Developing first-year students’ academic numeracy skills: Toward a whole-of-institution approach

Kathy Brady
Student Learning Centre, Flinders University

Abstract

The broad diversity of students commencing at university is now a well-documented feature of higher education in Australia. The literature also reveals that the many commencing students lack the mathematical preparedness to meet the academic numeracy demands of their programs. Whilst it may be well-understood that students need a certain level of mathematics to study, for example, engineering, the numeracy demands in many other disciplines are not made so evident or explicit. Recent research has found low numeracy to be more problematic than low literacy with regards to successfully undertaking higher education studies, with resultant implications for student retention. This paper describes the journey undertaken at one university in adopting an institution-wide approach to developing their first-year students’ academic numeracy skills. A key component of the initiative presented is the development of a credit-bearing Academic and Professional Numeracy topic as a means to address the shortcomings in students’ numeracy skills.

Introduction and background

Numeracy in the tertiary domain places an emphasis on the application of mathematics and quantitative concepts within academic disciplinary contexts (Skalicky, Adam & Brown, 2010). In the Australian context, Taylor and Galligan (2002) were the first to describe the quantitative skills necessary for success in the university context as academic numeracy, a term that has now been broadly adopted. Drawing on Galligan’s most recent work (2013a; 2013b), I will be defining academic numeracy in this paper as the capacity to confidently and competently use mathematics at university level, and to be able to apply, interpret critique and communicate mathematical concepts in particular disciplinary contexts.

Many students commence university lacking even basic mathematics skills and an extensive study conducted in the UK (Parsons & Bynner, 2005) has revealed the serious implications that arise from students’ inability to manage their academic numeracy demands. This study found low numeracy to be more problematic than low literacy with regards to successfully undertaking tertiary studies, with resultant implications for student retention. In regard to this, what is more worrying is that the literature indicates that the students with the poorest skills, who most need support with numeracy, fail to access it (Pell & Croft, 2008). Recent research (McNaught & Hoyne, 2011) has examined the issues associated with students commencing university lacking skills in even rudimentary mathematics and identified factors that have precipitated this state of affairs. The first is that students are now completing less rigorous mathematics courses in their senior secondary education, with many studying no mathematics at all. Additionally, they find that the current generation of school leavers have become calculator dependent; lacking mental mathematical skills and the ability to reason and analyse without the use of technology.
It may be well-understood that students need a certain level of mathematics to study engineering or physics; however, the numeracy demands in other disciplines such as in nursing, business, education, or indeed science disciplines such as biology or earth sciences are not so evident or explicit. In this regard, the literature provides a wealth of evidence that first-year students are underprepared to manage the numeracy demands in a range of courses such as nursing (Eastwood, Boyle, Williams, & Fairhall, 2011), health sciences (McNaught & Hoyne, 2013), and business (McClure & Sircar, 2008). However, poor mathematical skills are only part of the problem. The phenomena of mathematics anxiety or mathematics phobia has been well documented (Wilkes, 2010; Rylands & Coady, 2009; Li, 2003) as a key reason for school students, and adults alike, having an aversion to studying mathematics and using even simple mathematics in their daily lives. The long-term outcome of mathematics anxiety/phobia is low numeracy levels or innumeracy. As previously stated, the implications of this for students being able to manage tertiary numeracy requirements is that low levels of numeracy is more problematic than poor literacy when it comes to successful undertaking higher education studies. According to Pell and Croft (2008) students’ lack of mathematical preparedness results in disillusionment, loss of self-esteem and, ultimately, withdrawal. On the other hand, Thomson and Hillman (2010) have determined that students who recognise the value of mathematics are more likely to be successful in their tertiary study endeavours.

Whilst the field of research in numeracy and mathematics education is extensive, work that has been conducted in the tertiary sector is limited, with most studies concentrating on preparedness for university mathematics. One very useful study, however, has been conducted by Galligan and Taylor (2005) which investigated academic numeracy in non-mathematical university courses. They found a significant mismatch between the skills of commencing students and the numeracy demands embedded in courses. Most recently Galligan (2013a) has argued that few Australian universities actively aim to improve students’ academic numeracy despite the fact that Graduate Qualities and the Graduate Employability Indicators suggest that they should. Students should leave their university studies more competent, confident and critically aware of the mathematics in their courses, in their professions, and in their personal lives. Hence, ‘like academic literacy, academic numeracy is a university-wide issues and if it is to be seriously addressed, then a systematic approach is essential’ (Galligan, 2013, p.744). In reflecting this recommendation the initiative presented in this paper involves adopting a university-wide approach to developing first-year students’ academic numeracy skills in order to best develop their capacities to manage the numeracy demands in their programs.

Towards a university-wide approach

Akin to most other Australian universities, it has become clear at Flinders University that due to the widening participation agenda there is a critical need to address the literacy and numeracy skills of many first-year students in an effort to provide these students with the best possible means of success. A number of strategic actions have been adopted in the past three years to deal with this issue: the current Teaching and Learning Plan comprises a commitment to enhance and the academic literacy and numeracy skills of first-year undergraduate students via for-credit studies; a priority action of the 2012 Operational Plan is the implementation of the First-Year Transition and Retention Project encompassing ‘a number initiatives...[including] the development of a strategy to build first year literacy/numeracy’; and also in 2012 Vice-Chancellor’s Committee endorsed the adoption, development and implementation of credit-bearing numeracy and literacy topics.
The adoption of a university-wide approach to addressing students’ academic literacy skills was successfully completed in 2013 as Faculties are now required to demonstrate either that context-specific literacy content is integrated into professionally-oriented courses, or alternatively they are responsible for accommodating the for-credit topic *Academic and Professional Communication* in the course rules for generalist undergraduate degrees (Brady, 2013). The university’s attention has now turned to addressing students’ academic numeracy needs. The leadership for this project has been assigned to the university’s academic support unit, the Student Learning Centre (SLC).

During 2013 the SLC conducted a numeracy audit of all programs with non-specialised mathematics components to provide baseline data on the breadth and the depth of the numeracy demands in all programs across the university. The qualitative data collected in the numeracy audit also provided very concerning picture of the students’ inability to manage these numeracy requirements. In addressing the question: “What deficiencies do commencing students have in meeting the numeracy demands of your program?” some of the responses provided by program co-ordinators were as follows:

- [Students] don’t meet expectations, [they] come in with Year 9 maths as a max or refuse to know any maths at all; Some students don’t even know how to add up a bill in the supermarket but expect to be able to study science
- Poor grounding in very basic maths; intimidated by numbers
- They cannot work with decimal point or fractions and these skills are required for medication calculations. Also can’t understand basic statistical information in journals nor work out what their grade might be in a topic if it is divided between several pieces of work
- Cannot divide by 10 or 100, cannot convert between orders of magnitude (e.g. milligrams to micrograms); do not check their mathematical calculations, and do not think about how to best order of magnitude they should expect for an answer to their
- Many students are simply afraid of anything mathematical; without this cultural shift there is little prospect for anything

Clearly there is a mismatch between the skills of commencing students and the numeracy demands embedded in their programs, as has been highlighted in the literature. In the meantime, there appears to be no positive signs that the issues associated with the students’ lack of mathematical competence will be resolved.

Thus, a working party comprising representatives from each Faculty and key academics from the SLC was formed to recommend a university-wide framework that would be adopted to ensure students become sufficiently competent in the numeracy skills in order to be able to participate effectively in their studies. The key features of this framework are, firstly, that Faculties will be responsible for identifying students’ numeracy needs through methods that may include reviews of academic progress, or discipline-specific competency testing. Secondly, Faculties will provide students with opportunities to become competent in their numeracy skills through the explicit integration of course or program specific numeracy content (an approach mostly likely to be suited to professionally oriented programs or courses); or through the incorporation of a credit-bearing academic numeracy topic within course rules, either for all students or for targeted students. The credit-bearing topic, *Academic and Professional Numeracy*, will be designed and delivered by the Student Learning Centre in collaboration with the School of Computer Science, Engineering and Mathematics. The curriculum development phase of this project is taking place in 2014. This
work involves the development of content, and the design of topic delivery materials for both the internal face-to-face version and an on-line distance delivery. Implementation of the topic will then occur in 2015.

**Academic and Professional Numeracy**

Given that the numeracy demands of different programs requires different mathematical, statistical or quantitative skills according to the discipline, and given also that students possess differing pre-existing skills and knowledge, as well as different perceptions of their personal numeracy, the *Academic and Professional Numeracy* topic is customised using a modular approach to the curriculum. The topic comprises four modules, selected from a larger suite of modules (Table 1). The four modules selected will address the numeracy demands of any particular program or discipline context. Specific modules in the topic could be mandated as a requirement of a program in which a student is enrolled. For example, specific statistical content might be required for biological science students, while the mathematics of measurement and dosage calculations might be required for health science students.

<table>
<thead>
<tr>
<th>Module</th>
<th>Number Fundamentals</th>
<th>Whole number operations, the properties of whole numbers including integers.</th>
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<tbody>
<tr>
<td>Module B</td>
<td>Further Number Concepts</td>
<td>Operations involving fractions, decimals and percentages, ratio and proportion, rounding, significant figures.</td>
</tr>
<tr>
<td>Module C</td>
<td>Extended Number Concepts</td>
<td>Use of exponents and logarithms, scientific notation, surds.</td>
</tr>
<tr>
<td>Module D</td>
<td>Algebra</td>
<td>Algebraic terms and expressions, formulae, and equations.</td>
</tr>
<tr>
<td>Module E</td>
<td>Graphing</td>
<td>Reading and interpreting graphs and charts, plotting graphs, equations of straight lines, scatter plots, lines of best fit.</td>
</tr>
<tr>
<td>Module F</td>
<td>Spatial Thinking</td>
<td>Units of measurement, measurement of 2D and 3D figures, scale, trigonometric rations, Pythagoras rule.</td>
</tr>
<tr>
<td>Module G</td>
<td>Statistics</td>
<td>Measures of central tendency and variation, representations of statistical information, sampling, analysis of data.</td>
</tr>
<tr>
<td>Module H</td>
<td>Counting and Probability</td>
<td>Permutations and combinations, calculation of experimental and theoretical probability, representation of probability events</td>
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**Table 1: Modules and their content**

**Conclusion**

This paper has detailed the journey undertaken at one university moving toward an institution-wide approach to developing first-year students’ academic numeracy skills. A new credit-bearing topic *Academic and Professional Numeracy* is being designed and developed. The efficacy of this approach is, however, yet to be determined. The imperatives presented in the literature seem to indicate that the issues associated with students managing the numeracy demands of their courses have implications for students themselves, and the institution. From the student point of view, meeting the numeracy requirements of their course will ultimately lead to a greater chance that they will be successful in their studies. From the institution point of view this will result in improved retention rates. However, careful and effective evaluation will be required to inform further developments in the credit-bearing topic. Thus, I have two questions for which I would value input from colleagues: What other university-wide
strategies designed to address students’ academic numeracy needs might we consider? And what forms of evaluation would best determine the effectiveness of our initiative?

References


