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Personal and Professional Numeracy: A Unit for Pre-Service Teachers at the University of Tasmania

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Personal and Professional Numeracy: A Unit for Pre-Service Teachers at the University of Tasmania

Abstract

This paper addresses issues associated with the development of a unit preparing pre-service teachers to be quantitatively literate in three respects. These issues surround (i) the need to be aware of numeracy demands across the curriculum, (ii) the need to model numerate behavior in all interactions of teachers, and (iii) the need to be able to interpret and use system data provided from local and national testing programs. The context for the unit described is Australia, where a national testing program for literacy and numeracy requires teachers to analyze extensive data on their students, a national curriculum requires teachers of all subjects and levels to encompass literacy and numeracy in their teaching, and national standards for the teaching profession are being progressively introduced to set and assess teachers' proficiency across their careers. The unit consists of 12 topics covered in lectures and tutorial material, which was offered to over 800 students in External and On-campus modes in 2010.

Keywords

Critical numeracy, quantitative literacy, pre-service teacher education

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Cover Page Footnote

Jane Watson is Professor of Mathematics Education at the University of Tasmania in Australia. Her major research interests lie in school students' understanding of Statistics, Probability, and Statistical Literacy, as well as in the pedagogical content knowledge needs of the teachers who are teaching them.

Introduction

“I don’t need to do maths, I’m going to teach *languages other than English!*” This is a typical comment heard from Australian pre-service teachers. In a sense they are correct: they do not need the mathematics curriculum and method units that are offered to primary and secondary teachers. The world of teaching is changing, however, both in Australia and in other countries, as requirements for numeracy or quantitative literacy skills are being imposed on those who wish to receive teacher registration. The question of what kinds of skills are required is a vexed one. Should there be a basic mathematics skills test made up of numerical problems involving multiplication, division, addition of fractions, finding percentages, calculating areas of figures, reading graphs, working out probabilities, and solving equations? Although most would agree that these are important skills for teachers to have, there is a growing consensus that these skills are not enough (e.g., Madison and Steen 2008).

Background in the Australian Context

Several factors in the Australian context influence what might be expected in terms of numeracy from beginning teachers. Each Australian state and territory has its own teacher registration procedures, but moves are underway to develop national professional standards for teachers.¹ The state of New South Wales (NSW), the largest state by population, has led the nation in setting requirements for teachers who will be employed in that state. To this point they have been associated with required units in pre-service teacher education programs. Pre-service teacher preparation programs in Australia are generally either 4-year initial degrees or 2-year post-graduate degrees. The Queensland Government, however, has gone further and announced that from 2011, all primary teachers seeking registration in that state will be required to pass a test of “knowledge and skills in literacy, numeracy and science to teach in a primary education setting. Applicants will be required to demonstrate threshold levels of:

- knowledge and understanding of content and processes
- pedagogical content knowledge of the area

¹ The standards are being developed under the auspices of the Australian Institute for Teaching and School Leadership, <http://www.aitsl.edu.au> (accessed October 22, 2010)

- an additional component of personal competency for literacy and numeracy only.”²

The requirements for teacher registration reflect other educational initiatives taking place in the national arena. Since 2008, the National Assessment Program Literacy and Numeracy (NAPLAN) has tested all students in Australian schools in grades 3, 5, 7, and 9 each year in these two areas.³ Although the Numeracy test contains some items that are numerical only, most are embedded in a contextual setting requiring literacy skills and knowledge of mathematical terminology, such as “number sentence”⁴ and “quadrilateral.” The outcomes for students on every item are given to the states, which then may decide how this information is passed on to schools, teachers, and parents. Further, in 2010 the Australian government released the *MySchool* Web site, which allows for comparison of schools across neighborhoods or the nation based on NAPLAN outcomes. There is hence increasing pressure on schools and teachers to improve student performance on these tests.

In parallel with the introduction of NAPLAN, the Australian government began the development of a national curriculum based on an underpinning philosophy expounded in a *Shape Statement* (National Curriculum Board [NCB] 2009) and the initial creation of four subjects across the 13 years of schooling (pre-grade 1 to grade 12): English, History, Science and Mathematics. A significant inclusion in the *Shape Statement* is numeracy, alongside literacy, as a requirement of the curriculum across all subjects. Besides the fact that “the curriculum will include a strong focus on literacy and numeracy” (NCB 2009 p. 9), three specific requirements are put in place:

Literacy and numeracy need to keep developing across the school years as the curriculum areas put them to work in increasingly distinct and complex ways. The nature and functions of literacy and numeracy become more differentiated as the school subjects become more recognisably different, based more and more on their informing disciplines. (p. 10)

[I]t is important to conceptualise literacy and numeracy over the full range, from the acquisition of initial skills to the development of sophisticated skills, put to work in different ways in different knowledge domains and social contexts. (p. 10)

Numeracy knowledge, skills and understanding need to be used and developed in all learning areas. Initial and major continuing development of numeracy will be in mathematics but the national curriculum will ensure that this competency is used and developed in all learning areas. (p. 12)

² <http://www.deta.qld.gov.au/child-care-and-other-acts/pdf/explanatory-qct.pdf> (accessed June 30, 2010)

³ For details on NAPLAN go to <http://www.naplan.edu.au> (accessed June 30, 2010)

⁴ A number sentence is an equation.

Although not all curriculum areas have had draft curricula developed, there is pressure on pre-service teachers to have acquired the skills and understanding to be able to cope with numeracy across the curriculum. Hence pre-service programs feel the necessity to provide the foundations, building on the skills the pre-service teachers bring to a program.

These three factors – teacher registration requirements, the need to interpret NAPLAN and other system data, and the cross-curriculum demands for numeracy in a national curriculum – led the Faculty of Education at the University of Tasmania to create a new unit⁵ within a revised pre-service program, entitled “Personal and Professional Numeracy.” The new unit is worth 12.5% or one quarter of a semester’s workload (in a two-semester academic year).

Background in the Local Context

The University of Tasmania offers two main pre-service teacher education programs that require enrolment in Personal and Professional Numeracy: a 4-year Bachelor of Education (BEd) for primary and early childhood teachers and a 2-year post-graduate Master of Teaching (MTeach) for primary and secondary teachers.⁶ Due to the foundational nature of the unit and for reasons of economy it was decided that Personal and Professional Numeracy would be taught to all first year students in both programs in the first semester of their course.

At the same time that this change was taking place, the Faculty also decided that whereas in the past the two programs had each been offered face-to-face on two of the three university campuses, they would now be offered on-line to External students as well, with the same learning outcomes for each mode of delivery. The result of this initiative was an increase in initial enrolment from a previous expectation of about 250 students to over 800. Hence as well as developing the content of the unit, it was necessary to consider implementation across the two modes of delivery and ensure the same potential learning outcomes.

Although other faculty members had had previous experience with External students and on-line delivery, the author had not. The MyLO blackboard system⁷ was the avenue for information delivery for all students. The Echo 360 video-recording system⁸ was used for recording lecture-type material, including other

⁵ In Tasmania the word “course” equates with an entire program in which a student is enrolled whereas a “unit” is a self-contained and assessed sub-component of a course. Usually there are eight units offered for full-time students in one academic year.

⁶ The secondary specializations offered are English, History and Society, Science, Mathematics, Music, Multi-Media, Drama, Visual Arts, Design and Technology, ICT, and LOTE (Languages Other than English).

⁷ <http://www.blackboard.com/default.aspx?lang=en-us> (accessed October 22, 2010)

⁸ <http://www.echo360.tv/products/index.asp> (accessed October 22, 2010)

linked video material, and software and Web-linked demonstrations. Face-to-face delivery of this lecture material took place on one campus, whereas face-to-face students on the other two campuses had to watch the lectures via the video system Lectopia⁹ through MyLO. On-campus students on the three campuses had 2-hour face-to-face tutorials once a week, whereas External students were assigned to tutorial groups of 30 or more, with an assigned on-line tutor. The tutorial content provided to External students was the same as for the On-campus students, with specific questions to be discussed on the MyLO Discussion Board. There was a total of 10 tutors, including the author: three taught face-to-face only, three taught on-line only, and four taught both. The number of groups per tutor ranged from one to four. All students had access to the Unit Coordinator (the author) via email or telephone.

Background Content Planning

As there was no mathematics prerequisite for either the BEd or the MTeach program (except for those enrolling in Secondary Mathematics 7-12, which required at least two years of university mathematics), it could only be assumed that students had completed grade 10 mathematics at some level at school. Twenty-five years of previous experience of the author with both pre-service and in-service teachers led to the belief (confirmed by Schield 2008) that many of these pre-service teachers would not possess the proportional reasoning skills that are the basis of the middle school mathematics curriculum (grades 5 to 9): fractions, percentages, rates, ratios, and proportions. These concepts are at the heart of the quantitative literacy needs across the curriculum (e.g., Watson 2004; Schield 2008) and also of the statistical literacy needs for interpretation of system data (e.g., Watson 2006). It was hence decided to start with these fundamental ideas and keep referring back to them throughout the unit to reinforce their importance, and their application.

In relation to the overall programs in which Personal and Professional Numeracy was embedded, the unit was considered a foundation unit, not a “curriculum and method” unit. Hence when examples relevant to other curriculum areas were introduced it was stressed that these were intended to motivate an appreciation of numeracy across the curriculum. As most examples were from current media reports, the author also believed that the unit was meeting to some extent the personal numeracy/quantitative literacy goals that should be the outcome of any university education (Steen 2008). This was further conveyed to the pre-service teachers by indicating that in all aspects of their professional lives they should be modeling numerate behavior to their students, to the students’

⁹ <http://www.lectopia.com.au/> (accessed October 22, 2010)

parents, and to their fellow teachers. An extension in the Australian context was to be able to interpret system data, such as NAPLAN, about students in order to plan appropriate interventions.

Unit Content

The learning objectives of the unit mathematically focused on the proportional reasoning needed for quantitative literacy, merging into the statistical literacy necessary for interpreting system data. Based on the belief that many students would not be enthusiastic about enrolling in the unit, several strategies were used to assist in scaffolding learning.

Every topic was introduced using a critical numeracy framework (Watson 2004). The framework has three tiers. The first is “understanding the terminology,” and includes basic definitions and expectations. The second is “understanding the terminology in context,” which includes many examples in different settings. The third tier is “questioning claims made without adequate justification,” which involves the critical thinking that may evolve differently in different contexts. Every lecture followed this format, with only slight variation. To create interest some contexts were based on newspaper articles with somewhat humorous claims, such as that dogs living with smokers have a lower chance of cancer if they have long noses than if they have short noses, whereas others were quite serious, such as the diagnosis of disease or arguments about global warming. Where possible, cartoons were shown to allow a pause for a chuckle, assuming the students’ numeracy levels allowed them to see the joke. The cartoon in Figure 1, created by a colleague, is one example.

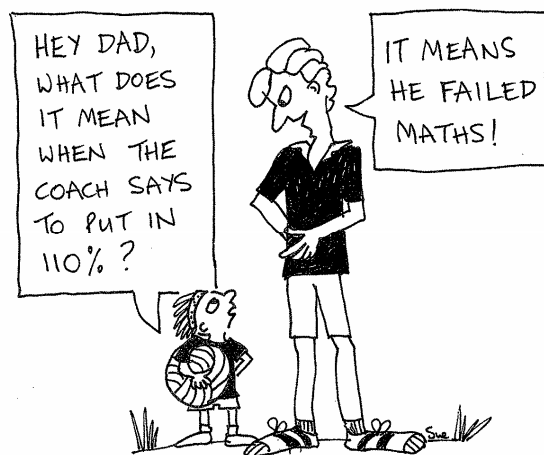


Figure 1. Cartoon from lecture on percent (© Sue Stack, 2009).

At times when introducing a concept, extracts from research of school students' understanding (Watson 2006) were shown to illustrate how development occurs and what understanding the pre-service teachers might expect to see in their classrooms. This was related to interviews on average and sampling, and to survey items on sampling, graphing, and chance. At times the pre-service teachers were presented with a question and asked to solve it before observing the responses of school students. Some very short extracts from television advertisements were shown to illustrate the use of average, percentage, and inferential claims in the media. Extended extracts from a national television program called Media Watch exposed journalists' errors with respect to average and sampling.¹⁰ A publicity video by the Australian Securities and Investments Commission heralded the value of Consumer and Financial Literacy being included in the national curriculum. Videos from gapminder and Cambridge University were also shown in relation to risk.¹¹ At times demonstrations were based on "live" interaction with the data handling software for middle school, *TinkerPlots* (Konold and Miller 2005) or representations created in *TinkerPlots* were used to illustrate concepts. The Web site, *Numeracy in the News*,¹² was also introduced and lessons found there were shown to illustrate specific cross-curriculum applications of numeracy. Appendix 1 contains a snapshot of the content of the lectures in the unit.

Again associated with creating interest and alleviating tension, the "textbook" chosen for the unit was *The Tiger that Isn't: Seeing through a World of Numbers* (Blastland and Dilnot 2008). Available in paperback at \$A23, it was perhaps the cheapest and most read textbook of the year. Written by two British journalists for a popular audience and based on a BBC radio series, the book addressed all of the topics in the unit and a chapter was assigned reading for nearly every topic and two chapters for one topic. Besides the textbook, one or two readings from the mathematics education literature were assigned for each week (and available on-line through the university library). Some readings, such as Zacharias (1974) and Steen (2007) were meant as background to the unit, whereas others, such as Parker (2004) and Clarke, Roche and Mitchell (2008) were intended to assist pre-service teachers with their own understanding as well as provide the primary group with ideas to be used later in their teaching. Two articles at the end of the

¹⁰ <http://www.abc.net.au/mediawatch/transcripts/s2536433.htm> (accessed June 30, 2010)

<http://www.abc.net.au/mediawatch/transcripts/s2605167.htm> (accessed June 30, 2010)

¹¹ <http://www.gapminder.org/videos/swine-flu-alert-news-death-ratio-tuberculosis/> (accessed June 30, 2010)

<http://www.youtube.com/watch?v=a1PtQ67urG4> [Professor Risk video] (accessed June 30, 2010)

¹² <http://www.mercurynie.com.au> (accessed October 22, 2010)

unit were directly linked to NAPLAN testing (Anderson 2009 and Perso 2009). Three articles based on *TinkerPlots* software (Watson 2008; Watson et al. 2008; Watson and Wright 2008) were intended to illustrate the use of technology in relation to critical numeracy across the curriculum and to provide ideas relevant to many of the pre-service teachers.

To enhance and reinforce the material presented in the lectures, tutorial material was provided each week. The material was written in a self-guided fashion for External students but also so that it could be covered in a 2-hour face-to-face session for On-campus students. Recent media releases on Web sites were used in order for External students to have access to full reports. Topics included an increase in asthma attacks, a Good Credit Guide, use of nappies (diapers), waits for elective surgery, childhood deaths from diarrhea, weather bureau reports of risk, detection of Down syndrome, and controversy over pedophile priests. Students were often asked to comment on sections of *The Tiger that Isn't* and compare and contrast with other material in the unit. As an example, the book's authors were highly critical of the production of league tables for UK schools, and the pre-service teachers were asked to compare the UK situation with that presented on the *MySchool* Web site in Australia and write a letter to the Minister for Education either supporting or not supporting the Web site. Various NAPLAN numeracy items were also presented to enable the pre-service teachers to become aware of what their future students will be facing. As an example of the tutorial expectations, some tasks from one "self-guided tutorial" are provided in Appendix 2.

Assessment

The assessment tasks for the unit consisted of two essay-type assignments to be handed in for marking in the middle and at the end of the unit and a 40-item on-line multiple-choice numeracy exam. The exam was placed within the unit by the faculty but only counted 10% of the overall mark; if the pre-service teachers did not receive 80% on the test, they could sit it again the following semester. Although causing stress to many, the test was not intended as a feature of the unit and although a practice test was provided, no specific instruction was provided except for the provision of NAPLAN items of a similar standard.

The first assignment (40%) was to solve a word problem that could be solved with or without algebra (Watson 1988).

Three tired and hungry men went to sleep with a bag of apples. One man woke up, ate $\frac{1}{3}$ of the apples, then went back to sleep. Later a second man woke up and ate $\frac{1}{3}$ of the remaining apples, then went back to sleep. Finally, the third man woke up and ate $\frac{1}{3}$ of the remaining apples. When he was finished there were 8 apples left. How many apples were in the bag originally?

Pre-service teachers were then asked to give the problem to others to solve, record and reflect on the various solutions in terms of appreciation of the variation in strategies used and implications for future teaching. Comments within face-to-face tutorial groups and in on-line discussions displayed a wide range of reactions to the problem. On one hand some panicked and just said, “I can’t do algebra problems – I never could!” On the other hand some believed algebra was the only avenue for solving the problem. Others were more creative and there were reports of families sitting around the kitchen table with real apples or nuts or other tokens, and acting out the problem. One pre-service teacher asked a 7-year-old boy who, after being told what “a third” meant, successfully solved the problem. Many primary school students solved the problem often by drawing representations or just imagining “one third and two thirds” in their heads. There were also many algebra-based solutions, especially from people with more mathematics background. Nearly every pre-service teacher who completed the assignment expressed amazement at the variety of solution strategies, not all of which achieved the correct answer of 27. Well over 2500 people solved the problem and it even achieved notoriety in a local Sunday newspaper commentary:

SLEEPING men who wake only to eat apples, then nod off again? That was part of a seriously weird “practical” arithmetical puzzle posed to first year University of Tasmania at Launceston education students, including CATHERINE, of South Launceston.

“The puzzle involved three apparently ‘tired and hungry men’ who were asleep but who woke up to eat from a bag of apples,” the student reports. It seems the dilemma revolved around every male eating a third of the bag’s contents.

“When the third man had eaten his share there were eight apples left, you had to calculate how many apples there were to start with,” Catherine reports. “My ‘helpful’ dad figured it out as 21.3 apples recurring.”

A group of Launceston primary school teachers invited to “workshop” the problem had no immediate success even if one chalkie wanted to undertake the brain exercise in a thoroughly practical way.

“She planned to ‘try it out with a whole bunch of sleeping guys and big hessian bag full of fruit’,” Wry and Dry’s source relates.

Hmmm. ...

(Stevenson, 2010)

This is exactly the sort of publicity one might hope to get for a critical numeracy unit—a light-hearted side to a serious issue for pre-service teachers.

The second assessment task (50%) asked the pre-service teachers to find a media article or advertisement that would facilitate the development of critical numeracy skills as introduced in the unit. They were then to develop a plan to teach a lesson with the material, teach it to a small group of people (perhaps children, depending on their context) and evaluate the critical numeracy aspects of the experience in various ways. Given the potential cross-curricular nature of

numeracy in the new national curriculum it was felt that most of the pre-service teachers would be able to find something that linked to their future teaching. Those who could not, perhaps pre-school teachers, were asked to imagine that they had been invited by the Parents Association to give a presentation on the importance of numeracy to their children in today's world. The range of extracts chosen was very wide. Although many chose supermarket advertisements with discounts and special prices that offered opportunity for the first two tiers of the critical numeracy framework, few developed these for the third tier of the framework, critical thinking and questioning. Some, however, accepted the challenge. A pre-service social science teacher chose youth crime statistics for a legal studies class, a music teacher chose a Web site on illegal music downloads, and a deaf teacher chose an article on cochlear implants. Although percent was the most commonly chosen numeracy content, some of the best assignments focused on sampling issues and risk. This assessment task did not achieve publicity in the local media but many commented that they had never before appreciated the power of numeracy across the curriculum and in their own interaction with reports from the media.

To give an idea of how the assessment for each task took place, the rubric used for the second task is provided in Appendix 3. At the University of Tasmania, numerical marks are given in relation to the following letter grades: Fail, NN (<50%); Pass, PP (50-59%); Credit, CR (60-69%); Distinction, DN (70-79%); and High Distinction, HD (80-100%). Students were provided with the criteria, including explanations in the Unit Outline, and with the rubric itself on the MyLO site several weeks before the assessment task was due.

Evaluation

Students (Pre-Service Teachers)

Student outcomes for the unit can be evaluated in several ways. In a new unit with over 800 enrolments, the initial withdrawals before the university census date (5 weeks into the unit), 264 students, may not have been related to the unit content but to other life issues, employment, lack of adequate Internet connection, or inability to pay university fees. This left 633 students enrolled in the unit. After the census date students who did not withdraw but who handed in no assessable work (29) were deemed absent (AN). Again it is difficult to judge the reason as to why as no work was submitted – in this case however it may be that students attempted but could not complete the first assessment task (the one based on solving a mathematics problem) and gave up. Students who remained enrolled and submitted one or both assessment tasks but failed to receive the pass mark of 50% (81) received the grade NN. Of these, 52 only submitted the first assessment task whereas 29 submitted both. Although the overall failure rate was 17.4%, the

percent of students who completed the work in the unit and failed was only 4.6%. Students achieving a pass or better numbered 523 (82.6%), with a higher percentage passing in the MTeach than in the BEd.

The viewing of the on-line lectures diminished significantly over the semester, as did the attendance at face-to-face lectures. This is apparently a common phenomenon, not only due to withdrawals and dropouts, but also due to increased assignment work across the program and the possible perception that once the topic for the second assessment task was chosen it was no longer necessary to learn about further topics. There were over 1500 accesses to the first part of the first lecture, but only 144 to the first part of the final lecture. As well, student interaction with the on-line discussions diminished throughout the unit. Periodically there were emails to the author from students who continued to have a view equivalent to the student at the beginning of this paper. Further explanation and justification were attempted to dissuade students from the narrow “apprentice” belief about what teacher education (not teacher training) involves.

All students were given the opportunity to answer 15 Likert scale (1 for Strongly Disagree to 5 for Strongly Agree) questions about the unit, External students on-line and On-campus students on hard-copy. Overall, the response rate was 44%. Five of the questions considered students’ learning to think critically and independently and gain a command of the content. Ten questions dealt with the unit addressing its learning outcomes, the assessment and workload, the interaction with staff and usefulness of feedback, and the understanding and skills gained in the unit. The On-campus students had an average score of 3.9 out of 5.0 with the External students slightly lower due to the less positive response of the 16 External MTeach students who replied. Extra written responses were overwhelmingly positive about the tutors in the unit. The MTeach students, with at least three years’ of previous experience at university were generally quite positive about the lectures and content whereas the BEd students, for whom this was usually their first semester at university, were more critical of the lectures for being difficult to follow, too long, too boring and/or assuming too much mathematical background. There was also some (justified) criticism of the visual quality of the video (due to the desire on the part of the university to keep the download size reasonable). There were, however, some encouraging exceptions from the BEd students: “I thought the lectures were very well done. I thoroughly enjoyed them and I learnt a great deal from them. [Better] lectures than any other unit.”

Tutors

All tutors in Personal and Professional Numeracy were either full-time seconded¹³ teachers (either primary or secondary) or people employed on casual contracts (PhD students, senior secondary teachers, or research assistants). All had the necessary mathematics background for the unit. Some faced the same challenges as the author in convincing students that the unit was necessary for their teacher preparation, especially those in face-to-face settings. The major feedback from tutors was related to the poor basic numeracy skills (percent and proportional reasoning) of the students and the need for even more teaching of skills than was provided in the “terminology” section of the lectures. Some face-to-face tutors added instruction and practice during their tutorial sessions. On-line tutors reported disappointment with the decreased interaction across the semester but could not suggest solutions. The tutors were very positive about being involved with the unit and wished to continue in the future. Useful suggestions were made for improving the experience of on-line students, including real-time Elluminate¹⁴ sessions to answer specific student questions where mathematical procedures could be explained in more than one way.

Author Reflection

The author firmly believes the content of Personal and Professional Numeracy is necessary for teachers in the 21st century. There were no complaints that there was too much material in the unit, which on one hand rather surprised the author. On the other hand, most likely the students just stopped viewing or attending lectures and completing the tutorial work (as documented above). Because of the large enrolment, the administrative side of the unit became overwhelming and assistance measures were not in place. This was the most testing aspect of the unit, and the author’s on-line tutorial group suffered neglect as a consequence. The continued creation of on-line lectures after the unit had begun sometimes produced cognitive conflict with the material being currently presented face-to-face (e.g., momentary memory lapses on what had been covered and what had not).

It is difficult to respond to the varied student feedback, which ranged from “the content was too difficult” to “the content was too easy.” These comments almost certainly reflect the incoming mathematical background of the particular students in two programs, both of which had no mathematical prerequisite. It

¹³ Seconded teachers are classroom teachers who leave their schools for a year or two to work with the university lecturers, adding credibility to the pre-service program. They are paid their normal salaries while seconded.

¹⁴ Elluminate is a software platform that provides audio, video, whiteboard, file-sharing and other forms of interaction among students and tutors or lecturers. For details see <http://www.illuminate.com/support> (accessed October 21, 2010)

could be suggested that the Numeracy Exam conducted at the end of the unit should have been conducted at the beginning and the 80% pass mark used as a prerequisite for entry to the unit. This may be considered in the future but is unlikely to alleviate the problem completely.

The Faculty of Education plans to continue the unit for beginning students but based on the feedback and student outcome differences for the two programs, there are likely to be modifications. These changes may reflect recognition of the initial backgrounds, both mathematical and in terms of life experience, of the two cohorts of students. It will be interesting to follow the students in their other units as they progress through their degrees and observe if Personal and Professional Numeracy has an impact on other learning outcomes.

Conclusion

The unit described in this case study had broader aims than those discussed at the Wingspread Workshop (Madison and Steen 2008) because besides preparing teachers to deal with numeracy across the curriculum, it also had the aim to prepare them for modeling numerate behavior in the school environment and for dealing with system data on their students. It is the belief of the author that many aspects of Personal and Professional Numeracy are essential to all university graduates, not just those intending to be teachers. She believes it is possible to imagine a university-wide unit with a core of basic proportional reasoning skills and critical statistical literacy thinking, supplemented by each faculty with the applications and additional mathematics techniques (e.g., geometrical) relevant to its content domain.

A project carried out by the Centre for the Advancement of Learning and Teaching at the University of Tasmania (Skalicky et al. 2010) found that most teaching units across the university wanted their students to have basic quantitative understanding and the authors recommended that a university graduate attribute¹⁵ should encompass such understanding. Perhaps the cross-curricular quantitative literacy program advocated by Steele and Kiliç-Bahi (2008) or the more broadly based concept of a Quantitative Studies Center suggested by Karaali et al. (2010) could serve as models here and elsewhere. Although these ideas are proposed for smaller liberal arts colleges in the U.S., the needs are similar for students in larger universities in other countries such as Australia. Perhaps Personal and Professional Numeracy provides another starting point for addressing the needs of these students.

¹⁵ The Generic Graduate Attributes currently advocated by the University of Tasmania are found at <http://www.teaching-learning.utas.edu.au/orientation/generic> (accessed October 24, 2010)

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Appendix 1

Content in Personal and Professional Numeracy

Week/Topic	Highlights
1. Introduction	<ul style="list-style-type: none"> • Purposes • Definitions of numeracy • Adult Quantitative Literacy • Framework for Critical Numeracy • Example with Decimals • “Numeracy in the News” Web site
2. Percent	<ul style="list-style-type: none"> • Terminology • Slight diversion into fractions • Percent to judge risk • Examples of incorrect media reports of percentage increase and decrease • Lesson from Web site on Salt Consumption
3. Proportional Reasoning	<ul style="list-style-type: none"> • Distinguish Rate, Ratio, and Proportion • Example of WHR (Waist to Hip Ratio) • Link Rate to Average • Solving problems with proportions • Driving vs Walking when drunk

Week/Topic	Highlights
4. Consumer and Financial Literacy	<ul style="list-style-type: none"> • Litres per flush for different brands of toilet • Based on goals for schooling • Understanding money • Consumer education • Personal finance • Money management • Advertisements • ASIC video • Negative numbers: elevators and debt
5. Average	<ul style="list-style-type: none"> • Mean, median, mode, mid-range • Examples of student understanding • Golf commentary videos • Web site lesson on “junk” in the home • Student understanding of 2.3 children • Effect of outlier on salt data • “Nation of gamblers” (Media Watch)
6. Graphs	<ul style="list-style-type: none"> • Only a few defined: stem-and-leaf, pie, stacked dot • Early childhood student examples • Student interpretation of an “association” statement, presented as a graph • Media examples (good and bad) • Salt data distributions • Errant pie graph student survey item
7. Box Plots, Hat Plots and Variation	<ul style="list-style-type: none"> • “Variation” as the essential foundation • Measurement of variation via box plots and hat plots (simpler version) • Outliers and examples with salt data • Box plots in context: education and pesticides • Example comparing two Australian football codes • Live demonstration of cross-curriculum data sets using <i>TinkerPlots</i>
8. Sampling	<ul style="list-style-type: none"> • Student understanding • Essential nature of relationship to populations • Media examples; size one and two • Web site lesson on “myth, fact, and fiction” • Student survey, critical thinking questions • “A Nation of Pot heads?” (Media Watch)
9. Chance	<ul style="list-style-type: none"> • Ways of viewing chance and intuitions • Chance language: ordering newspaper headlines • Theoretical and relative frequency probability • Student understanding • Conditional probability – Media examples • Odds, student survey item
10. Risk	<ul style="list-style-type: none"> • Dictionary definition and examples • Perceived risk = f(hazard, outrage) (Sandman 1993) • Examples contrasting hazard and outrage • Gapminder video on swine flu and tuberculosis • Critical thinking related to <i>Time</i> magazine article (Kluger 2006) • Elephants, sharks, and walking vs driving drunk • <i>Professor Risk</i> from Cambridge University
11. Inference	<ul style="list-style-type: none"> • Distinguish formal and informal inference • Informal inference with box plots • Variation in box plots for various small samples from a “population” – “live” demonstration • Rules for making decisions on population difference based on box plots (Chris Wild)

Week/Topic	Highlights
	<ul style="list-style-type: none"> • Live demonstration of sampling from two “populations” • Serious and frivolous examples • Example of “lurking” variable - classroom data and ABS data
12. System data	<ul style="list-style-type: none"> • Example of system data reported via box plots • Critical thinking required for interpreting box plots • NAPLAN data reports • Linking data about items to actual items • <i>MySchool</i> Web site, comparing schools

Appendix 2

Week 5 Self-Guided Tutorial: Personal and Professional Numeracy – Average

1. Blastland and Dilnot, in the title of Chapter 5 of *The Tiger that Isn't*, liken averages to a “white rainbow.”
 - a. What point are they making about averages with this metaphor?
 - b. Why is understanding this an important part of numeracy?
 - c. What was the most surprising example of average in the chapter? Could you imagine using it in a classroom? Share your thoughts on the Discussion Board.
2. The article by Stack and colleagues¹⁶ is based on the experiences of Tasmanian teachers. Again could you imagine using something similar in a classroom? How would you change them? About what grade would you imagine the activities might be useful? Share your ideas on the Discussion Board.
3. The following activity is to help reinforce your understanding of averages (measures of central tendency), if you feel it is helpful.
 - a. Devise a set of 10 numbers for which
 - i. The mean, median, and mode are all the same
 - ii. Mean > median
 - iii. Median > mean
 - iv. Median > mode
 - b. Sally’s pedometer has recorded the following numbers of steps through the working week.

¹⁶ Stack, S., J. Watson, S. Hindley, P. Samson, and R. Devlin, 2010. What’s average? *Australian Mathematics Teacher*. 66(3): 7-15.

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
5213	6069	7089	7265	6054	?

- i. Calculate her average daily steps during the week.
- ii. How many steps will she need to take on Saturday in order to make her average for the six days 7000 steps?

4. Read the extract from the article on nappies:

Enviro action cut from cloth
 GENEVIEVE MORTON
 March 08, 2009 12:00am

THIS modern mum has washed her 1000th cloth nappy.
 Miriam Herzfeld, 34, of West Hobart, has been adding up nappy washes since her daughter Elizabeth was born 12 months ago and considers herself a "cloth revolutionary".
 And she's not alone.
 Sustainable Living Tasmania reports more and more new mums are opting for reusable cloth nappies -- disgusted by the estimated one billion disposable nappies thrown into landfill every year in Australia.
 The average Tasmanian baby uses 8000 nappies. An average six nappies a day over two years produces about 730kg of solid waste. ...
 (Downloaded from http://www.themercury.com.au/article/2009/03/08/59975_tasmania-news.html, March 18, 2009)

- a. The term "average" is used twice in the extract. Consider what it means in each case.
- b. How many nappies would be used in two years at a rate of 6 per day? How can this be reconciled with the claim that, "the average Tasmanian baby uses 8000 nappies"?
- c. How many kg of waste would 8000 nappies produce? [This is a review question from our work on proportional reasoning!]

5. In the following Elective Surgery article the median waiting time is reported.

Elective surgery wait list grows

MARIA RAE

October 31, 2008 08:10am

MORE Tasmanians are waiting for elective surgery, and for longer times.

The Department of Health and Human Services annual report shows an extra 1315 were on the waiting lists last financial year.

The rise has been blamed partly on bed closures because of building works.

But the bulk of extra patients came from an audit that found they were previously unknown to the department.

This boosted the numbers on the North-West Regional Hospital eye and general surgical lists.

The median waiting time for patients also rose from 38 to 39 days. ...

Downloaded from http://www.themercury.com.au/article/2008/10/31/35661_tasmania-news.html,
March 18, 2009

- a. Why might this statistic have been used?
 - b. What do you think the distribution of wait times would look like? Draw a sketch.
 - c. The median is commonly reported in relation to house prices. Why might real estate agents prefer this statistic to the mean house price? In what context might an estate agent be inclined to use the mean?
 - d. Contrast these examples with Stephen Jay Gould's experience with abdominal mesothelioma as described by Blastland and Dilnot in *The Tiger that Isn't*.
6. Here is an "average" item from NAPLAN Year 9 2008 (Calculator) for you to trial.

22 Gina needs to travel by train for 22 days during May.
A daily ticket will cost her \$6.60 and a monthly ticket will cost her \$105.60.
What is her average **daily saving** if Gina buys a monthly ticket?

\$1.80

\$4.80

\$39.60

\$99.00

- a. How easy is it?
- b. Why do you think the distractors were chosen?
- c. Explain what understanding would be associated with them. Share your thoughts on the Discussion Board and see if the group can come up good explanations or a better set of distractors.
- d. Then create a question similar to this one, post it in MyLO and explain your choice of the answer options.

Appendix 3. Assessment Task 2, Rubric

Criteria	HD	DN	CR	PP	NN
1. Understanding of the quantitative aspects of the chosen media report or advertisement	Media extract selected includes critical content allowing students to make and justify decisions using numeracy skills and judgements related to a context meaningful to them	Media extract selected includes critical content allowing students to display numeracy skills and links to a context meaningful to them	Media extract selected contains mathematics content assessable to students and a meaningful context	Media extract selected contains mathematics content assessable to students	Inappropriate choice of media extract, without thought for student background
2. Planning and implementation of an activity	Planning and implementation clearly structured, leading to unambiguous evaluation of the value of the media extract to meet the requirements of numeracy in context.	Strong evidence of linked lesson planning, implementation, and evaluation of the value of the media extract to meet the requirements of numeracy in context.	Evidence of lesson planning, implementation, and evaluation of the value of the media extract to meet the requirements of numeracy in context. but few links between them	Some evidence of lesson planning and implementation but little evaluation of the value of the media extract to meet the requirements of numeracy in context.	Inadequate evidence of plan
3. Inferences about the quantitative thinking of 'students'	Evidence presented in a structured fashion that "tells the story" of the experience unambiguously, including links from the 'student' thinking to the related literature based on the context of the media extract chosen	Strong evidence of observations of and insights into 'student' thinking and clear links made between these and readings of the literature on quantitative literacy/numeracy for the extract chosen	Multiple evidences of observations of and insights into 'student' thinking and relationships shown between these and readings of the literature on quantitative literacy/numeracy for the extract chosen	Some evidence of observations of and insights into 'student' thinking but clear links are not made between these and readings of the literature on quantitative literacy/numeracy for the extract chosen	Little evidence of observations of and insights into 'student' thinking or reading of the literature on quantitative literacy/numeracy
4. Evaluation of the effectiveness of your teaching and application of learning to future teaching	Evaluation and implications form a cohesive whole that show evidence of insight into own actions, underpinning reasons and student learning. Evidence of the development of principles to guide future teaching.	Evaluation evidences insight into own actions and reasons underpinning them. There is a strong focus on student learning. Implications for future teaching that are related to insights from the evaluation	Evaluation focuses on the impacts of teaching on student learning. Implications for future teaching clearly relate to the evaluation	Evaluation describes actions and applications at relatively superficial level. Links between evaluation and future applications are not always clearly articulated	Evaluation consists only of a description of teaching events
5. Communication using appropriate mathematical and English language conventions	Presentation of publication standard. Almost no errors in spelling or grammar	Presentation appropriately structured with clear sections that link coherently, using correct terminology. A few small errors but substantially well presented and written. All references correct and consistent.	Presentation appropriately structured and terminology used correctly and appropriately. Some aspects of referencing inconsistent and some typos evident	Presentation appropriately structured but includes inconsistent use of terminology, incomplete referencing, some spelling errors, or grammatical mistakes	Does not meet requirements for academic writing with inadequate structure, incorrect use of terminology, grammatical and spelling errors, and lack of adequate referencing