

Pre-service teachers and numeracy in and beyond the classroom

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Data from a pilot study concerned with pre-service teachers' perceptions of the numeracy demands on Australian teachers are reported. The sample comprised 211 students enrolled in pre-service teacher education courses at a large Australian university. While most recognised the importance of mathematics and its applications in everyday life, less than half considered there were mathematical demands on teachers beyond their teaching domain. NAPLAN-related information data was used to examine the group's ability to access, apply, and interpret the statistical information.

Introduction

In Australia there is no shortage of recent reports concerned with the quality of pre-service teacher education and graduate performance (e.g., Australian Institute for Teaching and School Leadership [AITSL], 2014), the falling interest among students at all levels of education in mathematics (e.g., Wienk, 2014), the scope and quality of the mathematics curriculum (Donnelly & Wiltshire, 2014), and its relevance to the work place and daily life of the country's students and citizens (e.g., The Australian Association of Mathematics Teachers [AAMT] and the Australian Industry Group, 2014). The pilot study reported in this paper was fuelled by the contents and recommendations of several such reports, the challenges they present for those involved in initial teacher education, and the need, ultimately, to develop practical solutions.

Providing a context

The establishment in 2010 of AITSL powered a renewed focus on the requisites for excellence in teaching and school leadership. Expectations for commencing and newly graduated teacher education students have also attracted close and careful scrutiny. With respect to the former, a clear standard has been advocated by state Ministers for Education: that all initial teacher education students will have a level of literacy and numeracy equivalent to the top 30% of the population. At the end of their course, it is mandated, graduate students must "have an understanding of their subject/s, curriculum content and teaching strategies ... (and be) able to design lessons that meet the requirements of curriculum, assessment and reporting" (AITSL, n.d., para 2). With respect to numeracy, they are expected both to know and understand appropriate teaching strategies and their applications in teaching areas. Elaborations of this expectation are readily found, for example:

In the Australian Curriculum, much of the explicit teaching of numeracy skills occurs in Mathematics. Being numerate involves more than the application of routine procedures within the mathematics classroom. Students need to recognise that mathematics is constantly used outside the mathematics classroom and that numerate people apply general mathematical skills in a wide range

of familiar and unfamiliar situations. (Australian Curriculum and Assessment Reporting Authority [ACARA], n.d., para 1).

That the teaching of numeracy embraces aspects beyond the mathematics classroom is a view echoed by the AAMT:

To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life. In school education, numeracy is a fundamental component of learning, discourse and critique across all areas of the curriculum. (c. 1998, p. 2).

In brief, all teachers, not only those explicitly involved in teaching mathematics, are deemed responsible for contributing to the numeracy development of their students. It can be inferred from the mantra above that teachers should also be familiar with the quantitative requirements of various work settings, including those relevant and applicable in their own work place. As Steen (2001) maintained, “(n)umeracy and mathematics should be complementary aspects of the school curriculum. Both are necessary for life and work, and each strengthens the other. But they are not the same” (p.15).

The influential Organisation for Economic Co-operation and Development [OECD] (2013) summarised indicative levels of information-processing skills used in nine clusters of occupation. Numeracy was defined as the “ability to access, use, interpret and communicate mathematical information and ideas in order to engage in and manage the mathematical demands of a range of situations in adult life” (p. 59). Numeracy skills were said to apply at all levels of occupation and to increase with the demand of reading skills required. The numeracy demands of the school work place were not specifically identified.

In a recent project 12 secondary school mathematics teachers spent time in various Australian businesses to explore in some depth the nature and scope of the quantitative skills needed and used by workers in different settings (The Australian Association of Mathematics Teachers and the Australian Industry Group, 2014). The project “was designed to look at the requirements for mathematical skills and understanding in the modern workplace and to develop a clearer picture of the matches and mismatches between current mathematics (curriculum, teaching methods and resources) and the quantitative skills required” (p. 11). Space constraints prevent inclusion here of a summary of the project’s main findings and recommendations. Intriguingly, none of the teachers was allocated the work place seemingly best known to him/herself, that is a school, and given the task to identify and clarify the quantitative skills required in this setting. While much emphasis has been placed on the numeracy skills linked to teaching mathematics or to meet the numeracy demands of other disciplines in the classroom (e.g., Geiger, Forgasz, & Goos, 2015), little attention has been given to the numeracy demands of the school work place *per se*, that is, work not directly linked to classroom teaching but necessary to function as a teaching professional. Pre-service teachers’ views about the mathematical/quantitative demands in everyday life and on their role as teachers were examined in the pilot study reported here.

In this paper we focus primarily on pre-service teachers’ perceptions of applications which are part of their teaching responsibilities but may be outside their subject teaching areas. A specific example to probe their “ability to access, use, interpret and communicate mathematical information” (OECD, 2013, p. 59) was included in the survey. We presented performance data from The National Assessment Program – Literacy and Numeracy [NAPLAN] and asked respondents to interpret the data. The NAPLAN tests are said to “provide information for students, parents, teachers and principals about student achievement which can be used to inform teaching and learning programs” (Victorian

Curriculum and Assessment Authority, 2015, para. 3). The sharing of test information constructively with both students and parents is evidently an obligation for teachers if an important goal of the testing regime is to be realised. The data are also intended to be used to check the efficacy of instructional programs in place.

The study

Aims

The central aim of the study was to develop an instrument to determine teachers' views of the numeracy demands on Australian teachers and their numeracy capabilities as captured in statements such as that of the AAMT (c. 1998) and the OECD (2013) and, in the first instance, to trial the instrument with a group of pre-service teachers. The research questions of particular interest in this paper are:

1. What are pre-service teachers' views about their proficiency in mathematics?
2. What are pre-service teachers' views about the importance of mathematics for teaching?
3. Do pre-service teachers recognise mathematical demands in everyday life?
4. Do pre-service teachers recognise mathematical demands on teachers in schools apart from what is taught to students?

The instrument

The full instrument included biographical items (e.g., gender, level of schooling able to teach in at the completion of the course, and if relevant – specialisation/teaching methods). Views about, and attitudes towards, mathematics (e.g., importance of mathematics for teachers, levels of confidence, etc.), and the utility of numeracy skills for teaching and for teachers in their workplace, the school, were also tapped.

As well as numerical items gauging basic mathematical skills, numeracy problems were set in the following contexts: everyday life, informed citizenry, and the workplace (the school). Participants were not only asked to provide answers to numeracy items and items involving numerical calculations, but also to indicate their level of self-efficacy in the answer they gave. Most of the numerical items were in multiple-choice format; for others, participants had to provide answers and explain their responses. The numerical items were drawn from publicly available Australian grade 9 NAPLAN tests¹ and from the pool of released PISA² items (with permission); a few items were developed by the researchers. The instrument was prepared for online completion using Qualtrics (www.qualtrics.com). Selected items are included in the presentation of the results.

Space constraints prevent a more detailed listing of the contents of the full instrument and limit inclusion of the often informative and thoughtful explanations given.

Data gathering

All pre-service teachers enrolled at one Australian university which offers undergraduate and graduate programs in teacher education were invited to participate in

¹ NAPLAN is the National Assessment Program for Literacy and Numeracy which, since 2008, has been administered to all Australian students in grades 3, 5, 7 and 9.

² PISA is administered every three years to samples of 15 year old students in many countries around the world, including Australia.

the pilot study. The university's guidelines for the recruitment of its students for research studies were adopted: advertisements were placed on selected Moodle sites with a link to the online instrument; lecturers in core units of study advertised the study in their classes; and posters and flyers were displayed within the buildings at the university campuses where the students were enrolled. A four week timeframe was allowed for the online instrument to be completed.

The sample – contextual details

The university from which the sample was drawn offers teacher education courses that would qualify teachers for early years [EY] teaching (birth to 8 years of age), primary (elementary) [P] teaching (grades Prep to 6), secondary [S] teaching (grades 7 to 12), as well as two cross-sectorial levels: EY-P (birth to grade 6) and P-S (grades P to 12).

The sample comprised 237 students. Of these 23 (10%) opted out of the survey after answering only the first two or three items. These surveys were excluded from the analyses. Of the remaining 214 respondents who answered all or most of the items, 174 (81%) were female and 40 (19%) were male. Just over half, 119 (56%), were aged under 25. Of the rest, 53 (25%) were aged between 25 and 34, while 42 (20%) indicated they were older than 35. The gender and age distributions are in line with data provided by AITSL (2014) for the 2012 initial teacher education intake. That year females comprised 76%, and 64% of the intake were aged under 25.

Most of the respondents, 164 (78 %) of the 211 who answered the question, had completed their secondary schooling in Australia. Only eight among the respondents nominated mathematics as one of their secondary teaching specialisations.

Results

Pre-service Teachers and Proficiency in Mathematics

The majority of respondents 104 (54%) considered themselves to be good or excellent at mathematics, 75 (39%) self-rated as being average, and 15 (8%) thought they were weak or below average. As reported by Forgasz, Leder, Geiger, and Kalkhoven (submitted), these judgements were supported by the group's more than credible performance in solving the set of numerical items taken from the sources already described above.

Pre-service Teachers' Views about the Importance of Mathematics for Teaching

As reported above, only eight of the group gave mathematics as their specialisation. Yet most respondents considered it important for teachers to be good at mathematics: 147 (76%) agreed, 18 (9%) disagreed, and 29 (15%) were unsure. Just over half (100: 52%) thought they had studied enough mathematics to be a competent teacher, with the remainder almost equally divided between those who thought they had not (45: 23%) and those who were unsure (49: 21%).

Pre-service Teachers and Mathematical Demands in Everyday Life

Many of the respondents (≈ 200) to items relevant to this issue recognised the importance of mathematics and its applications in everyday life. For example, approximately 90% agreed that "In everyday life, understanding fractions, decimals, and percents is very important in our society", considered that "given the price per square metre, I could estimate the cost of new carpet needed for a room" and that they "could

easily extract information from tables, plans, and graphs”. In contrast, only 21% agreed that “mathematics is communicated well in newspapers and the media”, 44% disagreed, and the remaining 35% indicated that they were uncertain.

Pre-service Teachers’ Recognition of Mathematical Demands on Teachers in Schools apart from what is taught to Students

1. *Direct responses to the above item.* Respondents were about equally divided between those (44%) who considered that there were mathematical demands on teachers apart from what is taught to students and those who were unsure (42%); the remaining 14% considered that there were no such demands. Those who acknowledged that there were numeracy demands on all teachers beyond the classroom touched on a number of pertinent areas in which numeracy skills are needed. Representative explanations for the Yes, No, and Unsure responses included:

Yes: Understanding of statistics for analysis of NAPLAN results, class tests etc.

Yes: Teachers need to possess broader/higher levels of organisational/analytical/linguistic skills which are entailed in mathematical abilities in order to successfully perform bureaucratic/organisational responsibilities required in school settings.

Yes: Mathematics such as class numbers, number of years teaching, salary...

Unsure: I would say that there are mathematical demands on everybody, to some level, but whether teachers have more than anybody else is questionable.

Unsure: I don't have any experience to decide

No: I am not aware of the external mathematical demands on teachers

No: I don't really think there are

2. *The NAPLAN-information item and pre-service teachers’ responses.* The information below was provided on the survey preceding the NAPLAN questions:

Here are the NAPLAN Reading and Numeracy results for Year 7 students at one Australian school (Aussie HS) taken from the MySchools website. The school's results (blue) are shown together with 'similar schools' (orange).

The instructions for interpreting the graphs are provided below the graphs.

The NAPLAN data that were provided are shown in Figure 1. Students had to interpret these data to answer the NAPLAN-information item questions. The specific questions asked about the data are used as headings for the relevant results. Because of space constraints, only a limited number of explanations for the answers selected are provided.

a. In which Year did the Aussie HS Students achieve Best in Reading?

The majority of those who answered this question (128: 89.5%) selected 2012 as their answer. A small number answered 2010 (9: 6.3%) or 2011 (6: 4.2%).

b. In which Year did the Aussie HS Students achieve Best in Numeracy?

Most (114: 81%) selected 2012. Of the others, 2 (1.4%), 12 (8.6%), 10 (7.1%), and 2 (1.4%) selected 2008, 2010, 2011, and 2013 respectively.

For both items most participants focussed on the mean score obtained by the school's students on the test. That the difference in the mean scores between the school and

“similar” schools, in favour of the school, was also largest in 2012 rarely featured as a reason for it being selected as the year of the school’s best performance.



Figure 1. NAPLAN-information item (devised by research team – drawn from publicly available data from MySchools website)

For the Literacy item (a.), those who did not select 2012 generally gave mathematically irrelevant explanations such as “It is shown in the graph” and “The average achievement bubble is at its highest point over the selected year period”. These students did not demonstrate the relevant mathematical skills to interpret the graphical representation.

In general, the Numeracy results (b.) elicited more complex explanations, not necessarily demonstrating mastery of the pertinent mathematics, for example:

The orange bar reached the highest score (when also taking into account the margin of error). (Explanation in support of choosing 2010 as the best year of Numeracy performance)

On the numeracy graph the school diamond was at its highest point in 2012. However the margin of error was higher in this year. It was also only one of 2 years where the school performed above the average. (Explanation in support of choosing 2011 as the best year of Numeracy performance).

c. *Based on the Reading and Numeracy NAPLAN results, what should the Curriculum Co-ordinator be concerned about: Reading, Numeracy, Both Reading and Numeracy, Neither Reading nor Numeracy, or Unsure?*

Each of the options listed was selected by at least some of the respondents. Twelve (8.5%) identified Reading, 98 (69%) nominated Numeracy, Both Reading and Numeracy

was selected by 20 (14.1%), seven (4.9%) considered that neither was of concern, and five (3.5%) indicated that they were unsure. A selection of explanations for each of the alternatives presented serves as indicators of the sample's proficiency in interpreting graphs, a skill some 90% had claimed they had mastered.

Not all respondents provided an explanation for their interpretations but, for this item, too, a majority did. A representative sample of responses is shown below.

Reading

It seems that in reading, most students are on average unlike numeracy

Reading has sharply declined from 2012 to 2013 - you would want to know what drove it so sharply down (also what was (it) about their literacy program that caused big spike in 2012) - even though it is still ahead of average or similar schools, the gap is much narrower in 2013 vs. 2012 with other similar schools. / / Numeracy can still be improved (always room for improvement!) however scores are still close to the average

Numeracy

Numeracy is a concern as it has dropped (in) the last two years and is now below the average for similar schools in the area. In Reading the Aussie HS regularly receives higher average student scores than similar schools and the average student scores are fairly consistent. In Numeracy the Aussie HS mostly had lower average scores than similar schools and student scores are also less consistent.

Both Reading and Numeracy

Schools should never just focus on one subject, all subjects are important. If the school must have separate teachers in order to help students understand then so be it (if this were a primary school).

Whilst numeracy needs more help there is still room for improvement for reading

Whilst the numeracy results were lower, neither was consistently above average.

The results in 2012 were improving but slipped backwards in 2013.

Neither Reading nor Numeracy

The coordinator doesn't need a standardised test to dictate where his (sic) students are struggling

All subjects. The question doesn't ask me if it specifically relates to just this data or for just this year (2012).

Unsure

My first instinct said that the co-ordinator needs to focus on reading because the score was so much better for numeracy in 2012. However on the other hand the results for numeracy are generally lower than the national average. So I'm inclined to say both but I'm not entirely sure.

That the one set of information generated subtle differences in interpretation can be seen from the excerpts above. As expected, many of the more thoughtful, elaborated, responses referred to both sets of data. Yet it also appears from the responses that different directions for the school's teaching and learning programs might be inferred from the data.

The findings above suggest that the majority of the pre-service teachers in the study were able to interpret the data presented to them and provide appropriate supporting explanations. What was evident, however, was that most of the explanations were fairly superficial and did not reflect a full appreciation for the arguments that might be needed to convince others of their views.

Final comments

The pilot study yielded fruitful insights into the pre-service teachers' perceptions of the numeracy demands on Australian teachers. Although the sample who participated in the pilot study comprised students from only one university, the group's gender and age distributions were similar to those reported by AITSL (2014) for the 2012 initial teacher education. The data reported here are particularly relevant to pre-service teachers whose specialisation is not in mathematics. As indicated by AAMT (c. 1998, p. 2), "in school education, numeracy is a fundamental component of learning, discourse and critique across all areas of the curriculum". That less than half of the sample (44%) agreed that there were mathematical demands on teachers apart from what is taught to students is a matter of concern. Whether those preparing to be teachers of mathematics share this view warrants close scrutiny.

Do Australian teacher education programs present pre-service teachers with examples which illustrate the types of numeracy demands on teachers that they will encounter when they work in schools? The NAPLAN item in our survey draws on fairly sophisticated graphical representations; the interpretation of the data requires a good understanding of the related mathematical concepts. The numeracy demands on teachers in schools are not limited to the interpretation of NAPLAN data. We are left to speculate on what AITSL will produce as the numeracy/mathematics test that pre-service teachers will need to pass prior to graduating from teacher education programs.

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