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Australia's Literacy and Numeracy Test for Initial Teacher Education Students: Trends in Numeracy for Low- and High-Achieving Students

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Abstract: The numeracy capabilities of pre-service teachers are a recent focus in the Australian educational system. In this article, we discuss findings from an analysis of data from the Literacy and Numeracy Test for Initial Teacher Education Students (LANTITE), which is administered by the Australian Council for Educational Research. In our analysis, we considered numeracy test data from 20 students from one Australian university: those who achieved the 10 highest and the 10 lowest overall numeracy scores in 2016 at this university on their first attempt of the test. We found that these groups clearly have particular characteristics that were linked to their success or failure on the numeracy test. We discuss programs and resources that the university has made available for students in preparation for the LANTITE and provide additional suggestions to support such students going forward.

Introduction

The Australian Council for Educational Research (ACER, 2016) defines personal numeracy as "interpreting and communicating important non-technical mathematical information, and using such information to solve relevant real-world problems to participate in an education community, to achieve one's goals, and to develop one's knowledge and potential as a teacher" (p. 21). Both ACER and the Australian Government Department of Education and Training (AGDET) acknowledge the importance of teachers having strong numeracy skills to function successfully in their roles as teachers, both inside and outside the classroom, and in adult society generally (ACER, 2016; AGDET, 2017). Numeracy is a general capability in the Australian Curriculum, which means that it is the responsibility of all teachers to develop students' numeracy capabilities (Australian Curriculum, Assessment and Reporting Authority [ACARA], n.d.). Furthermore, based on the accreditation standards of the Australian Institute for Teaching and School Leadership (AITSL, 2015), graduates of teacher preparation programs are expected to "know and understand literacy and numeracy teaching strategies and their application in teaching areas" (p. 11).

To assess whether pre-service teachers are prepared for the numeracy (and literacy) demands of their profession, the Literacy and Numeracy Test for Initial Teacher Education Students (LANTITE) was created by ACER, on request of the Australian government (ACER, 2016). The LANTITE was implemented on July 1, 2016; the initial policy was that all students who completed undergraduate or postgraduate programs in teacher education in Australia had to pass this test in order to be registered to teach in Australia (AGDET, 2017). The policy changed in 2017: From this point onward, passing LANTITE became a requirement for graduation from an initial teacher education course. Passing this test indicates that the students are considered to be in the top 30% of the adult population in Australia with regard to personal literacy and numeracy (AGDET, 2017). In this paper, we discuss the results of students who achieved the top 10 and bottom 10 scores in 2016 at one Australian university (herein referred to as University X) on their first attempt of the numeracy component of the LANTITE test, in order to better garner an understanding of the factors that may contribute to these students' success (or failure) on this test.

Overview of the LANTITE: Numeracy Component

The numeracy component of the LANTITE is composed of 65 questions, for which 52 have an online calculator available, compared to 13 without a calculator available (ACER, 2017b). Of the 65 questions, there are four calculator trial items and one non-calculator trial item that do not contribute to the test results (ACER, 2017b). The questions are selected response format (e.g., multiple-choice) or short answer format (ACER, 2017b). The test is two hours in duration, and is focused on three numeracy contexts that are relevant to teachers: "personal and community, schools and teaching, and further education and professional learning" (ACER, 2017b). The test is divided into three numeracy content areas, which parallel the mathematics content strands in the Australian Mathematics Curriculum (ACARA, n.d.-a), both in topic and proportion: Number and Algebra (40-50% of the test questions), Measurement and Geometry (20-30%), and Statistics and Probability (25-35%) (ACER, 2016). The content areas and examples of content are shown in Figure 1.

Numeracy area	Example content
Number and algebra	Proportional reasoning; ratio; fractions (including score conversions); percentages (including weighted percentages across assignments); decimals; scientific notation; money; budgeting; interest calculations; basic operations; simple formulae; calculation of GST
Measurement and geometry	Time; timetabling and scheduling (e.g. parent–teacher interviews, timetables across multiple campuses); knowledge about space and shape, symmetry and similarity relevant to common 2D and 3D shapes; quantities, including areas and volumes; use of given relevant routine formulae; conversion of metric units; use of maps and plans, scales, bearings
Statistics and probability	Interpreting mathematical information such as graphs; statistics and data (including NAPLAN data); comparing data sets or statistics; statistics and sampling, including bias; distributions; data and interpretation validity; reliability; box plots – matching data to displays; actual against predicted scores; assigning a grade based on a raw score; interpreting/calculating an ATAR; drawing conclusions about student achievement based on data

Figure 1. Content areas and examples of content on the LANTITE numeracy test. (ACER, 2016)

In addition to having the questions in set proportions by content area, the questions are also organised in set proportions by numeracy process. Namely, there are three numeracy processes assessed in the LANTITE numeracy test: (1) Identifying mathematical information and meaning in activities and texts, (2) Using and applying mathematical knowledge and problem solving processes, and (3) Interpreting, evaluating, communicating, and representing mathematics (ACER, 2016). Respectively, these processes account for 15-25%, 50-60%, and 20-30% of the questions on the numeracy test (ACER, 2016).

To illustrate the content areas and numeracy processes, we provide examples of two sample LANTITE numeracy questions. The question in Figure 2 is an example of a "calculator available" question, while the question in Figure 3 is an example of a "calculator not available" question.

Numeracy Sample Question 2

GYM COSTS

Here is the schedule of costs for Gym and Swim memberships at a sports facility.

	Gym only ($)	Swim only ($)	Gym and Swim ($)
12 Months (upfront)	596	461	773
12 Months (monthly debit)	51	33	66
6 Months (upfront)	330	295	502
Casual (per visit)	12	5	15

For a 12-month 'Gym and Swim' membership, how much **more** does it cost to pay by monthly debit rather than upfront?

$_______________

Figure 2. "Calculator available" sample question from LANTITE numeracy test. (ACER, 2016)

This open-ended question is part of the Number and Algebra content area, as well as the "Using and applying mathematical knowledge and problem solving processes" numeracy process. Students are required to correctly select the appropriate data from the table (i.e., referring to the 12-month "Gym and Swim" memberships) and then make a comparison of the prices. That is, students need to compare the provided 12-month upfront price ($773) with the total cost for 12 months, paying each month, which requires a calculation ($66 x 12 = $792). Then, they need to subtract the upfront price from the monthly price ($792 - $773 = $19).

Numeracy Sample Question 10

GEOGRAPHICAL DISTRIBUTION OF AUSTRALIANS

The Australian Bureau of Statistics conducts a census every five years.
In 2011, the population of Australia was 22 million.
About 2% of these people lived in remote or very remote areas.

About how many people lived in remote or very remote areas in Australia in 2011?

A 11 000
B 44 000
C 110 000
D 440 000

Figure 3. "Calculator not available" sample question from LANTITE numeracy test. (ACER, 2016)

This multiple-choice question is part of the Number and Algebra content area, as well as the "Using and applying mathematical knowledge and problem solving processes" numeracy process. Working without any tools, students are required to calculate 2% of 22 million. Notably, the responses provided feature the correct answer (440,000), an incorrect answer due to a place value error (44,000), and two similar answers, but using ½% instead of 2%. To correctly answer the question, the students need to be able to translate "22 million" into a numeral (22,000,000) and then calculate 2% of this value, which may be done by taking 1% of the value (22,000,000 x 0.01) and then doubling the answer, by directly calculating 2% of the value (22,000,000 x 0.02), by using a fractional approach to the calculation (22,000,000 x 2/100), or by using another method.

When students receive their results, they are not provided with specific scores – either overall or for any category of the test. Rather, they receive a graphical representation of their scores, by category and overall, simply showing the relationship between each score and the standard (i.e., passing score), as shown in Figure 4.

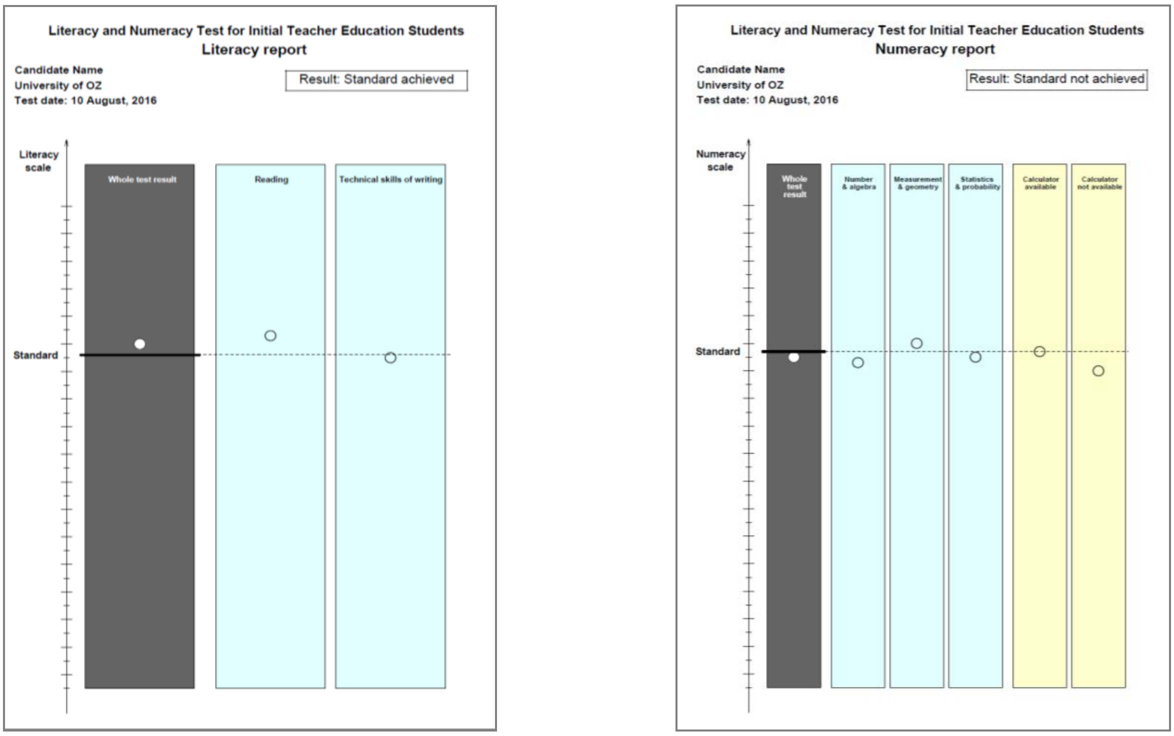

Figure 4. Sample individual reports from LANTITE (literacy on left, numeracy on right). (ACER, 2017a)

Hence, there is no way for students to know their scores on the test, or what a "cut-off" score is to achieve the standard required. As we will discuss, universities are also not provided with explicit information regarding "cut-off" scores, but this information can be deduced if the students' marks are sufficiently close to the "cut-off score" (e.g., if a student with a score of 107 met the standard required but a student with a score of 106 did not meet the standard, that means that 107 is the cut-off score). Additionally, the method for deriving the whole test result from the numeracy content area results, or from the calculator availability results for numeracy, is not explained in any available documentation.

Related Literature

Since the LANTITE is new, there is not much literature, save for that in the popular media, about the test. We therefore begin our discussion of related literature by addressing general issues with standardised testing. Then, we provide an overview of research conducted about literacy and numeracy tests for pre-service teachers in other countries. We conclude by addressing what little research has been done specifically about the LANTITE test.

Issues with Standardised Testing

A number of issues have been raised with standardised testing generally. Such tests typically comprise multiple-choice questions that give no indication of whether the student has applied correct reasoning versus simply guessing (Clements, 1980; Perso, 2009). In addition, these closed questions cannot measure students' confidence and disposition to use mathematics (Perso, 2009), an important element of numeracy as depicted in Goos, Geiger, and Dole's (2014) 21st Century Numeracy Model. Popham (1999, 2001) questioned the validity of large-scale assessments, citing the limited number of items and selection of items by test developers for the purpose of score discrimination between students rather than measuring instructional effectiveness. Concerns have also been raised about the timed nature of such tests and issues with fluency, which might prevent students from demonstrating what they actually know (Perso, 2011). The timed nature of tests – both standardised tests and classroom tests – can also cause pressure, stress, and anxiety for students (Ashcroft & Moore, 2009; Boaler, 2014).

Other issues centre on the language aspect of standardised testing, particularly for mathematics and numeracy tests. Numerous researchers have suggested that the linguistic complexity of standardised tests may act as a barrier to the numeracy or mathematics of the presented problems (Abedi & Lord, 2011; Schleppegrell, 2007). In particular, linguistic complexity may impact students for whom English is an additional language (O'Keeffe, O'Halloran, Wignell, & Tan, 2017). Additionally, based on an analysis of numeracy tests for nursing students, Wright (2007) challenged the notion that written numeracy tests are appropriate since the clinical practice of numeracy in nursing is verbal, not written, and it can be difficult to transfer between written and oral mathematics. Similarly, a large proportion of everyday numeracy experiences for teachers, learners, and the general public are done mentally or verbally, without written calculations.

Furthermore, Zevenbergen (1998) suggested that access to resources, environments, and interactions for the development of linguistic competence is not socially equitable, so those from low SES backgrounds are likely be disadvantaged in mathematics learning. This may be one factor explaining links found between numeracy performance and disadvantaged social backgrounds. In examining student performance for mathematical literacy in the Programme for International Student Assessment (PISA) assessments, Thomson, De Bortoli, and Underwood (2017) found that "students in the higher quartiles of socioeconomic background performed significantly higher than those in the lower quartiles of socioeconomic background" (p. 186). This pattern was consistent over five test cycles across 12 years.

Other Countries' Literacy and Numeracy Tests for Pre-Service Teachers

National pre-service teacher literacy and numeracy assessments have been implemented in several countries; however, the focus has mainly been language proficiency (ACER, 2016). Australia, Canada, Germany, and Singapore have language proficiency requirements for pre-service teachers that must be demonstrated prior to admission to an initial teacher training university program (ACER, 2016; Australian Government, n.d.; Ministry of Education Singapore, 2017). In Hong Kong, pre-service teachers must meet designated standards on a literacy test prior to registration as a teacher of English (Coniam & Falvey, 2001).

Compulsory testing in both literacy and numeracy for teacher registration began in the U.K. in 2000 (ACER, 2016). After operating for over a decade, the U.K. Department for Education (U.K. DfE) toughened the Qualified Teacher Status (QTS) test requirements, setting a higher pass mark and requiring prospective teachers to pass both tests within three attempts before commencing teacher training (U.K. DfE, 2013). The pass rate for both tests dropped from 98% in 2011/2012 to 88% in 2012/2013 (U.K. DfE, 2013). There is a provision for candidates who fail three attempts to reapply to re-sit the tests and reapply for teacher training after two years (U.K. DfE, 2013). Issues identified with the U.K. QTS tests include technical issues with computer-based testing and the timed nature of the test (McNamara, Roberts, Basit, & Brown, 2002). These issues with the pre-service teacher tests in the U.K. have implications for Australian pre-service teachers' performance on the LANTITE. In particular, students who have not undertaken written tests in quite a while might experience a decline in their test-taking skills. Additionally, completing a test via computer may be unfamiliar for some students and there may be technical issues (Hextall, Mahony, & Menter, 2001) such as computers crashing or the internet dropping out during remote proctoring.

In 2008, Chile introduced a national testing program for exiting pre-service teachers called the INICIA Programme (which translates to Initial Diagnostic Pedagogic Evaluation for Future Teachers) as a form of accreditation in response to a wide range of quality in teacher education programs within the deregulated tertiary education sector (Meckes, Taut, Bascopé, Valencia, & Manzi, 2012; Tatto, 2015). The paper-and pencil-tests cover content knowledge, pedagogical knowledge, and pedagogical content knowledge, as well as writing and ICT skills (ACER, 2016). As such, the tests cover a much wider range of knowledge and skills than the U.K. tests. In contrast to the U.K. tests, the INICIA tests are voluntary, although most institutions with initial teacher education programs do participate (Meckes et al., 2012). Additionally, results are reported at the institutional level, not the individual level, and have been used by many institutions to improve their teacher education programs through changes to the curriculum and program courses, and changing their graduate profile and teaching staff (Meckes, 2012).

The LANTITE tests appear to be modelled on earlier iterations of the U.K. QTS tests as the LANTITE is now a requirement for professional registration as a teacher with the state teacher registration body. The Australian tests are also online and limited to literacy and numeracy, in contrast to the Chilean tests. Results are reported at the individual level to both the pre-service teachers, for registration purposes, and to Australian educational institutions, providing an opportunity for analysis of the LANTITE data and feedback to teacher training programs.

Australia's Literacy and Numeracy Test for Initial Teacher Education Students (LANTITE)

Most of the current literature about the LANTITE test contains a discussion of the test's purpose or potential issues rather than an analysis of the test (e.g., ACER, 2016; McGraw & Fish, 2017; Perkins, 2016). McGraw and Fish (2017) argue that

> *the use of high stakes tests associated with ATAR ranking scores and LANTITE literacy and numeracy testing… when used in isolation as gatekeeping devices, serve[s] as simplistic measures that fail to recognize the complexity of what it means to teach and learn well. (p. 2)*

Such restrictions risk limiting the diversity of people who enter teaching, particularly since some of these people may thrive once in tertiary education and develop skills not fostered at school (McGraw & Fish, 2017). For instance, the LANTITE is a potential issue for the recruitment of Indigenous Australians in the Northern Territory into teaching programs (van Gelderen, 2017) due to low levels of literacy and numeracy competency, particularly for those from remote areas (Wilson, 2014). Additionally, there are issues associated with the high cost and level of support needed to prepare such potential students for tertiary-level studies (Wilson, 2014).

To the best of our knowledge, the only example of research specifically about the LANTITE numeracy test is a preliminary analysis of the 10 sample numeracy test items (ACER, 2015), as discussed in two publications (O'Keeffe, 2016; O'Keeffe et al., 2017). O'Keefe (2016) found that these items align with Year 6 mathematics in the Australian Curriculum but have a high lexical density, presenting challenging literacy demands for pre-service teachers. O'Keefe et al. (2017) highlighted issues with both the test items' linguistic complexity and the relationship between images and text. The researchers found that the complexity with text clauses was "not always grammatically necessary" (p. 250). As a result, O'Keeffe (2016) questioned the alignment of the sample test items with the AITSL goal of ensuring that teachers are in the top 30% of the adult population for literacy and numeracy.

As demonstrated, there is a paucity of literature regarding literacy and numeracy tests for pre-service teachers, particularly the LANTITE test in Australia. Our study therefore contributes to this burgeoning field of research.

Methodology

In the following sections, we provide an overview of the research design for our analysis of a subset of a large-scale dataset. The research was guided by the following research questions:

1. What performance patterns exist by numeracy content area and by calculator availability between high achievers and low achievers on the numeracy component of the LANTITE?
2. What demographic patterns exist between high achievers and low achievers on the numeracy component of the LANTITE?
3. What educational pathway patterns exist between high achievers and low achievers on the numeracy component of the LANTITE?
4. Of the low achievers who re-sat the numeracy component of the LANTITE, how did their outcomes differ between their first test sitting and their second test sitting?
5. Of the low achievers who re-sat the numeracy component of the LANTITE, how did they engage with the university-provided numeracy preparation resources?
6. What links exist between numeracy and literacy performance on the LANTITE?

We begin by discussing the data sources and participants in the research. Then, we outline our analysis methods.

Data Sources

Data were provided to University X's Faculty of Education by ACER about each student's performance on the LANTITE. The Faculty of Education then added matched demographic information and course enrolment details. With regard to the numeracy component of the test, the students' scores were provided for five categories: three numeracy content areas – Number and Algebra, Measurement and Geometry, and Statistics and Probability – and two question types (across the numeracy content areas) – those for which a calculator could be used and those for which a calculator could not be used. As noted earlier, ACER does not provide information regarding the maximum possible score or "cut-off" score (i.e., where the standard was achieved). However, we deduced the cut-off score by considering the scores of the students who achieved the standard against those who did not achieve the standard. In 2016, the minimum score to achieve the standard for the numeracy test was 107 points.

Participants

In 2016, the LANTITE took place in May, August, October, and December. Across these four sittings, 698 students from University X completed the LANTITE, of whom 694 completed the numeracy test. Summary data for the cohort are presented in the findings to provide context.

For the purposes of the analysis, we selected the students who achieved the 10 lowest and 10 highest scores on the numeracy component of the LANTITE, to see if there were any trends amongst those who were especially high achieving or low achieving (herein referred to as "high achievers" and "low achievers"). These students represent the top 1.4% and bottom 1.4% of the sample, those at the extremes in terms of numeracy scores on the LANTITE. Specifically, the low achievers had overall numeracy scores ranging from 87 to 98 points (average of 94 points), while the high achievers had overall numeracy scores ranging from 157 to 158 points (average of 157 points).

Analysis

We analysed the data provided for each student through summary statistics and descriptive analyses, methods of analysis that are commonly performed on quantitative data. For instance, we compiled average scores overall and for the subsections (i.e., numeracy content areas and calculator availability) of the numeracy component of the LANTITE for the groups of high achievers and low achievers, as well as for the 2016 cohort as a whole. Additionally, the pathways of the low achievers, after failing their initial attempt at the numeracy test, were examined for subsequent performance when re-sitting the numeracy test by comparing average overall scores, as well as individual students' change in scores for each subsection.

Findings

The summary data for the 694 students at University X who sat the numeracy test in 2016 are provided in Table 1, highlighting the scores for the numeracy test overall, as well as for each of the five categories.

	Category					
	Overall Score	Number and Algebra	Measurement and Geometry	Statistics and Probability	Calculator Available	Calculator Not Available
Minimum Score	87	77	88	92	88	60
Maximum Score	158	145	143	154	157	135
Range	71	68	55	62	69	75
Mean Score	124	123	123	124	124	121

Table 1: Summary Statistics for the Numeracy Component of the LANTITE from University X in 2016

As shown in Table 1, there was a large range (55 to 75 points) in the scores for all the categories, indicating a substantial difference in the students' numeracy skills, as measured by the LANTITE. With regard to mathematical topics, the students generally performed best in Statistics and Probability, which perhaps is not surprising, given the frequency with which students would encounter these topics in everyday life (e.g., in popular media). The questions for which a calculator was not available were overall done more poorly than those for which a calculator was available, which suggests a lack of basic computational skills, or at least the fluency to apply these skills efficiently under timed-test conditions.

In the following sections, we discuss trends in the high achievers' and low achievers' scores on the numeracy component of the LANTITE. We begin by considering the students' scores by numeracy content area and then by calculator availability. Next, we examine trends in the students' demographic data (e.g., gender) and educational pathways. We then discuss the trajectories of the low achievers, after failing their first attempt at the numeracy component of the LANTITE. Finally, we consider possible links between these students' results on the numeracy and literacy components of the LANTITE.

Scores by Numeracy Content Area

As noted earlier, the students from University X generally performed best on questions in the Statistics and Probability content area of the numeracy test. In Table 2, the average scores for each numeracy content area are shown for the high achievers and low achievers.

	Number and Algebra	Measurement and Geometry	Statistics and Probability
High Achievers	141	139	153
Low Achievers	90	95	99

Table 2: Average Scores by Numeracy Content Area for High Achievers and Low Achievers on the Numeracy Component of the LANTITE

As shown in Table 2, the pattern of scores differs for the high achievers and low achievers. While, on average, both groups attained the best scores in Statistics and Probability content area (following the trend of the 2016 cohort as a whole), the high achievers' worst results were achieved in Measurement and Geometry, while the low achievers' worst results were achieved in Number and Algebra. However, the average scores for the high achievers were very similar between these two content areas, while the low achievers, on average, did better (by five points) in Measurement and Geometry than in Number and Algebra. This weakness in the Number and Algebra content area arguably carries over to the other numeracy content areas: If students have weaknesses in this area, they may consequently face difficulties in the other numeracy content areas, which build on and incorporate these concepts.

Scores by Calculator Availability

Across the three numeracy content areas, some questions could be completed with the assistance of calculators, while others had to be completed by hand (i.e., with no calculator assistance). In Table 3, the average scores for the high achievers and low achievers are shown for the calculator and non-calculator questions.

	Calculator Available	Calculator Not Available
High Achievers	156	131
Low Achievers	95	88

Table 3: Average Scores by Calculator Availability for High Achievers and Low Achievers on the Numeracy Component of the LANTITE

As shown in Table 3, both groups performed substantially better when calculators were available, suggesting weaknesses in the ability to perform calculations by hand.

Specifically, the high achievers' average score was 19% higher when calculators were available, while the low achievers' average score was 8% higher. This result poses an interesting conundrum. Presumably, the high achievers had both strong conceptual understanding and procedural fluency. Since the low achievers lacked in both areas, simply having a calculator available would not be that helpful if the students did not know how to solve a problem in the first place. In contrast, calculator availability may have helped the high achievers to avoid making the "silly mistakes" that sometimes occur due to rushing or skipping steps when conceptually strong students solve problems (Assouline & Lupkowski-Shoplik, 2011). For both groups, it is possible that the skills needed to perform calculations by hand are weaker due to the ubiquitous nature of technology: Since virtually all pre-service teachers have smartphones and other technology readily available, they are less likely to need to do calculations by hand (or in their heads) in their everyday lives.

Demographics

The low-achieving group comprised 10 women, while the high-achieving group comprised eight men and two women. While, at first glance, this result appears to suggest a gender difference in numeracy skills, a closer examination reveals that it is instead indicative of the streams and specialisms of the students, as we will discuss in the next section.

Within the low-achieving group, all but one of the students (who was born in 1979) were born between 1987 and 1993. Similarly, the high-achieving students were all born between 1988 and 1994. Thus, the students at both ends of the spectrum, in terms of numeracy test results, can be considered "traditional" (i.e., completed secondary school by age 18 and then began university studies immediately afterward) in age, since participants were either undergraduate students or master's students.

When considering these students by residency status, domestic students dominated both the high-achieving and low-achieving groups. Namely, all 10 of the low achievers and eight of the high achievers were domestic students. Hence, it does not appear that being educated in Australia is a particular advantage or disadvantage when completing the numeracy component of the LANTITE. Analysis of the entire cohort's performance may provide further insight into the role that residency status (particularly the location where students completed their secondary school education) may play.

Educational Paths

All but one of the low achievers (who was a second-year postgraduate student) were fourth-year undergraduate students. In contrast, the high achievers had a mix of levels of study: five fourth-year undergraduate students, one first-year postgraduate student, three second-year postgraduate students, and one postgraduate student in fifth year or above (Presumably, this student misinterpreted the question to mean the total number of years in university studies, as opposed to strictly in postgraduate studies).

With regard to streams (i.e., grade-level qualifications), 8 of the 10 low achievers were in either an Early Years/Primary (birth to Year 6) or Primary (Foundation to Year 6) stream. The other two low achievers were a Primary/Secondary teacher and a Secondary pre-service teacher. In contrast, 9 of the 10 high achievers were in the Secondary stream (Years 7 to 12), and five of the high achievers (of the seven for whom specialism data were available) were verified as having Secondary specialisms in mathematics or related fields (e.g., accounting, general science). Thus, the gender imbalance between low and high achievers is likely an outcome of students' stream and specialism selections. At University X, the majority of Primary students are women whilst over half of Secondary mathematics education students are men. This gendered enrolment pattern has been widely reported, both in Australia and internationally (e.g., McGrath & Van Bergen, 2017; Weldon, 2015).

Trajectories of Low-Achieving Students

The 10 low achievers all failed the numeracy test and had to re-sit the test. Of these 10 students, five chose to re-sit the numeracy test in 2016. While the five students still failed the numeracy test on their second attempt, on average, the performance of these students improved in each category of the test, as well as the overall score, as illustrated in Table 4. Notably, two of these five students were close to passing the numeracy test, with overall scores of 103 on the second sitting. As we will discuss in detail in the next section, support and practice contributed to these pre-service teachers improving their numeracy results. Of the five students, four engaged with one or more of University X’s support services, which included online resources, workshops, and individual consultations.

	Category					
	Overall Score	Number and Algebra	Measurement and Geometry	Statistics and Probability	Calculator Available	Calculator Not Available
First Sitting	91	88	93	97	93	84
Second Sitting	101	101	100	101	101	99

Table 4: Comparison of Average Scores for Five Low Achievers on their First and Second Sitting of the Numeracy Component of the LANTITE in 2016

Some interesting trends emerged at the individual student level, as shown in Table 5. All five students improved their overall score and Calculator Available score. However, only one student improved on every category of the test. As the test items were not the same at each test sitting, it is perhaps not surprising that some students’ scores were lower for a particular category, which could have been reflective of the difficulty (or topics) of specific items on the second test relative to the first test. The timed aspect of the test was a potential issue noted in the U.K. test literature (McNamara et al., 2002). In the LANTITE test, once students move forward to the Calculator Not Available section, they cannot go back to the previous questions. Better time management is one possible explanation for the substantial improvement of Student C on the Calculator Not Available items.

	Category					
	Overall Score	Number and Algebra	Measurement and Geometry	Statistics and Probability	Calculator Available	Calculator Not Available
Student A	3	-4	7	11	5	0
Student B	9	14	-8	13	13	-7
Student C	11	11	14	6	3	46
Student D	12	20	13	-5	11	16
Student E	12	25	9	-8	10	21

Table 5: Change in Category Scores for the Five Low Achievers who Re-Sat the Numeracy Component of the LANTITE in 2016

Supports for Students who Failed the Numeracy Component of the LANTITE

A number of supports were put in place to help all pre-service teachers at University X prepare for both the numeracy and literacy components of the LANTITE test. These complementary supports were envisaged as a funnel-like structure, illustrated in Figure 5, with the potential for all students to access the online resources but only a few to be offered individual consultations.

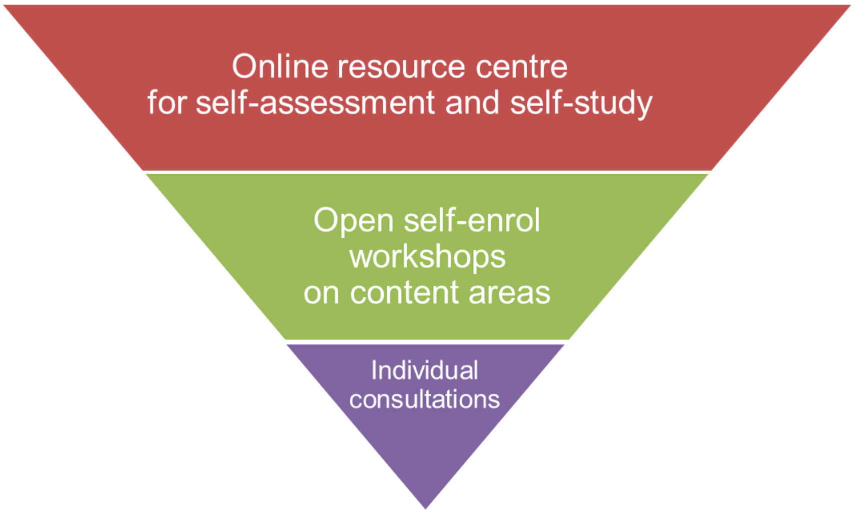

Figure 5: Resources available to students to assist with LANTITE preparation.

An online resource centre was created for self-assessment and self-study, and all pre-service teachers were notified about the resource centre by email. The resource centre had information about the LANTITE tests, links to sample problems, and some content area quizzes and practice numeracy tests. Given the limited official resources (i.e., only 10 sample questions at that time) publicly available for LANTITE preparation, students were provided links to sample National Assessment Program – Literacy and Numeracy (NAPLAN) tests, which are undertaken by Australian school students in Years 3, 5, 7, and 9; problems from past PISA assessments; and links to the resource page for the U.K. QTS tests, which must be undertaken by those aspiring to study a teaching course.

Additionally, a LANTITE introductory session and series of hands-on group workshops were run, which addressed the core content areas for numeracy (and literacy). These were advertised to all pre-service teachers who could choose to register to attend a particular workshop session on-campus or online, or watch a recording later. The introductory session covered the structure of the two LANTITE tests, the test environment, and tips on how to prepare. Two common themes expressed by students during the workshops were that it had been many years since they had last sat a test and that few had experienced an online test situation. The content workshops offered revision of the big ideas in each content area and the opportunity for students to work through and discuss sample problems in Number and Algebra, Measurement and Geometry, or Statistics and Probability.

Students who did not meet the standard for the numeracy test on their first or subsequent sittings were offered individual consultations to help them to identify the gaps in their numeracy knowledge or skills and develop a preparation plan for their next sitting of the LANTITE numeracy test. Some students chose not to take up this opportunity, whilst other students met with the numeracy consultants multiple times to address their gaps and ensure conceptual understanding of the mathematical skills required for numeracy contexts.

As mentioned, five students who failed the numeracy test on their first sitting decided to re-sit it in 2016. All but one of these students engaged with the supports provided by University X, but they did so in varied ways. None of the students utilised all three layers of the supports offered. Students A and C had one individual consultation each, and their "whole test" scores increased by three points and 11 points, respectively, on their second sitting. Student B accessed the online resources multiple times and achieved a whole test score gain of nine points. Student E attended one individual consultation and a workshop on Measurement and Geometry. Overall, Student E's whole test score improved by 12 points, with a gain of 25 points in Number and Algebra and 9 points in Measurement and Geometry. However, Student D did not access any of the resources offered and still obtained an increase of 12 points in the whole test score on the second sitting. Since we cannot know what non-university resources the students used to prepare for their second numeracy test sitting, it is not clear what role the university supports played in improving these students' overall scores.

Links to the Literacy Test Results

Although we focused on the numeracy results of these 20 students in our analyses, we also were interested in these students' literacy test results. Perhaps unsurprisingly, all 10 high achievers passed the literacy test, while only two low achievers did. The actual test items may have had a similarly high lexical density to the sample numeracy test items, as identified by O'Keeffe (2016) and O'Keeffe et al. (2017). Thus, the language used in the test items could have been an impediment for the low achievers in decoding and answering the numeracy test questions.

As discussed by numerous researchers (e.g., Abedi & Lord, 2001; Vilenius-Tuohimaa, Aunola, & Nurmi, 2008), success in mathematics is highly linked to one's literacy/language skills, due to the amount of decoding that must take place when reading mathematical questions. For instance, Abedi and Lord (2001) found that reducing the language complexity of mathematical questions particularly benefitted low/average level mathematics students and English Language Learners (ELLs), while not making a significant difference to the higher achieving students with English as a first language. These researchers suggested that the more complex language did not slow the stronger mathematics students down, as they already had strong language skills, while language complexity was a substantial issue for the weaker mathematics students and ELLs. Being a test of numeracy necessitates that all the questions involve mathematics in a context and thus involve some reading – at least a sentence or two.

Discussion and Conclusions

There were clear differences in the composition of the "high achiever" and "low achiever" groups, as evidenced by the findings presented. Namely, the high achievers were generally those with mathematics-focused specialisms, studying to be secondary teachers, while the low achievers were generally those studying to be primary teachers. None of the low achievers had a mathematics-related specialism (or, in most cases, a specialism at all). We were not surprised to learn that five of the high achievers had specialisms in mathematics or related fields (e.g., accounting, chemistry), as these students would have a great deal of numeracy expertise beyond the "average person" (Recall that the students only need to achieve a score that would place them in the top 30% of the adult population in Australia). Conversely, it is well documented (e.g., Ball, Hill, & Bass, 2005; Bursal & Paznokas, 2006) that primary (generalist) teachers tend to have high levels of mathematical anxiety and weak mathematical skills. Hence, it was not surprising that all of the low achievers were preparing to be primary teachers.

Our findings provide information that will guide those from University X, as well as other Australian institutions, who offer test preparation support to students. Namely, supports should focus on refreshing test-taking skills, especially time management and exposure to online tests. Furthermore, reinforcing literacy skills, developing strategies to decode numeracy contexts and questions, and strengthening fluency with computations will help students to succeed not only on the LANTITE test, but also in other numeracy encounters in their careers as teachers and in everyday life. Such supports may be particularly important for students who have not undertaken much mathematics study at senior levels of secondary school or at university, or in recent years. This group of students may include primary pre-service teachers and those secondary school pre-service teachers whose specialisms are not focused on mathematical reasoning.

Now that the LANTITE tests have been operating for a few years, University X has a clearer understanding of the test requirements and their impacts. Additional staffing has been designated to support students, and the online resource centre has been completely revised. In addition, 30 practice questions and a full practice test are now provided by ACER and preparation resources are available from external providers (e.g., Cambridge LANTITE Edge). To further investigate the ways that students prepare for the LANTITE numeracy test and refine supports offered, pre-service teachers at University X are being invited to participate in a questionnaire and follow-up interview after their test sitting. Findings from the questionnaires and interviews will provide additional information about students' preparation strategies and testing experiences, which will further contribute to this emerging field of research.

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