Are you ready to play the science game?
Melding maths skills for transition into university science

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Abstract

Mathematical skills are used in all areas of science, but often students come to university ill-prepared for the mathematical requirements of their courses. However studies have shown that mathematics educational level is a strong indicator of future success for students embarking on science courses. The change to a new degree structure at Murdoch University in 2014 provided an opportunity to design a new transition unit for science students incorporating mathematical activities which allow authentic experiences of science. It was seen as imperative to meld mathematics with science in a meaningful way to assist students to perform at their best as they enter the science 'game'.

Introduction

The transition into the academic culture of university can be challenging. Students have to deal with a completely new learning environment, manage their time at study and in paid employment, adjust to online learning systems and university regulations. Providing academic support and small group learning activities can help to acculturate students and give them a sense of belonging so vital to university retention and success (Brinkworth, McCann, Matthews & Nordström, 2009). Various universities require students to take a transition unit in their first semester to assist with their adjustment to university studies and also to instill the basic academic skills required for their courses. However the level of preparedness for studies may also be influenced by the skills and attitudes students bring with them (Tariq & Durrani, 2012).

The problem of falling standards in mathematical literacy of students entering university has been in the public eye recently, due to statements by Australia's Chief Scientist in 2013 and the focus on STEM subjects to try to improve interest in science studies (Office of the Chief Scientist, 2013). A forum held as part of an Office of Learning and Teaching project, 'First Year in Maths'[1], reported the decline in mathematical background of students enrolling in science courses at tertiary level. Assumed knowledge at Year 10 level is the only mathematical requirement at many Australian universities and significant numbers of students begin their science studies with only basic mathematical competency (King & Cattlin, 2015).

[1] *Building Leadership Capacity in University First Year Learning and Teaching in the Mathematical Sciences* (see fyimaths.org.au), led by D. King with project manager J. Cattlin, both of The University of Melbourne, in partnership with the University of Adelaide, Curtin University and the University of Sydney, from 2012 -2014.

Studies have shown the positive correlation between mathematical skills and successful studies in science. Nicholas, Poladian, Mack and Wilson (2015) highlighted that the level of mathematical education was a strong predictor of success in science. Students entering university with only basic levels of secondary school mathematics were shown to be less successful in first year science studies than their more mathematically-proficient counterparts. Mature age students also may not have recent experience in mathematics nor fluency in mathematical techniques (McKenzie & Schweitzer, 2001).

This provides a challenge for coordinators of tertiary science transition units in particular, as the use of numeracy (Yasukawa & Johnston, 1994) and higher level mathematical skills is pervasive in science disciplines. When students commence university studies without recent experience in mathematics or low level proficiency, how can support be provided to help the students not only to improve their mathematics skills but to synthesise their numeracy competencies with their other academic skills?

Opportunity

Murdoch University moved to a new Bachelor degree structure in 2014, with compulsory transition units in each of the major degrees. The student cohort for the Bachelor of Science transition unit is varied in both breadth (with students from vastly different areas of science like psychology, marine science, physics, microbiology, chiropractic and computer science) and depth (from alternative pathway students to the highly-competitive veterinary science group). The unit developers saw the opportunity to design a unit of study that would meld academic skills that are needed for science – such as critical thinking, scientific method, mathematical skills, scientific writing and other forms of science communication.

The university has no formal mathematics entry requirements, only assumed knowledge at Year 10 level. So it was seen as important to blend mathematical skills together with the necessary academic literacy competencies in authentic learning and assessment tasks that allowed for deeper learning experiences through reflection on the use of mathematical concepts in practical situations (Biggs, 1999). The unit developers wanted to achieve a flow of learning activities that encouraged students to synthesise their knowledge to produce an understanding of the interplay of mathematical and other skills in science.

The science transition unit content was planned to be delivered in weekly two-hour lectures with occasional guest lecturers from different disciplines. Guided activities on various skills developed in the lectures formed the basis of two-hour weekly tutorials/workshops. To engage with the diversity of the student cohort, examples in lectures, tutorial activities and assessments were taken from a variety of science areas.

Transition unit activities incorporating mathematical skills

Science transition students are automatically enrolled in an online mathematics diagnostic quiz, which they can access from the time of enrolment, typically well-before the start of semester. The quiz evaluates basic mathematical skills to assess student preparedness for the

mathematical side of their science studies (Kemp, Fletcher & Middleton, 2011). Students are given immediate feedback from the quiz and encouraged to complete a mathematics refresher programme offered on campus prior to semester, with materials also available online. In this way students see that the university values their mathematical skills and is offering timely assistance to improve or practise them before commencing their science studies.

The first assessment in the science transition unit is a series of online Numeracy Modules, with associated online quizzes. While the initial three weeks of lectures cover academic integrity, referencing, scientific method, critical thinking, reading and writing, students must complete, in their own time, ten specified modules and quizzes. Some examples of topics covered in the self-contained modules are decimals, fractions, percentages, scientific notation, units, graphs, sampling, averages and variation in data.

In the first of the weekly tutorial sessions, the ice-breaker activity is a data collection exercise. Students time how long they can balance in various standing positions. The data is entered into an Excel spreadsheet for use in later tutorial activities. The concepts of data and the scientific method are explored and students gain practice with basic data entry skills in Excel.

The rationalisation for the numeracy assessment and the initial tutorial exercise is that science students need to be ready to apply mathematical skills in other concurrent units of study. By having basic numeracy skills refreshed during the first three weeks of semester, students should be well-prepared for their application within any other science units. Drop-in support sessions are offered through the semester for any students experiencing difficulties.

In Week 4 the lecture continues the theme of critical thinking in the context of the graphical presentation of data. Students are guided in the process of reading graphs within the context of a research question: to glean as much information as possible, to relate variables and units to their context, and to interpret basic statistics. Simple types of data sets are presented and consideration is given to which sort of graph is appropriate for each type. Instructions are presented for graphing and performing simple statistical calculations in Excel.

In the associated tutorial students have to interpret numerical information and produce appropriate graphs of given data sets. One tutorial activity is the analysis of their “balance” data from Week 1. They must consider the data from different balance positions, formulate a research question, calculate appropriate means and standard deviations (which involves re-organisation of the data), produce graphs on Excel, and then write about their results.

By this time of semester, students have searched scientific literature through library databases and completed a written, referenced, assessment task comparing scientific sources. The focus of the unit then turns to reporting the results of scientific studies. A lecture on writing a scientific report guides students through the required sections of a report to help them in formally present their own scientific investigations. In a tutorial, students use their “balance” data graphs and interpretation of results, together with some short reference material provided on the balance topic, to produce a basic scientific report.

The science transition students now have enough skills to attempt the major assessment in the unit: the analysis of a data set on a given topic to produce a full scientific report. There is a choice of topics from different areas of science, at a level accessible to all students, but based on authentic research. This assessment requires the synthesis of many skills: formulating a research question and hypothesis; finding and using good quality references on the topic; writing a coherent introduction and a concise methods section; presenting basic data analysis through appropriate figures and statistics; writing results and discussion sections; and summarising the work in a formal conclusion. Students first submit the preliminary sections of the report as a formative assessment, then receive detailed feedback to guide the formulation of the full report, due at the end of semester.

The construction of the scientific report blends or 'melds'[2] a variety of academic skills, but is grounded in the mathematical analysis of the data set and the interpretation of the results. The scientific investigation cannot take place or be communicated effectively without using mathematical skills. Students must be able to move seamlessly between mathematical and academic literacy skills, producing the opportunity to synthesise their skills within an authentic scientific context.

Later unit content moves into science communication, collaboration and peer review. Further mathematical skills are addressed in lectures on mathematical models and working with numbers sensibly. Tutorial activities ask students to find mathematical models in their own areas of science studies and to communicate them to their tutorial group. This reinforces the claim made at the start of semester that mathematics is used in every science area as they can see it in their own chosen field of science. Further activities require students to use Excel to fit basic models to given data sets and to work with equations and significant figures.

Specific mathematical skills are addressed in approximately 25% of the lecture and tutorial content. However those skills must be used in assessments worth 75% of the final unit mark. Yet with learning support and structured tutorial activities, the mathematics covered in this science transition unit is achievable with the assumed knowledge of Year 10 mathematics.

Conclusion

Students coming to university with basic mathematical backgrounds are sitting at the table, waiting to start their science studies. This transition unit gives numeracy support and the chance to develop and consolidate quantitative skills to a level sufficient for science studies. It is hoped that students will have enough mathematical skills and understanding of their important place within science to be able to not just sit at the table, but to "meld" them with enough academic skill "points" to enter and play the science game effectively in their future studies at Murdoch University.

Acknowledgements

[2] In card games such as canasta and other versions of rummy, players must 'meld', i.e. produce cards which earn points to a required level in order to enter the main game and have a chance of winning. See http://www.hoylegaming.com/rules/showrule.aspx?RuleID=204

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Discussion points

- This initiative tries to remedy the problem of poor mathematical background of students entering university science courses. Have universities created this problem by not requiring better mathematical backgrounds of their science students?
- Are we being honest with students about how difficult science can be without a good background in mathematics? How might this affect retention in science courses?
- Is there a role for a probationary year of university studies for those without the requisite maths skills, particularly in the physical sciences?

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