

## Numeracy Across the Curriculum in Initial Teacher Education

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Numeracy is the responsibility of all teachers in Australia. Graduates from Initial Teacher Education programs must demonstrate knowledge and understanding of numeracy teaching strategies. Currently, there is a limited research base to inform curriculum design of courses that develop strategies for embedding numeracy across the curriculum. This paper reports on the impact of one such course by drawing on pre-service teacher responses to two course tasks completed at the beginning and end of the course. The findings suggest pre-service teachers' confidence to address numeracy may have increased after studying the course.

Numeracy – “a term used to identify the knowledge and capabilities required to accommodate the mathematical demands of private and public life and to participate in society as informed, reflective and contributing citizens (Geiger, Goos, & Forgasz, 2015, p. 531) – is an important capability in today's technology-rich and globalised world (e.g., OECD, 2013). It is also critical for learning in subjects across the curriculum (e.g., Blow, Lee, & Shemilt, 2012; Hilton & Hilton, 2016). Thus, schools have a significant role to play in providing opportunities for students to develop their numeracy capabilities. However, there is debate about the best ways to achieve this. One approach that has shown promise is to exploit numeracy learning opportunities in subjects across the curriculum (Geiger, Goos & Forgasz, 2015); but there is limited research about how teachers learn to recognise and respond to the numeracy demands inherent in the range of subjects they teach. This lack of research extends to the preparation of pre-service teachers (PSTs).

In Australia, numeracy is seen as the responsibility of all teachers because of its place as a general capability in the Australian Curriculum (Australian Curriculum, Assessment, and Reporting Authority [ACARA], 2017). The Australian Professional Standards for Teachers (APSTs) (AITSL, 2011) set out what teachers need to know and be able to do to promote students' numeracy development at four career stages: graduate, proficient, highly accomplished and lead. This standard (Standard 2.5), which also addresses literacy, is aligned with the need for all teachers to address the general capability of numeracy in the subjects they are teaching. The APSTs also provide the framework for accreditation of initial teacher education (ITE) programs (AITSL, 2016). Graduates from these programs need to demonstrate that they have met graduate level for each standard. For the numeracy standard, this means demonstrating knowledge and understanding of teaching strategies for numeracy and their application in teaching areas (AITSL, 2011). The approaches taken by ITE providers to prepare future teachers to address numeracy demands and opportunities in the subjects they will teach varies. Some universities offer a course that focuses on numeracy alone (e.g., Monash University; see Forgasz & Hall, 2016) while others, as is the case of the university where this study was conducted, have one course that aims to address both literacy and numeracy. Forgasz and Hall (2016) have reported on the evaluation of a course focusing on numeracy offered in five Master of Teaching programs (Early Years, Early Years/Primary, Primary, Primary/Secondary), but there does not appear to be any other research in this area. Thus, there is a limited research base to inform the design of courses in ITE programs that specifically address embedding numeracy across the curriculum. This study aims to contribute to addressing this gap.

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The study builds on earlier work with practising teachers (e.g., Bennison, 2017) by investigating how a course within a pre-service teacher education program can help shape a future teacher's identity as an embedder-of-numeracy. The course, *Literacy and Numeracy Across the Curriculum*, is normally taken in the final year of a four-year dual degree ITE program which combines a Bachelor of Education (Secondary) and a Bachelor of Science or Bachelor of Arts. One of the aims of the course is to build PSTs' capacity to embed numeracy into the subjects they will teach in ways that develop students' numeracy capabilities and enhance subject learning. The purpose of this paper is to report the preliminary findings of this small pilot study. In doing so, the following research question will be addressed:

What impact does the *Literacy and Numeracy Across the Curriculum* course have on secondary pre-service teachers' capacity to address numeracy in the subjects they will teach?

### Theoretical Framework

The theoretical framework for the study has two elements: numeracy and teacher identity. First, the study draws on the 21<sup>st</sup> Century Numeracy Model developed by Goos, Geiger, & Dole (2014). This model has been used in a series of research and development projects to assist teachers to embed numeracy in subjects across the curriculum (e.g., Geiger, Goos, & Dole, 2015; Goos et al., 2014). It has five dimensions: *mathematical knowledge* (mathematical concepts and skills, problem solving, estimation), *context* (capacity to use mathematical knowledge within and beyond school settings), *dispositions* (confidence, flexibility, initiative, risk taking), and *tools* (representational, physical and digital), which are embedded in a *critical orientation* (making decisions and judgements, supporting or challenging arguments). This element of the theoretical framework informed the design of learning activities in the numeracy component of *Literacy and Numeracy Across the Curriculum* and was utilised to code qualitative data. Second, learning to be a teacher involves developing a teacher identity (Sachs, 2005). The framework for identity as an embedder-of-numeracy (Figure 1) identifies knowledge, affective, social, life history, and contextual factors likely to influence how practising teachers promote numeracy learning through the subjects they teach (Bennison, 2017). Promoting numeracy learning across the curriculum requires appropriate mathematical, pedagogical, curricula, and subject knowledge as well as a range of affective attributes including a rich personal conception of numeracy and the motivation to embed numeracy into the subjects taught. The ways in which the numeracy component of *Literacy and Numeracy Across the Curriculum* contributes to developing the knowledge and affective attributes needed to promote numeracy learning is of interest in the present study. The PSTs experiences in the course will contribute to their initial identity as an embedder-of-numeracy. Once they begin teaching, these experiences will become part of their life history as new experiences shape their ongoing identity development.

### The Course: Literacy and Numeracy Across the Curriculum

The *Literacy and Numeracy Across the Curriculum* course aims to assist PSTs to refine their personal literacy and numeracy skills and to explore ways to teach literacy and numeracy across the curriculum in secondary contexts. This paper is concerned with outcomes related to the numeracy aspect of the second of these aims.

The course was offered over a ten-week semester in 2018 with students expected to attend a 2-hour lecture and 2-hour tutorial each week. Because the course addresses both literacy and numeracy, the lectures and tutorials were shared with the numeracy component being taught by the author of this paper. The course has three summative assessment tasks:

a text analysis (literacy), a rich investigative task (numeracy) and an assessment of personal literacy and numeracy. The weekly schedule for the focus content (literacy or numeracy) was determined by the dates that assessment tasks were due: literacy task at the end of Week 4 and numeracy task at the end of Week 7. The third assessment task was completed by PSTs during the lecture in Week 10. The content focus for each of the weeks in which numeracy was addressed is shown in Table 1.

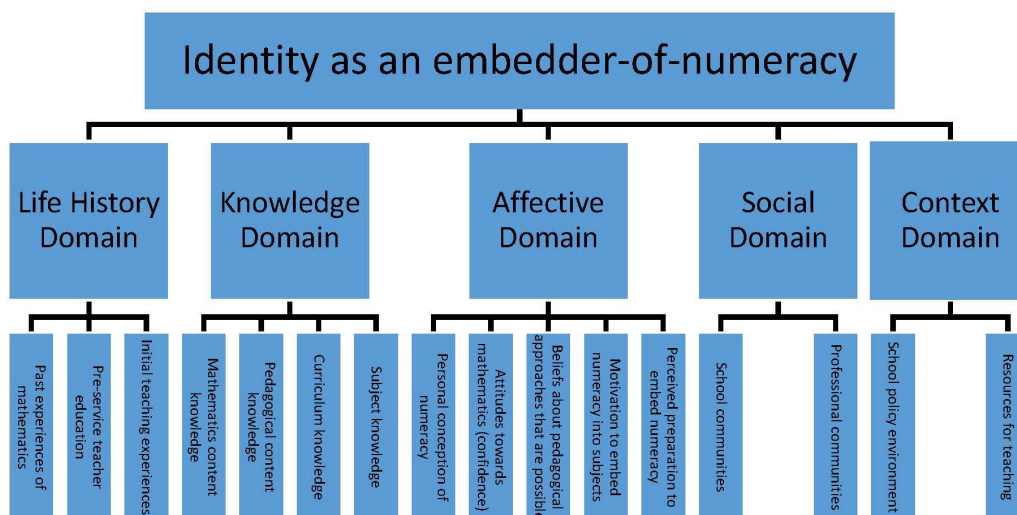


Figure 1 A framework for identity as an embedder-of-numeracy (Bennison, 2017)

Table 1  
*Weekly Numeracy Focus in the Literacy and Numeracy Across the Curriculum Course*

Week	Content focus
1	Introduction (Shared with Literacy). Numeracy in the Australian Curriculum
5	What is numeracy?
6	Numeracy across the curriculum
7	Personal numeracy
9	Critical numeracy and becoming a teacher of numeracy

The 21<sup>st</sup> Century Numeracy Model (Goos et al., 2014) was utilised in the *Literacy and Numeracy Across the Curriculum* course to assist PSTs’ to develop an understanding of what numeracy is and to develop tasks that embed numeracy into the subjects they will teach in authentic ways that support subject learning. PSTs were given opportunities to explore and analyse tasks that were developed by practising teachers in earlier research that investigated the potential of a professional development intervention based on the 21<sup>st</sup> Century Numeracy Model. These tasks included the use of timelines in Science to understand the extent of geological time (Bennison, 2015) and the use of pedometers in Health and Physical Education to monitor personal activity (Geiger, Goos, & Dole, 2015). The numeracy assessment task for the course required PSTs to develop a rich investigative task for one of their curriculum specialisations. The purpose of the rich investigative task was to develop students’ conceptual understanding in the particular learning area and their numeracy capabilities. As part of this assessment task, PSTs provided a reflective essay on their understanding of numeracy and an analysis of their rich investigative task in terms of how it promotes students’ numeracy capabilities, in relation to all dimensions of the 21<sup>st</sup> Century

Numeracy Model, and targets conceptual understanding in an authentic manner in the learning area.

## Research Design

The study was conducted during 2018 at a university located in Queensland. Ethics approval was obtained for the study. Data collection included two course tasks that PSTs completed at the beginning and end of the *Literacy and Numeracy Across the Curriculum* course and interviews with a small number of PSTs. This paper draws on data that were collected through the two course tasks: Numeracy Confidence Survey and Understanding Numeracy Task.

### *Participants*

All PSTs enrolled in the *Literacy and Numeracy Across the Curriculum* course in Semester 2 2018 were invited to participate in the study. There were 37 PSTs who completed the course and of these, 26 (70%) consented to participate in the study. Twelve (32%) of these PSTs completed the Numeracy Confidence Survey and nine (24%) completed the Understanding Numeracy task at the beginning and end of the course. Each PST at this university has two curriculum specialisations. Of those PSTs who completed the Numeracy Confidence Survey on both occasions, one had mathematics as one of their curriculum specialisations and the remainder were not preparing to become mathematics teachers. The curriculum specialisations for this latter group included English, geography, Health and Physical Education, history, science and drama in various combinations. This paper reports on data that were obtained from the 11 PSTs who did not have mathematics as one of their curriculum specialisations.

### *Data collection*

PSTs completed the Numeracy Confidence Survey and Understanding Numeracy task in Week 1 and Week 9. During the Week 9 tutorial, PSTs were given an opportunity to compare their responses in Week 9 with those from Week 1 and use this comparison to reflect on their professional growth during the course. These two course tasks also served as data collection instruments for this study.

Both data collection instruments have been used in previous research with practising teachers (e.g., Goos, et al., 2014). The Numeracy Confidence Survey was developed from the numeracy standards for graduate teachers developed by the Queensland Board of Teacher Registration (BTR, 2005). It contains 22 items organised around the domains of professional knowledge, professional attributes and professional practice. Although these standards pre-date the APSTs (AITSL, 2011), they have a similar structure and focus on numeracy. Respondents were asked to rate their confidence on each of the items (see Table 2 for some items) using a 5-point Likert-type scale (1 = very unconfident, 2 = unconfident, 3 = somewhat confident, 4 = confident, 5 = very confident). For the Understanding Numeracy Task, respondents completed five numeracy stems (Numeracy involves ...; A numerate person knows ...; A numerate person is ...; A numerate person can ...; An individual's numeracy can be improved by ...).

### *Data analysis*

The small number of PSTs who completed the course tasks on both occasions meant that statistical analysis of the Numeracy Confidence Survey responses was not meaningful. For each PST, the Week 9 response on each item was compared with the corresponding Week 1 response and any change was recorded; for example, if a PST's response on an item changed

from 3 (somewhat confident) to 4 (confident) or 5 (very confident), the PST was recorded as being more confident after the course. Thus, PSTs were recorded as being less confident, having no change in confidence or more confident on each survey item.

PSTs' responses to the Numeracy Stems task were analysed by using the five dimensions in the 21<sup>st</sup> Century Numeracy Model (Goos, et al., 2014) to code each response. For each PST, the Week 9 response was compared with the Week 1 response and changes noted.

## Findings

### *Numeracy Confidence Survey*

Of the 22 items on the Numeracy Confidence Survey, the 11 items in Table 2 were the ones most closely aligned with the aims of the *Literacy and Numeracy Across the Curriculum* course. For this reason, findings presented in this section focus on these items.

When the PSTs completed the Numeracy Confidence Survey in Week 1, most reported being confident on each of item in Table 2 except for Item 6 (knowledge of a range of resources and strategies) and Item 14 (communicating informed perspectives of numeracy). For these items, 5 PSTs reporting being somewhat confident or unconfident and 3 PSTs reporting being somewhat confident or unconfident, respectively. In Week 9, when the survey was completed for the second time, the level of confidence reported by the PSTs increased on these items: for Item 6, all except two PSTs reported being confident or very confident; for Item 14 all except two PSTs reported being confident or very confident.

Comparing individual PST responses for each item reveals the number of PSTs whose level of confidence decreased, remained unchanged and increased (see Table 2). About half the PSTs became more confident about the meaning of numeracy in their curriculum area (Item 4), that they could demonstrate knowledge of a range of appropriate resources and strategies to support students' numeracy learning in their curriculum area (Item 6), develop and communicate informed perspectives about numeracy within and beyond the school (Item 14) and model ways of dealing with numeracy demands of their curriculum area (Item 21). However, there were also students who reported being less confident on several of the items, including Item 6 and Item 14.

### *Understanding Numeracy Task*

Comparing an individual PST's response to each of the sentence stems in the Understanding Numeracy Task in Week 1 to their response to the corresponding sentence stem in Week 9 revealed subtle if any changes in their understanding of numeracy. For the purposes of this paper, the Week 1 and Week 9 representative responses from two of the PSTs to one of the sentence stems, Numeracy involves ..., are presented:

Numbers. (PST 1, Week 1)

Using mathematics, such as problem solving and interpreting data. (PST1, Week 9)

Understanding how to apply maths skills in real world settings. Being able to make sense of mathematical problems. (PST 6, Week 1)

Using mathematical skills and knowledge in real-life situations. (PST 6, Week 9)

Table 2

*Selected findings from teachers whose curriculum specialisation was not mathematics*

Item	Less confident	No change	More confident	Total*
Professional Knowledge				

3	Understand the pervasive nature of numeracy and its role in everyday situations	2	6	3	11
4	Understand the meaning of numeracy within their curriculum area	1	5	5	11
5	Recognise numeracy learning opportunities and demands within their curriculum area	2	7	2	11
6	Demonstrate knowledge of a range of appropriate resources and strategies to support students' numeracy learning in their curriculum area	2	4	5	11
Professional Attributes					
7	Display a positive disposition to supporting students' numeracy learning within their curriculum area	2	5	4	11
12	Exhibit a commitment to ongoing improvement of their teaching strategies to support students' numeracy learning	2	7	2	11
14	Develop and communicate informed perspectives of numeracy within and beyond the school	0	6	5	11
Professional practice					
15	Promote active engagement in numeracy learning within their own curriculum context	1	5	4	10
17	Take advantage of numeracy learning opportunities when planning within their own curriculum context	1	5	4	10
20	Demonstrate effective teaching strategies for integrating numeracy learning within their own curriculum context	1	6	3	10
21	Model ways of dealing with numeracy demands of their curriculum area	0	4	6	10

Note: \*One PST did not complete items 15-22 in Week 9.

Both PSTs identified that mathematics was involved in numeracy on both occasions. PST 6 made a connection to real world settings (*context*), but this was not part of PST 1's response on either occasion. There was some variation in their perception of the *mathematical knowledge* needed and no mention of *dispositions*, *tools* or *critical orientation*.

### Discussion and Concluding Remarks

The need for all Australian teachers to adopt strategies that support their students' numeracy development is explicit in the APSTs (AITSL, 2011) and the Australian Curriculum (ACARA, 2017). Research on how practising teachers can be supported to

address numeracy in the subjects they teach is growing (e.g., Goos et al., 2014) but research on how best to prepare PSTs is in its infancy. This paper has reported preliminary findings from a one-year pilot study that aimed to investigate the impact of a course designed to support PSTs to develop the capacity to address numeracy in the subjects they will teach.

A major limitation of the study was the pool of potential participants. When planning the study, it was envisaged that the cohort would be approximately 100 PSTs. However, the number of PSTs who enrolled in the *Literacy and Numeracy Across the Curriculum* course in Semester 2 2018 was much less than this. PSTs also had the option of undertaking the course over the Summer Semester, with anecdotal evidence suggesting that many PSTs elected to take this option to reduce their workload in their final year. The study was revised to include PSTs enrolled in this second offering of the course, but the data collected from this cohort could not be included in the analysis presented in this paper because of the different way in which the course was offered: a one-week intensive of lectures and tutorials followed by independent study.

The response rate for PSTs who completed the Numeracy Confidence Survey and Understanding Numeracy task on both occasions in Semester 2 2018 (32% and 24%, respectively) was reasonably high when compared to evaluation of a similar course conducted by Forgasz and Hall (2016) where response rate on the pre-course and post-course administration of their questionnaire was approximately 18 and 11%, respectively. The course Forgasz and Hall evaluated also utilised the 21<sup>st</sup> century Numeracy Model (Goos et al., 2014) but focussed only on numeracy and the pool of potential participants in their study was much larger (approximately 300). Forgasz & Hall's questionnaire was conducted online, and they looked at changes in cohort confidence rather than comparing individual responses. A major difference in the findings in their study when compared to findings reported in this paper was the lower PST confidence levels reported prior to the course: more than half of the PSTs reporting being 'somewhat confident' in "incorporating numeracy into the teaching of [their] subject area(s)" (Forgasz & Hall, 2016, p. 235). The interview data, which is yet to be analysed, may shed some light on why the PSTs in this study reported relatively high confidence levels prior to undertaking the course.

The small number of PSTs who completed the Numeracy Confidence Survey on both occasions and the high levels of confidence reported in Week 1 make it difficult to make any strong claims from the data. The findings indicate that the course probably had an impact on the PSTs' confidence in various aspects of addressing numeracy in the subjects they will teach. However, the study also highlights the challenge of evaluating the impact of courses when there are small cohorts, and the broader issue of getting feedback from PSTs. The study begins to address the lack of research on ITE courses that are designed to prepare PSTs to address numeracy in the subject they will teach. Further research is needed in this area.

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