Mapping student learning throughout the collaborative inquiry process: the progressive e-poster

Kathy Takayama and **John Wilson**, School of Biotechnology and Biomolecular Sciences, University of New South Wales
k.takayama@unsw.edu.au j.e.wilson@unsw.edu.au

Background

21st century research approaches in the biological sciences continue to progress at an ever-increasing pace. Advances in computer technologies have resulted in exponential increases in the rate at which biological data are collected, accumulated, disseminated and applied. Biology education has remained predominantly content-centric, focused on prescribed activities with little autonomy, and pedagogies have remained stagnant in comparison to the implications of research outcomes (National Research Council 2003; Handelsman, Ebert-May, Beichner, Bruns, Chang, DeHaan, Gentile, Lauffer, Stewart, Tilghman, and Wood 2004). There is a critical need for evidence-based reform to align the link between current research and pedagogical practice. This project addresses this need through the creation of collaborative learning communities from a crucial starting point: 'thinking about thinking', i.e., the enhancement of learning through individual and group reflection and analysis of the scientific inquiry process.

This project aligns science teaching and learning to the scientific research method using an approach that enhances student engagement and aligns desired learning outcomes with professional practice. The aim was to shift the assessment-driven motivation of students toward intrinsic motivation through collaborative inquiry, and encourage them to reflect on their own learning as they integrate theory with practice. The approach centres on the creation of learning communities structured to facilitate students' metacognitive awareness of both individual and collaborative learning processes. The integration of reflection, analysis and critique of process (as opposed to outcome) into a research-based e-poster project enhances student learning by reinforcing the iterative process of the scientific method. The strategic structure of the online and face-to-face components of the collaborative inquiry process acknowledges and builds upon the disciplinary, cultural, and social diversity of the class.

The context and setting

The second year undergraduate course, Fundamentals in Microbiology & Immunology (MICR2201) has a large enrolment of 280 students. The students represent a diverse range of backgrounds, including majors in Microbiology, Medical Microbiology and Immunology, Molecular Biology, Food Science and Nutrition, Biotechnology, Nanotechnology, Bioinformatics, Biochemistry, Genetics, and Marine Science. The course forms a cornerstone of the foundational theoretical and practical training for many students in the Faculty of Science at the University of New South Wales, and it is a prerequisite for many higher level courses in the life sciences. The course is comprised of 2 x 1 hour lectures, 1 x 1 hour tutorial, and a 1 x 3 hour laboratory practical per week. The tutorials (10 – 15 students) and laboratory practicals are taught by experienced postgraduate tutors, many of whom have taken this course in the past. Each group of students remains with the same tutor for the tutorials and labs.

Integration of theory and practice

Significant changes have been implemented in the course curriculum since 2003 to facilitate conceptual understanding and deep learning. This includes the creation of a *WebCT* component that reinforces foundational understanding, and facilitates laboratory investigations by linking theory to practice. As this is the first exposure to the microbiology laboratory for most students, basic microbiological skills are progressively taught in synchrony with the fundamental concepts of the lectures. A significant portion of the formative assessment includes an individual research project conducted in parallel with the basic laboratory component. The aim of the students' research project is to isolate and identify a single bacterial genus (fondly referred to as their 'bug') from an environmental sample through the practical application of students' conceptual understanding of bacterial metabolism, morphology and physiology. The application of their theoretical understanding is central to the development of their rationale for determining experimental process at each stage of their research project, and the interpretation of these processes.

The formative assessment for the research project has, in years past, followed a traditional approach that included a formal scientific paper for the bug research project, laboratoryquizzes, and evaluation of laboratory notebooks. Two years ago, we developed a learner-centred assessment component called the 'Bug Book', which allows flexibility in mapping individual progress. The Bug Book encourages students to put their own creative imprint on the documentation of their research process to suit their learning styles, and emphasis is placed on reflective process rather than experimental outcomes. The impact of the Bug Book has been an enhancement of students' intrinsic motivation, fostered by a sense of ownership of their work and self-directed learning. These outcomes reaffirm the importance of contextual learning environments that facilitate enhanced engagement and deeper learning in students (Ramsden 1992). The Bug Book has also continued to be a valuable reference and learning resource for students, who continue to utilise them in their subsequent microbiology courses. Such constructive alignment of a student-centred assessment task promotes the enhancement of teaching and learning (Biggs 1996).

Fostering collaborative learning communities

A hallmark of scientific research is the collaborative and multidisciplinary nature of research inherent to the process. Emphasis on the process of inquiry engages students in an authentic learning experience (Takayama 2005). Whilst we have been aware of the challenges in fostering authentic inquiry through group work in a large class setting, our goal was to develop a truly collaborative learning experience in the context of the bacterial isolation project. Student feedback on the Bug Book highlighted the marked impact that a learner-centred assessment project has on intrinsic motivation. We therefore developed a framework for collaborative learning within a large class that integrated reflection, evaluation and critique of both scientific process and learning experience within the assessment. The framework was strategically designed to provide relevance and application, key criteria for authentic learning experiences (Chinn and Malhotra 2002; Herrington and Herrington 1998; Kolb 1984; Meyer 1992). In so doing, the goal was to achieve constructive alignment between the goal (to make 'scientific thinking visible') and learning outcomes within the context of a team inquiry project.

The traditional model that is used to teach the scientific method invariably follows a linear approach (Figure 1).

This conceptually linear approach, which leads toward a singular endpoint, reinforces a perception amongst students that the 'outcomes and conclusions' are the most important elements of the research process. This belief is perpetuated through the honours year of the undergraduate curriculum. However, scientific research involves continuous reflection, analysis, and communication, and this evaluative process contributes to ongoing development and discovery.

We have created our own model to develop a reflective, iterative approach to engage students in an inquiry process that is more cognisant of scientific professional practice (Figure 2).

This model represents a more authentic process with regard to the learning and teaching of scientific inquiry and equally importantly, a framework for assessment.

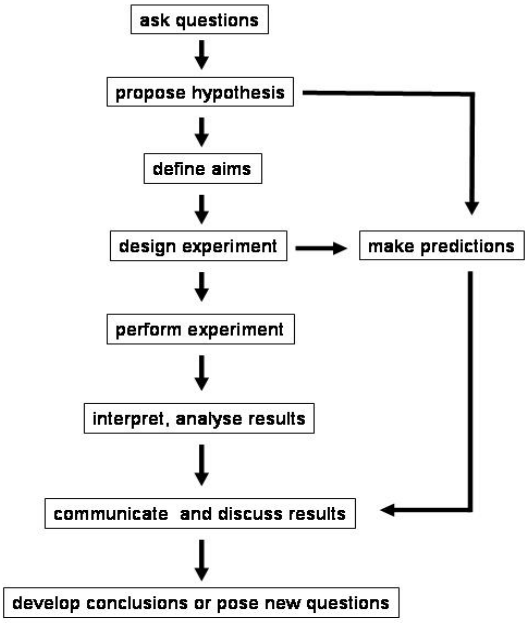

Figure 1. Traditional linear model

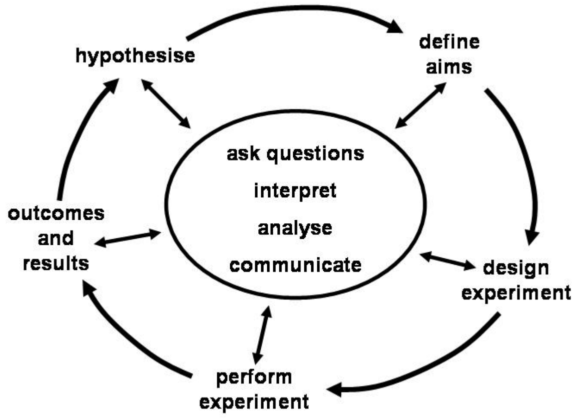

Figure 2. Our own model to develop a reflective, iterative approach to the teaching and learning of scientific inquiry

Approach

The progressive e-poster

The goal for MICR2201 was assessment for deep learning and promotion of metacognitive awareness of inquiry linked to the learning process. The progressive e-poster is a group assessment project that **maps student learning** on the process of collaborative inquiry. The e-poster modifies a traditional mode of communication of research in the biological sciences ('the poster'). It is distinct from the traditional scientific poster in purpose, format, and assessment practice. The traditional poster also follows a linear format similar to the linear model depicted above, whereby sections are presented sequentially: 'Aim, Background & Significance, Hypothesis, Materials & Methods, Results, Discussion, and Conclusions.' Whilst the utilisation of scientific posters for assessment has been reported previously (Billington 1997), the e-poster is unique in its focus on the learning process rather than reporting scientific outcomes. In the e-poster, students work with tutorial/laboratoryteam members (10 – 15/team) to collectively reflect on their scientific approach; develop their notions of what constitutes resources and references that are a) reliable and b) relevant to each stage of the project; continually develop/revise/build upon conceptual maps of their 'bug' and their experimental process; identify areas of uncertainty or concern; and discuss possible ways to address these issues. The 'progressive' format of this e-poster underlines the iterative model of inquiry: there are 3 submissions (at weeks 5, 10 and 13), and each poster progressively maps the team's experimental and reflective process (the templates and guiding questions for e-posters version 1 and version 2 are included in Appendix 1). Each team received an identical web e-poster template (with user and password login) created to assess the elements described above. Teamwork was facilitated through *WebCT* private discussion sections, and collective agreement was reached before the poster was submitted electronically.

The e-poster assessed student engagement in the process of inquiry, and facilitated review and reflection throughout the course (rather than at the end). For the instructor, this assessment approach progressively mapped group learning of the experimental, conceptual, and collaborative processes. Detailed rubrics were developed (see Appendix 2) to assess each version of the e-poster to ensure alignment with learning goals and consistency of assessment across all 22 teams. The rubrics were also distributed to the students to provide transparency of process. Our goal was to strengthen student engagement through contextual relevance in a process of inquiry that mirrors professional practice, and align the pedagogy of the discipline to the practice of the discipline. The iterative model of inquiry and learning promoted through the e-poster is relevant not only to undergraduate and postgraduate courses, but serves as a mentorship model for research supervisors.

Outcomes

Changes in the nature of MICR2201 following the introduction of the progressive e-poster were marked by the transformation of the tutorial groups into collaborative learning communities. In comparison to the previous two years, the quality of discussions in WebCT was indicative of higher levels of thinking, integration of theory and practice, and a culture of peer learning and teaching. Indeed this was one of the strongest elements of evidence demonstrating the evolution of students' intrinsic motivation with this assessment. The natural integration of theory and concept with practical application into the context of the research project can be witnessed in the e-posters (see link to sample poster below). Peer learning and teaching, as well as mentorship within the e-poster discussions, were also apparent. The e-poster functioned as an assessable component that structured the step-by-step processes of transfer and application, to make them 'visible' to the learner. As the tutorial groups evolved into learning communities, the discussions in *WebCT* revealed the students' own metacognitive realisation of the utilisation of the e-poster assessment for learning, rather than of learning: student post in *WebCT*:

> We should use version 3 of the poster as a learning tool and really focus on bringing it together conceptually. I would even suggest that we have a meeting (in a relaxed atmosphere) where we talk about anything that we are still confused about and help each other sort things out... I think this could be a really good revision that will make the poster even better and of course help us with the final...

The laboratory research project and the progressive e-poster were tightly linked to actively and intellectually engage students throughout the entire course. This engagement was strengthened through the collaborative framework of the learning process, and the challenge of open-ended inquiry. The outcomes from the e-poster are indicative of students' conceptual development regarding the iterative process of authentic inquiry. Several teams took the initiative to create their own original concept maps to document the evolution of their conceptual schema. Such documentation, dissemination, and integration of feedback into the continued self-reflection and critique at the group level are indeed indicative of scholarship. The progressive learning journey of one group may be viewed at:
http://www.cfkeep.org/html/stitch.php?s=15996728386727&id=79371591451924.

The challenge of developing and revising their own research approach created an engaging level of motivation for students. As an extension of this learner-centred approach, the e-poster provided an opportunity for creative teamwork aligned to the learning experience. Student responses to a Likert scale survey (Table 1) indicate that the e-poster primarily encouraged students to work collaboratively and to learn from their peers. As a formative assessment approach, the students also recognised the e-poster as a learning tool.

One of the goals in this course is to foster students' metacognitive awareness; i.e., thinking about their learning. The responses from the survey indicate that this desired outcome was not entirely achieved. Our interpretation is that the focus on group collaboration may have precluded individual introspection. In addition, students did not believe that the e-poster facilitated their problem-solving skills. We had initially assumed the e-poster would strengthen the connections of the other components of the course (laboratories, lectures, tutorials) and in so doing, facilitate students' problem-solving skills in the laboratory and tutorials. Focus group sessions have been scheduled to obtain further in-depth feedback from the students to investigate how to explicitly facilitate these connections and to address the weaknesses and strengths of the e-poster project.

Table 1. Student responses to Likert scale survey

Survey Question (Likert Scale: 4 = strongly agree; 3 = agree; 2 = disagree; 1 = strongly disagree)	Mean	SD	Min.	Max.
The e-poster project enabled me to understand concepts beyond those which were discussed in lectures.	3.12	0.60	2	4
The e-poster project challenged me to apply my conceptual understanding of microbiology.	3.12	0.51	2	4
The e-poster project facilitated the connection between lectures, tutorials and laboratories.	3.07	0.53	2	4
The e-poster project encouraged me to investigate topics that were outside of those covered in lectures, tutorials and laboratories.	3.23	0.60	2	4
The e-poster project helped me to learn to work in a group environment.	3.31	0.59	2	4
The e-poster project helped me to learn how to problem-solve.	2.84	0.62	1	4
The e-poster project helped me to understand the process of scientific inquiry.	3.04	0.49	2	4
The e-poster project prompted me to think about my learning.	2.94	0.66	1	4
The e-poster project enabled me to learn from my peers.	3.29	0.60	2	4
The e-poster is a learning tool.	3.26	0.56	1	4

Future work

The *WebCT* discussion postings (>15,000) and e-posters together represent a significant resource for analysing the students' cognitive and affective learning. We and others have found detailed analysis of online postings to be valuable in determining whether and how student learning is enhanced through specific contexts (Hazel et al. 1996; Takayama 2005; Treleaven 2003). We are in the process of developing specific rubrics for the analysis of: i) the *WebCT* postings, ii) the e-posters, and iii) the focus group interviews in order to identify the specific ways in which students have learned about the scientific inquiry process and the specific areas that need to be strengthened.

The following excerpt from one group's final e-poster provides anecdotal evidence that we are moving in the right direction; it is our goal to continue improving our model.

> ... We have gained an unbelievably in-depth understanding of the methodology involved from strategic planning, constant modification, and the execution of procedures. The need to adopt a flexible experimental protocol was realised at an early stage of the investigation to accommodate further structural changes ... What we have learned from other groups has been undeniably valuable for our own improvements. Our group has grown to realise the significance of team work in overcoming difficult challenges, both in the laboratory, and in the collaboration on the E-posters. We set uncompromisingly high standards for ourselves and this is reflected in our commitment and enthusiasm to this investigation. While there is some disagreement between group members in differing perspectives and ideologies, we believe that we have learned tremendously from each other as a result of the dynamics and the interactivity of the group over the course of this insightful experience. The camaraderie and sharing of knowledge gained are characteristics of our group, which we value highly.

Appendices
Available at http://science.uniserve.edu.au/pubs/procs/2005/takayama/appendices.pdf

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References
Biggs, J.B. (1996) Enhancing teaching through constructive alignment. *Higher Education*, **32**, 347-364.

Billington, H. (1997) Poster presentation and peer assessment: novel forms of evaluation and assessment. *Journal of Biological Education*, **31**(3), 218-220.

Chinn, C.A. and Malhotra, B.A. (2002) Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education*, **86**(2), 175-218.

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R., Gentile, J., Lauffer, S., Stewart, J., Tilghman, S.M. and Wood, W.B. (2004) Scientific teaching. *Science*, **304**, 521-522.

Hazel, E., Prosser, M., and Trigwell, M. (1996) Student learning of biology concepts in different university contexts. *Different Approaches: Theory and Practice in Higher Education, Proceedings HERDSA Conference, Perth, Western Australia, 8 –12 July*.

Herrington, J. and Herrington, A. (1998) Authentic assessment and multimedia: how university students respond to a model of authentic assessment. *Higher Education Research and Development*, **17**(3), 305-322.

Kolb, D.A. (1984) *Experiential Learning: Experience as the Source of Learning and Development*. New Jersey: Prentice-Hall.

Meyer, C.A. (1992) What's the difference between authentic and performance assessment? *Educational Leadership*, **49**, 39-40.

National Research Council (2003) *BIO2010: Transforming Undergraduate Education for Future Research Biologists*. Washington, DC: National Academies of Science.

Ramsden, P. (1992) *Learning to teach in higher education*. London: Routledge Press.

Takayama, K. (2005) Visualizing the science of genomics. In J.K. Gilbert (Ed.) *Visualization in Science Education*. Dordrecht: Kluwer Academic Publishers.

Treleaven, L. (2003) Evaluating a communicative model for web-mediated collaborative learning and design. Australian *Journal of Educational Technology*, **19**, 100-117.