Effective assessment of scientific reasoning and research skills in a large class setting

Kay Colthorpe
School of Biomedical Sciences, University of Queensland, k.colthorpe@uq.edu.au

Susan Theiss
School of Biomedical Sciences, University of Queensland, s.thiess@uq.edu.au

Judit Kibedi
School of Biomedical Sciences, University of Queensland, j.kibedi@uq.edu.au

There has been a strong push recently to encourage science students to develop the attributes of 'being a scientist' in their undergraduate years, particularly in their approach to science, through the development of skills such as critical thinking, problem solving and appropriate use of evidence. These skills have been developed through activities such as research experiences and inquiry-based classes. However, this creates a significant challenge: to develop and apply effective assessment methods that are aligned with the learning objectives and desired graduate attributes, in a program with large enrolments. This poster reports on a project designed to develop effective and sustainable methods of explicitly assessing the scientific and research skills of Bachelor of Science students in a large class setting with multiple markers. The efficacy of the assessment methods was evaluated by identifying evidence of scientific reasoning and research skills in student work, and comparing the outcomes of different markers. Student perceptions of the assessment tasks were also explored through course evaluation surveys. The results show that evidence of scientific reasoning and research skills were present and identifiable within the student work and could be graded in an equitable and repeatable manner, although differences did exist between markers. As student numbers in undergraduate science courses are increasing, there is a need to develop greater flexibility in assessment practices. This project demonstrates that it is possible to effectively and equitably assess scientific and research skills in large classes, and also emphasises the need for robust moderation procedures.

Keywords: large class; marking moderation; scientific reasoning
Theme: sustainable assessment practices and standards

Introduction: aims and background literature

Recently there has been strong push to encourage science students to develop the attributes of 'being a scientist' throughout their undergraduate years, particularly in their approach to science, through the development of skills such as critical thinking, information literacy and problem solving, and the ability to use evidence. This has been encouraged through the introduction of activities such as undergraduate research experiences and inquiry-based classes, and there is a growing body of evidence demonstrating the positive impacts of these changes (Hunter et al., 2007; Casotti et al., 2008; Gehring & Eastman, 2008).

However, while there has been considerable research and enthusiasm with regard to methods of promoting such skill development, developing effective and equitable assessment practices to explicitly evaluate the progressive development of these skills remains a difficult task (Harris et al., 2007). An increase in student enrolments across the university sector, particularly in the biomedical and health sciences, has led to marked increases in class sizes in recent years, further complicating this task (DEST, 2001, 2008). This creates a significant challenge: to develop and apply equitable and effective assessment methods that are aligned to the learning objectives and graduate attributes of the Bachelor of Science (BSc) program.

Context and design of assessment practice

The primary purpose of this project was to develop sustainable and effective methods of explicitly assessing scientific and research skills of BSc students in a large class setting, and to test the robustness of these methods where multiple markers are used. We developed and implemented a series of group and individual assessment tasks, including an oral presentation, an experimental proposal and a laboratory report, for a new second-level BSc

physiology course. By placing the emphasis of assessment criteria on the ability to critically and insightfully reason, we also attempted to highlight the value of these skills to students (Biggs, 1999).

The course had an enrolment of 400 students, and 16 teaching staff were involved in both administering and marking the assessment tasks. Marking was performed using criteria-based rubrics and took place after all staff had attended meetings at which appropriate standards and grades were negotiated (Sadler, 2005). The efficacy of the assessment tasks was evaluated by specifically identifying evidence of scientific reasoning and research skills within the student work, using criteria to examine reasoning, skill in data collection and analysis and the use of evidence in their experimental design proposals and written work. Mean student outcomes for each of these criteria from individual markers were compared. Where markers differed in mean or variability, blind double marking of a random selection of their marking was performed and compared. Student perceptions of the course and assessment tasks were explored in course evaluation surveys.

Results

Preliminary results have shown that evidence of scientific reasoning was present and identifiable within the student work, and that this could be graded in an equitable and repeatable manner by multiple markers. Students demonstrated varying ability to reason in their oral presentations, through linking of hypotheses and experimental design proposals and use of evidence to support both their hypothesis formulation and expected outcomes. In laboratory reports students demonstrated clearly defined standards of research skills within data collection and analysis, and in the formulation of discussion based on their results and evidence from literature. Mean student outcomes varied for each marker, with significant differences for at least two different markers on each criterion, but moderation of marking supported the outcomes awarded. Survey responses showed that the majority of students indicated that their knowledge, understanding and skills were adequately assessed, and that there was an appropriate match between the learning objectives and assessment tasks. However, comments from students also suggested that they still perceived these assessment tasks as means of testing knowledge rather than skills.

Implications for practice

As student numbers in undergraduate science courses increase across many universities, and the learning objectives of these courses move progressively toward consideration of graduate attributes, there is a need to develop greater flexibility and efficacy in assessment practices, particularly where multiple markers are required. These outcomes demonstrate that it is possible to effectively and equitably assess scientific and research skills in large classes. However, this study has also shown that some differences do occur within the outcomes awarded by different markers. As this design necessitated that teaching staff both administer and mark the assessment tasks, it is difficult to determine whether these differences are due to differing standards of teaching, learning or marking. In summary, this study has demonstrated that it is possible to effectively and equitably assess scientific and research skills in large classes, but has also emphasised the need for robust moderation procedures.

References

Biggs, J. (1999). What the student does: Teaching for enhanced learning. *Higher Education Research & Development, 18*(1): 57-75.

Casotti, G., Rieser-Danner, L., & Knabb, M. T. (2008). Successful implementation of inquiry-based physiology laboratories in undergraduate major and nonmajor courses. *Advances in Physiology Education, 32*(4): 286-296.

Department of Education, Science and Training (2002). Students 2001: Selected higher education statistics.

Department of Education, Science and Training (2008). Students 2007 [full year]: Selected higher education statistics.

Gehring, K. M. & Eastman, D.A. (2008). Information fluency for undergraduate biology majors: Applications of inquiry-based learning in a developmental biology course. *CBE Life Sciences Education, 7*(1): 54–63.

Harris, K-L., Krause, K., Gleeson, D., Peat, M., Taylor, C. & Garnett, R. (2007). *Enhancing assessment in the biological sciences: Ideas and resources for university educators*. Retrieved February 8, 2010, from http://www.bioassess.edu.au.

Hunter, A., Laursen, S L., & Seymour, E. (2007). Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development. *Science Education, 91*(1): 36-74.

Sadler, R. (2005). Interpretations of criteria-based assessment and grading in higher education. *Assessment & Evaluation in Higher Education, 30*(2): 175-194.