Using intervention strategies to engage tertiary biology students in their development of numeric skills

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***Abstract**: Tertiary Biology students are expected to calculate parameters from their experimental data gathered in practical classes, interpret the meaning(s) of these biological parameters and then discuss their findings in the context of the published literature. As teachers we expect students to have developed sound numeracy skills from their previous studies and be able to transfer these numeracy skills into their studies in Biology. However, Biology students are less than confident about performing calculations. Using research on student anxiety of learning mathematical skills (Meece , Wigfield and Eccles 1990; Boyd, Cullen, Bass, Pittman and Regan 1998; Klinger 2004) and self-efficacy intervention strategies (Hattie, Biggs and Purdie 1996; Pajares, Miller and Johnson 1999; Phan and Walker 2000; Schulz 2005), a numeric skills task was designed for second year plant science students and has been implemented since 2001. The numeric skills task allows each student to determine their confidence in: (a) their understanding of numeric concepts; (b) their understanding of quantities used in plant physiology; and, (c) their ability to calculate and convert between units of measure. An evaluation of the task shows that although all students were able to demonstrate their understanding of a physical parameter (e.g., volume), 32% of students were not confident with applying this understanding to estimating volumes, e.g., the volume of the tutorial room. A high proportion of students (47%) lacked confidence with converting between cubic metres and litres. Feedback from open-ended responses was categorised to measure student engagement with the task. Students who were the least confident with their answers had high levels of engagement with the numeracy task compared with those students who were more confident with their numeracy skills, indicating that students most likely to benefit from the task had been successfully targeted. Enabling students to engage in their own skills development appears to be a useful approach, particularly for students lacking confidence. This work is an analysis of a current assessment practice, and is being extended into a research project to help define the numeracy threshold of students in the Life Sciences.*

Introduction

Tertiary Biology students are expected to calculate parameters from their experimental data gathered in practical classes, interpret the meaning(s) of these biological parameters and then discuss their findings in the context of the published literature when preparing their laboratory reports.

As teachers we expect students to have developed sound numeracy skills from their previous studies and be able to transfer these numeracy skills to their current studies in Biology. It seems, however, that regardless of the academic background of our Biology students, they seem to be less than confident about performing calculations. Using research on student anxiety of learning mathematical skills (Meece, Wigfield and Eccles 1990; Boyd et al. 1998; Klinger 2004) and self-efficacy intervention strategies (Hattie et al. 1996; Pajares et al. 1999; Phan and Walker 2000; Schulz 2005), a numeric skills exercise was designed to focus students on key components of what they need to undertake calculations in biology. The numeracy exercise is carried out in a face-to-face tutorial and is embedded in a dialogue on assessment requirements for the course.

Calculations in biology require students to have: 1) a sound understanding of the parameters involved, 2) an ability to convert between units of measure, and 3) a concept of appropriate scale or magnitude of the results that are generated. In addition to focusing on the calculation, the numeracy exercise lets students reflect on their level of confidence. An evaluation of numeracy exercise allows us to determine the extent of numeracy anxiety in Biology students, as well as to assess the role(s) of learning strategies such as these in how students structure their own learning.

Materials and methods

In the classroom

The numeracy exercise (Figure 1) is part of an in-class discussion on the assessment requirements in a plant physiology course, which includes laboratory and field reports. Students work through the exercise individually and the exercise is discussed when completed.

Numeracy exercise

1. What do you understand by the term ‘volume’?

2. In metres^3, estimate the volume of the room you are sitting in now.

3. How did you go about making this estimate?

4. How confident are you with this answer?

I want to go to my happy place	Not betting	I’d bet 1 Mars bar	I’d bet 10 Mars bars	I’d bet my dog/car/ mobile phone

5. Using the answer you gave in Q2, express this quantity in litres (L).

6. How confident are you with this answer?

I want to go to my happy place	Not betting	I’d bet 1 Mars bar	I’d bet 10 Mars bars	I’d bet my dog/car/ mobile phone

7. Comment on this task.

Figure 1. The numeracy exercise is implemented in class as part of establishing a dialogue on numeracy skills in the context of student assessments

Determining students’ self-assessment of confidence

The primary intention of the analysis presented here was to describing students’ self-assessment of confidence in understanding a concept and confidence in making associated calculations. This exercise has been implemented since 2001. A more contemporary interpretation of confidence related to risk-taking was used in the numeracy exercise; students were asked what they would be willing to bet on their answer being correct. For the analysis, ‘I want to go to my happy place’ and ‘not betting’ have been classified as ‘not confident’; ‘1 Mars bar’ has been classified as ‘neutral’; ‘I’d bet 10 Mars bars’ and ‘I’d bet my dog/car/ mobile phone’ have been classified as ‘confident’. Note that students were not marked on whether they got the answer right or wrong.

Results

Only students in second year plant anatomy and physiology attended the tutorial as part of their curriculum. At the end of the tutorial, students were asked to submit their filled-in forms to allow for a more complete evaluation of their comments. The response rate was approximately 30%, with slight variations between classes and years. The data presented here represent the findings from three student cohorts (2001, 2002 and 2003). The detailed mathematical background of each student is unknown. Presumably they all completed high school mathematics. We know that they have completed a general program in first year science that, for the majority of students in this cohort, includes first year mathematics and first year chemistry. Two semesters of first year biology is the course prerequisite.

We acknowledge that because the task was designed as a class exercise rather than a research survey instrument, the analysis can only be viewed as a pilot study. Nevertheless, the evaluation of students' self-assessment of confidence in understanding a concept and confidence in making associated calculations and open-response components of the numeracy exercise showed some interesting trends.

The link between student confidence and calculations

All students were able to correctly demonstrate their understanding of a common physical parameter (e.g., volume), but a third of students (32%) were not confident with applying this understanding to estimating volumes, e.g., of the tutorial room. Almost half of the student responses (47%) showed that students lack confidence with converting between cubic metres and litres (Figure 2). 20% of students lacked confidence with estimating the volume of the tutorial room and with converting m^3 to L.

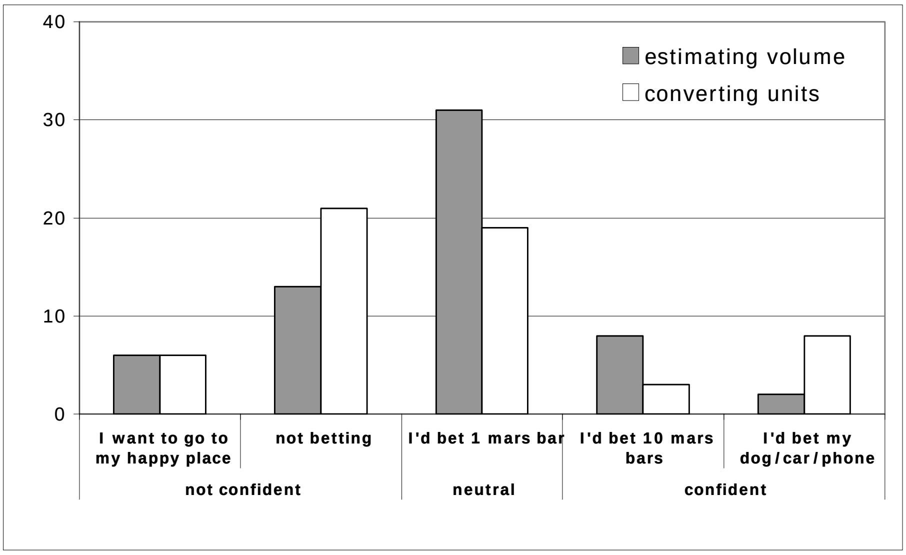

Figure 2. Student responses as to how confident they were with i) making an estimate of volume and, ii) with converting m3 to L (n = 60 students)

What did students think about this approach?

Students' comments on what they thought of participating in the numeracy task were grouped based on the similarity of response. Three categories of responses were able to be resolved and these reflected levels of student engagement in the task. Highly engaged student responses related the exercise to personal responsibility for his/her confidence with calculating and/or with an intention to improve their numeracy skills. Engaged student responses (34%) related the task to being about numeracy skills development. Student responses classified as Not engaged (14%) were largely dismissive of the task indicating that these students had not engaged to the same degree as students in the other two categories (Table 1, including example responses). We expect that a proportion of the students in the not engaged group are those students for which academic numeracy is not an issue.

The link between confidence and numeracy task engagement

Students who were the least confident with their answers had high levels of engagement with the numeracy task compared with those students who were more confident with their numeracy skills (Figure 3). This indicates that students most likely to benefit from the task had been successfully targeted. The relationship between low confidence and high engagement was less clear when students were asked to make an estimate (Figure 4 compared to Figure 3). We expect that this reflects that students are usually not asked to give estimates and we concede that the scope of the estimate asked for here was not defined in terms of an acceptable margin of error.

Table 1. Student perception of the numeracy task was determined phenomenographically by grouping like-responses together, which resolved three categories of engagement with the numeracy task (n = 50 student responses).

Engagement level		Descriptor	Student comment
Highly engaged	52%	Student has related the task to his/her confidence with calculating, and/or how they intend to address this.	*'Shows self-confidence/doubt in personal responses.'* *'interesting, good to have to think about what you know. I got all mine completely wrong! Need to work on this!!'*
Engaged	34%	Student has related the task to calculating and estimating; not with confidence.	*'difficult to convert to L", "good for thinking about maths'.*
Not engaged	14%	Responses were superficial.	*'I need a calculator'; 'tops'*

Discussion

This work is an analysis of a current assessment practice, and is being extended into a research project to help define the numeracy threshold of students in the Life Sciences, for example to define the common misconceptions that Life Science students have when they are working at the interface of physics (as they are here in plant physiology), chemistry, mathematics (statistics) and geosciences. Enabling students to engage in their own skills development appears to be a powerful classroom strategy, particularly for students lacking confidence with their ability. For this study we deliberately removed the notion of getting the right answer from the task to develop awareness of confidence. Being able to align confidence with ability is the next step that could prove valuable but as a teaching strategy, this remains to the trialled and tested.

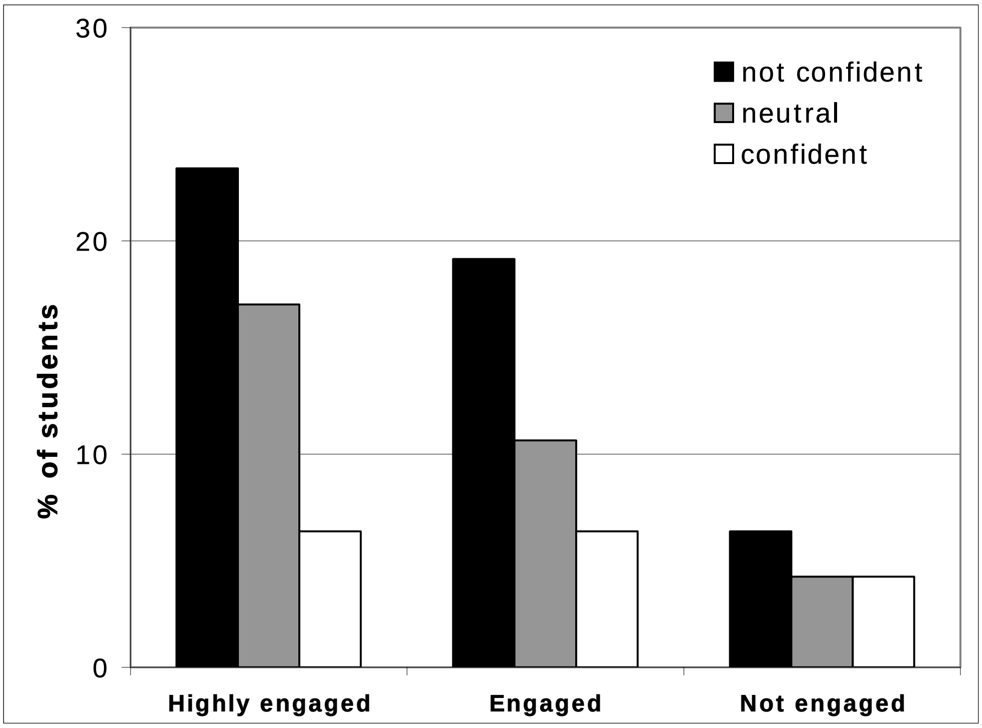

Figure 3. The students with the least confidence when converting between m^3 and L were the most engaged with the numeracy exercise (n = 47 students)

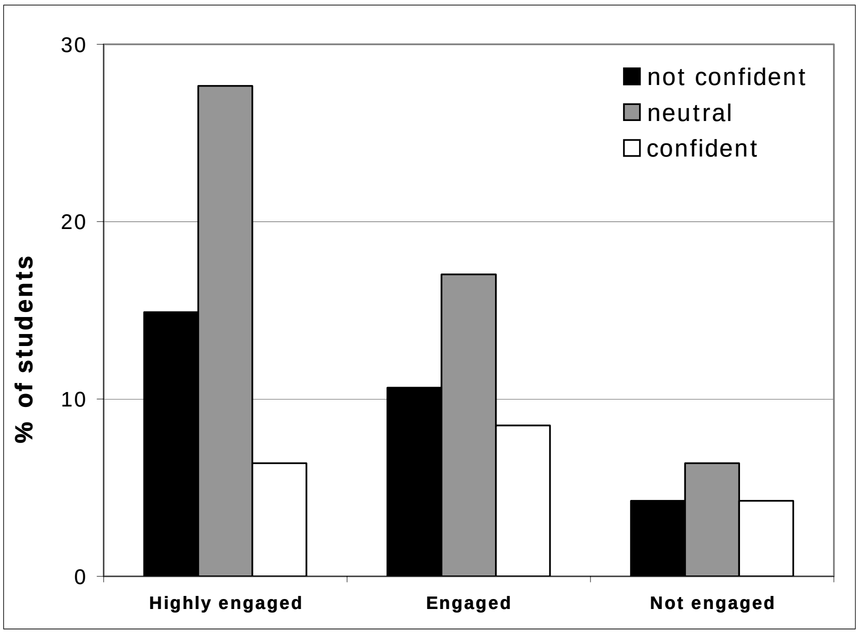

Figure 4. The students with 'neutral' confidence in estimating volume were the most engaged with the numeracy exercise (n = 47 students)

Acknowledgements

Eunice Wong is the recipient of a Summer Internship to the Research in Biology, Education and Training group, School of Biological Sciences, The University of Sydney. We thank our reviewers and Dr Elizabeth May for assisting with the preparation of this manuscript.

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