximately one-third of the respondents who attempted this question gave the correct answer. In each case, unlike the teacher education group, a higher proportion thought that their answer was correct, compared to the proportion of respondents who actually were correct. Thus, the practicing teacher respondents tended to over-estimate, while the teacher education students tended to under-estimate, their capability to respond to this question.

Are there differences between mathematics and numeracy? Approximately two-thirds of the practicing teachers answered this question. A high proportion of Australian respondents (87%) thought there was a difference, followed by the American (70%) and Canadian (67%) respondents. At the end of the numeracy course (EDF5017), it is worth recalling that 95% and 92% respectively of the 2015 and 2016 teacher education students thought there was a difference.

Asking respondents to define numeracy and mathematics produced informative and nuanced insights masked by the blunt "yes", "no", and "unsure" responses to the simple question: "Are there differences between mathematics and numeracy?" The themes emerging from the definitions of numeracy provided by respondents from each country were very similar, with a surprising overlap in the definitions given by those who believed/did not believe there was a difference. In all groups, there were explanations with a clear focus on manipulation of arithmetic procedures, such as:

- Working with numbers. Adding, subtracting, multiplying, and dividing without calculators. Finding perfect squares, cubes square roots, cube roots, order of operations. Finding factors of numbers.
- The ability to use the four operations and use reason to problem solve – akin to literacy.

Others, some 15% of those who thought there was a difference between numeracy and mathematics, as well as a few who considered there was no difference, stressed applications across the curriculum and/or in real life:

- The ability to use mathematical understanding and skills to solve problems and meet the demands of day-to-day living in complex social settings.
- Numeracy is the ability to use mathematics skills in the world/life. A person's numeracy is her level of competence with mathematical methods and results. Basic numeracy would require being able to add, subtract, multiply and divide reasonably small natural numbers and to know what percentages. This is needed, for example, to do your taxes. A higher level of numeracy (say high school) would require some knowledge of geometry and trigonometry, and maybe even calculus.
- The ability to work comfortably and accurately with numbers, especially in the everyday context; to be able to interpret numerical representations.

Those who were unsure if there was a difference between mathematics and numeracy typically provided explanations like: "don't know", "unfamiliar with the term", "understanding pattern in numbers", "basic number skills – ability to work with numbers", and "how mathematics and its functions are applied". That not all respondents in the "unsure" group considered numeracy issues to be important is captured by the comments from one of the respondents from the United States who claimed that numeracy is "a word that

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DOI: http://doi.org/10.5038/1936-4660.10.2.2

Common Core is trying to make more important than it really is to people with a life".

Numeracy demands on teachers in schools apart from what is taught to students. In common with the teacher education students, the majority of the practicing teachers (around 60% in each of the three countries sampled), thought there were numeracy demands on teachers apart from what is taught to students. The illustrations given by the practicing teachers mirrored those provided by the students. However, unlike the students who had completed the course, *Numeracy for Learners and Teachers*, in each of the teacher groups a sizeable minority thought there were no such demands. "I haven't found any yet - but there is always time!", "I don't understand the question", "I don't feel any additional demands on top of what I am required to teach", "not sure what a mathematics demand would be", and "Computer programs that automatically weight assessment tasks are a godsend" were among the explanations given by the teacher groups. Others did not expand on their "no" or "unsure" response with a specific example.

Summary and Conclusion

In Australia, there are now clearly enunciated curricular demands on teachers to develop students' numeracy skills across all school subject areas. Using an online survey, we explored the views of teacher education students preparing to enter the teaching profession about numeracy and mathematics. Their disposition and understanding to develop the numeracy capabilities of their students were also surveyed.

In an attempt to gauge how the term and aspects of "numeracy" are understood within the broader education community, Facebook was used as a powerful and economic vehicle for gathering data from teachers in three countries: Australia, the United States, and Canada. In broad terms, collectively and within each country, the experienced teachers' conceptions of numeracy and its relationship with mathematics generally mirrored those of the pre-service teacher education students involved in the study. 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.

The findings from the study of teacher education students at Monash University enrolled in a compulsory numeracy course provide suggestions for a way forward. It was evident that the course, *Numeracy for Learners and Teachers*, had impact. It helped the students garner a greater understanding of numeracy and, perhaps more importantly, helped them to feel more confident about incorporating numeracy into their teaching across a range of grade levels and subject areas. It is anticipated that these preservice teacher education students will become practicing teachers who will consciously consider ways to incorporate numeracy in their teaching; this action, in turn, should benefit the students in their future classrooms to develop numeracy competencies, as mandated in the Australian Curriculum (F-10). There may also be a flow-on effect; future colleagues of these preservice teacher education students are likely to benefit from their knowledge, experience, and expertise in the incorporation of numeracy across subject domains. Such collaboration could lead to a school culture with an emphasis on numeracy. In the longer term, the improvement in students' numeracy skills may well percolate through to PISA and PIAAC results for Australia.

There are implications of the research findings presented in this article for preservice teacher education programs, teacher educators, and those providing professional learning to practicing teachers. We argue that teacher education program providers, both within and outside Australia, should consider including a compulsory numeracy education course for all preservice teacher education students, if it is considered important that numeracy development be the responsibility of all teachers. Graduates of teacher education programs can effect change at the school level, which can have far-reaching effects for both their colleagues and the students they teach. Professional learning programs for all practicing teachers, not just for teachers of mathematics, on how (and why) to incorporate numeracy across the curriculum are needed to broaden teachers' understandings of numeracy, and to recognise its importance in whatever subject they teach. If a numerate citizenry is to emerge from the educational enterprise, such undertakings are imperative.

Acknowledgment

The research reported here was supported, and partially funded, by the Faculty of Education, Monash University.

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[8] See Table 1 for abbreviations and acronyms, such as ABS and ACARA.

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