INSPIRING STUDENTS TO STUDY THE MOLECULAR LIFE SCIENCES

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Introduction

Teaching first-year biology in an Australian university can be extremely challenging. Biology underpins many different programs of study, which leads to many different stakeholders with different opinions of what a first-year biology course should provide. This also leads to the students having a diverse range of initial interest towards biology. The task is further complicated as many universities do not require prior study of biology at high school before commencing university studies in this area. This is often in stark contrast to other science disciplines such as chemistry and physics. At Flinders University, we have a single, integrated School of Biological Sciences, which is responsible for the teaching of general first-year biology, where needed, in all the degree programs of the university. This is achieved via two courses: BIOL1101, Evolution of Biological Diversity, and BIOL1102, The Molecular Basis of Life. As a school, we became increasingly aware of the impact that the national downturn in demand for science courses (1) was having on both the quantity and quality of students graduating from our undergraduate degree programs, as well as the follow-on effects this was having on the numbers of honours and PhD students. Hence, in 2005, we embarked upon a mission to change the way we teach first-year biology, with the aim of increasing the number of students we inspire to study higher level biology by improving the first-year learning experience. This required examining the way we were teaching first-year biology to identify its shortcomings, followed by an extensive search of the published literature and practice in other universities across the nation and world to identify the best teaching practices and methodologies to achieve our aims.

Analysis of the Old Courses

The first course we targeted for improvement was BIOL1102, which was called Biology 1B: Gene Expression and, as part of the revision, was renamed The Molecular Basis of Life. The old course consisted of three traditional lectures and a three hour practical session each week, which alternated between a wet laboratory practical and a computer-based instructional exercise. Both types of practical exercise had assessment built into them. The other assessable components in the topic included a poster, a take-home wet exercise involving culturing of yoghurt and a final exam.

We surveyed students to determine their views of the course. This revealed that there was a large difference in the experience students had depending on whether they had previously studied year 12 biology. Those with year 12 background thought that they had already covered much of the material in the course and that it was too easy, while those without year 12 biology found the course extremely challenging. A detailed examination of past student performance showed that students who had not completed year 12 biology failed at twice the rate of those who had and their overall failure rate was higher than the university average.

Other key findings of our student survey were: students couldn't see the relevance of biology in the real world; the computer practicals were not engaging; the wet practicals were enjoyable, but didn't appear to relate to the lecture material; there was a lack of opportunity for students to test their knowledge prior to the final exam; and students found it difficult to foster interactions with other students that would lead to successful study networks.

The New Course

As our primary aim was to inspire more students to take further studies in biology, it was essential that the new course used examples that were relevant to the students and provided them with the opportunity to interact with the material rather than being passive observers (2). The new course has the following essential elements, some of which are reviewed below: 1) an interactive lecture format; 2) a pre-lecture each week to introduce material; 3) a Peer-Assisted Study Session (PASS) each week; 4) fortnightly wet practicals that complement the lecture material; 5) continual assessment throughout the semester; and 6) an investigative group research project.

Interactive Lectures

Instead of the traditional passive lectures, we have adopted two different interactive formats. The first two lectures in each week are delivered by an academic whose research field relates to the material being delivered, and in these lectures, students are introduced to new concepts and information. However, between three and six times during a 50-minute lecture, the lecturer poses a multiple choice question that tests the key concept they have been trying to introduce. When we first changed to this format, we trialled the use of electronic student response devices for collecting and collating the responses to the questions (3). In this study, we compared the use of the response devices with students answering questions by raising their hand. Although there were many advantages in using the response devices, such as a larger percentage of the class responding and instant reporting of the results, this was not found to flow through to increased learning outcomes when the final exam grades of the two groups of students were compared. However, a significant increase in final exam grades was observed between students with interactive lectures and those of previous years who had passive lectures (3).

The third lecture of the week, termed a lectorial, is delivered by the course convenor and demonstrates applications of the concepts and information delivered in the previous two lectures. During these sessions, students are led through a real world problem and are required to continually apply their knowledge to solve the problem (answer the question). Although these sessions are conducted with 250-300 students in the lecture theatre, students are encouraged to discuss the problems with each other (**Fig. 1**). Typically, students will consider 10-12 questions whilst investigating one or two large problems. One example of a lectorial topic is mapping the evolution and epidemiology of a virus, which allows students to apply their fundamental knowledge pertaining to the processes of DNA translation and the redundancy of the genetic code.

Fig. 1. Students problem solving in a lectorial session.

Pre-lectures

One of the most perplexing problems we had to face was how to make our course challenging for students who had studied biology at high school, whilst still allowing those who hadn't a similar chance of successfully completing the course. This issue of addressing variability in the basal knowledge of students is perpetual (4) and often arises in the more abstract sciences such as physics, maths and chemistry (5). Investigation of the student cohort revealed that approximately 50% of the students had no background knowledge, so we needed a solution that could efficiently be applied to about 250 students.

Our solution was to introduce a pre-lecture at the beginning of each week. This pre-lecture introduced the basic concepts covered in year 12 biology that underpinned the material to be delivered in the following lectures and lectorial that week. We also found that one of the biggest hurdles in learning biology is understanding the vocabulary; therefore, each week, we gave the students a vocabulary list that they could use to gauge their level of knowledge and decide if they would benefit from attending the pre-lecture. This vocabulary list also acted as a study tool.

The remaining week's lectures were then delivered assuming that students had the knowledge of year 12 biology, allowing us to quickly revise the year 12 concept and build from that point. There is no doubt that the students without year 12 biology have to work much harder, but we have provided them with a supported environment, which diminishes the feeling of being overwhelmed with the subject.

Peer-assisted Study Sessions

Peer-assisted study sessions (PASS) are offered in many courses across the nation and around the world (6). These have some similarity to small tutorials, however, instead of being led by an academic, they are led by a senior undergraduate student (second- and third-year students in our case). The dynamic is also very different to a tutorial, as the PASS leader is not the oracle of all knowledge, but a facilitator who directs the student to find the answers for themselves and ultimately improve their study skills. The PASS sessions are less formal than a normal tutorial and provide a venue for students to make friends and establish study networks and are viewed as beneficial in assisting the transition from school to university (7).

Continual Assessment

One relatively minor change that probably had significant benefits with regard to increasing student performance is continual assessment tasks that are informative to the final exam. Although the old course had assessment of practicals during the semester, little, if any, of this assessment would allow them to identify weaknesses in their knowledge or understanding of the material covered in lectures, which was the primary focus of the final exam. We therefore introduced weekly online quizzes and a mid-term exam to allow student to test their knowledge of the lecture material. These assessment exercises were weighted such that there was a big enough incentive for the students to complete the assessment, but small enough that if they didn't have sufficient knowledge and performed poorly, it wasn't the end of the world.

Evaluation of the New Course

The new first-year biology courses have resulted in many benefits for the School of Biological Sciences at Flinders. Student satisfaction with the first-year courses has improved significantly, with all of the scores for the standard questions in our student evaluation of teaching questionnaire increasing. The failure rate in the course dropped significantly and to our delight, students without year 12 biology now have the same success rate as students with year 12 biology. This in itself results in more students able to take second-year biology topics. *But were we able to increase the numbers of students taking second-year biology topics? More importantly for biochemistry, did we increase the number of students studying the molecular life sciences?* In 2007, after the introduction of the new BIOL1102 Molecular Basis of Life in 2006, we had a 20% increase in enrolment in second-year courses offered by the school. *But was this just year-to-year variation and how did the molecular life sciences fare?* If you look at student load in second-year molecular life science courses for the two years before the new course (2005 and 2006) and compare those with the two years after the new course (2007 and 2008), we see a 16% increase in student load (**Fig. 2**).

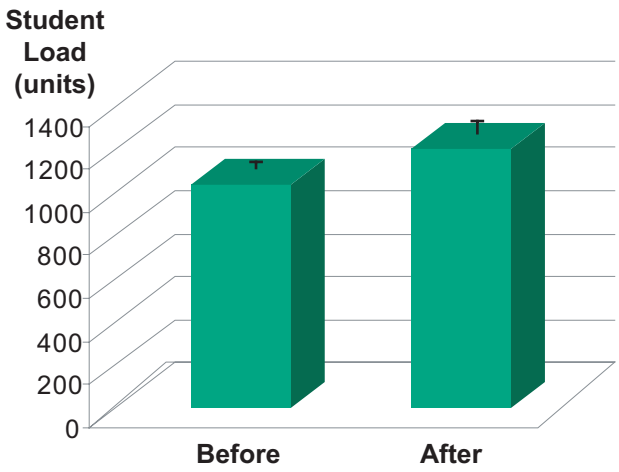

Fig. 2. Average student load in second-year molecular life sciences before and after course changes. Averages were calculated for two-year period before and after changes to the first-year course. Error bars show mean variation.

Therefore, the take-home message should certainly be that high quality and engaging teaching in first-year biology does inspire students to study the molecular life sciences!

References

1. Krause, K., Hartley, R., James, R., and McInnis, G. (2005) *The First Year Experience in Australian Universities: Findings from a Decade of National Studies.* The Australian Government, Department of Education Science and Training, Canberra
2. Collins, A. (1996) In: Vosniadou, S., De Corte, E., Glaser, R., and Mandl, H. (eds) *International Perspectives on the Psychological Foundations of Technology-Based Learning Environments.* Lawrence Erlbaum Associates, Hillsdale, USA
3. Burke da Silva, K., Wood, D., and Menz, I. (2007). *Proceedings of the HERDSA Annual Conference.* Adelaide
4. Ausubel, D. (1968) *Education Psychology: A Cognitive View*. Holt Rinehart and Winston, New York, USA
5. Sirhan, G., Gray, C., Johnstone, AH., and Reid, N. (1999) *University Chem. Educ.* **3**, 43-46
6. Arendale, D. (2004) In: Duranczyk, I., Higbee, J.L., and Lundell, D.B. (eds) *Best Practices for Access and Retention in Higher Education.* Center for Research on Developmental Education and Urban Literacy, General College, University of Minnesota, Minneapolis, USA
7. Topping, K.J. (1996) *Higher Educ.* **32**, 321-345