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ABSTRACT

The authors developed a collaborative learning environment (CLE) as a student-centered approach to assist students' understanding of difficult scientific concepts. Computer-facilitated investigative group projects were designed to enhance students' communication and reasoning skills, peer-learning, and peer-teaching. Projects were structured around cost-efficient Web-delivered tasks incorporating re-usable interactive Web components that store student responses in a server database (OCCA, or Online Courseware Component Architecture). These provide for group discussion, self-assessment, and peer review. Student submissions were accumulated in a portfolio to enable them to reflect on their learning. "Facilitutors" contribute to timely feedback using efficient templates for reviewing and annotating student work. Students work in groups (3 per computer) for 4 to 6 hours on their project within scheduled weekly CLE classes of 40 students with one facilitutor (repeated 8 times). Successful attributes of these tasks are described and evaluated, including strengths of on-campus collaborative learning and appropriate training of "facilitutors." (Author/AEF)

Learning of key scientific concepts in a web-based on-campus collaborative learning environment.

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Abstract: We developed a collaborative learning environment (CLE) as a student-centred approach to assist students' understanding of difficult scientific concepts. Computer-facilitated investigative group projects were designed to enhance students' communication and reasoning skills, peer-learning and peer-teaching. Projects were structured around cost-efficient web-delivered tasks. incorporating re-usable interactive web components that store student responses in a server database (OCCA - On-line Courseware Component Architecture). These provide for group discussion, self-assessment and peer review. Student submissions were accumulated in a portfolio to enable them to reflect on their learning. 'Facilitutors' contribute to timely feedback using efficient templates for reviewing and annotating student work. Students work in groups (three per computer) for 4-6 hours on their project within scheduled weekly CLE classes of 40 students with one 'facilitutor' (repeated 8 times). Successful attributes of these tasks are described and evaluated, including strengths of on-campus collaborative learning and appropriate training of 'facilitutors'.

1. Background

The need for intervention in our approaches to teaching

Previous attempts to introduce critical reasoning skills into the curriculum has been attempted at several levels of our teaching program. The need for intervention was shown at many levels,:

Graduates: Our research supervisors have reported that our graduate science students are good at reading, understanding and collating information, but are notably weak in identifying, documenting and articulating key issues. Employers told us that our university's graduates need better communications skills (McInnis 2000).

Hons year: Four years ago we introduced a task for which students had to identify information in their literature survey that was seminal, novel, controversial or not confirmed. They needed to be able to justify their selection with a short reasoned and critical synopsis of the material. Students are still unable to complete this task effectively

3rd year: Two years ago we introduced a paper-based sequence of exercises on original articles with 50 students, in groups of 5. Scheduled collaborative assignments replaced 10 lectures. Student responses were very positive indicating that they thought it effectively improved their reading and writing skills, although they found it challenging. This format was very staff intensive and assessors still found deficiencies in students' ability to identify key concepts and to negotiate within a group.

Information from a 3rd Year Trial for 55 students in 1998:

This study clearly showed a student desire to improve their capabilities to interpret and communicate physiological information and communication skills. Students worked in groups of 5 on a topic covered by three original published manuscripts. They then followed the same schema as in Fig 1 shown below for this project, except that they had considerable staff and postgraduate assistance within the scheduled times and gave an oral presentation on their findings: dealing with key concepts, assumptions and the validity of the conclusions.

Outcomes: Students' indicated that the task introduced was challenging, and that they valued using methods of learning that were unfamiliar to them. The assignments still showed that students had difficulty in identifying key concepts and communicating ideas within their working group –even though they had significant individual and small group assistance.

These basic skills are integral to the successful learning of even our most basic courses and underpin the integration of the material covered in the three separate teaching approaches of our courses: lectures, practical classes and computer-assisted learning sessions.

The trial demonstrated the need to develop an additional element for our electronic deliverable teaching strategy to support this initiative. The objective was not introduce it as a separate skill, but to incorporate it as one of our basic approaches to student learning embedding it within overall teaching framework. Such an innovation sat well with the overall course, since electronic and online strategies already underpin all our teaching formats (lectures, practical classes and computer-aided learning).

Electronic Teaching Approaches in Physiology
Scheduled computer-aided learning (CAL) sessions were introduced into Introductory Physiology in 1997 as part of an ongoing strategy of decreasing lectures (from 4 to 3 per week) and increasing self paced learning (2 hour CAL sessions were introduced, (Kemm et al, 2000b).

This initiative was directed to help students with their individual self-paced learning, to be more perceptive about their approaches to reading ie. be analytical about what is presented so as to eventually reflect and make judgements about content and conclusions. Small groups were used to expose students to different views and interpretations from which they could resolve their differences and develop a "consensus" point of view. It was simply not feasible to run this innovation as a paper-based study with direct tutor involvement for up to 360 students in Introductory Physiology. - (see below)

2. Aims and Intended Outcomes of the Physiology Small Group Project

The development of a small group project, in which computers are used for presenting the problem, providing interactive feedback and also for peer to peer communication is an important element of our current computer facilitated collaborative learning environment.

Aims:

?? To introduce graded weekly tasks into Science Teaching using a Web-based learning structure to further transform our teaching.
?? To assist students to better recognise, understand and communicate key scientific concepts.
?? To extend existing software developed in collaboration with the University Multimedia Education Unit..
?? To build in students a strong skills base, thus preparing students for more difficult tasks in later years.

Our graduates would then have a good appreciation of the professional skills required as graduates (e.g. ability to identify key issues, critical understanding and review of scientific literature, team work, report and grant writing, symposia presentations).

The planned outcomes and benefits were for students to:

?? appreciate the words used to describe a scientific phenomenon,
?? appreciate the accuracy of the descriptions
?? identify key concepts underlying the explanations of physiological processes,
?? write with clarity and with the precision required for scientific disciplines,
?? develop the individual and team skills (and confidence) required for analysing scientific information from published sources and from peers,
?? develop a portfolio of their learning activities permitting them to reflect and revise.

<u>*Integration within a course*</u>. This program would take the students through the process of in-depth learning using one of the subject modules in the physiology curriculum for that semester. This skill is essential for developing their ability to critically read and question the Physiology in their final undergraduate and Honours years.
In particular, the project was designed to enhance our final year teaching that involves greater emphasis on group work, assignments and student presentations. Presently students are poorly prepared for these tasks. This electronic resource will be an ongoing development extended to different areas of physiology.

3. Description of the Initiative

Overview of the student activities:
Small groups of students were guided using electronic help through a graded reading task to identify and rank key concepts in a fundamental area of physiology (Hooper 1992). Web-based interactive-help was used to progressively reveal issues for consideration and to assist in the groups' identification and ranking of the key concepts underlying the problem. They were given a collaborative writing task to draft a concise treatment of the problem (500 words max.). Peer review assisted them in generating good writing structures, essential for effective scientific communication. Students undertook a series of tasks over several weeks as shown in the schematic in Figure 1. Although the duration of the project has been shortened in response to student evaluation, the essential features remain as in this first implementation.

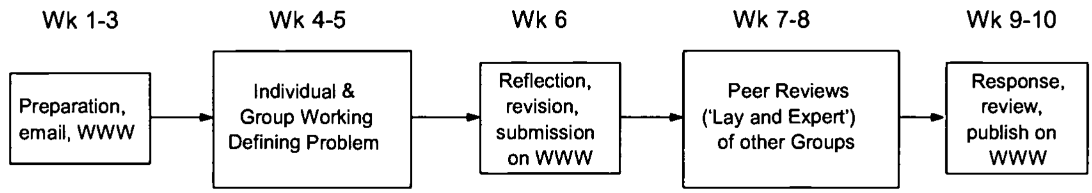

Figure 1.

Delivery of the Project:
The first implementation in 1999 used a proprietary learning framework, 'Top Class', to organise the web pages and to provide messaging between student groups and to/from the 'facilitutor'. (The term facilitutor seems appropriate to describe a tutor facilitating the collaboration amongst group members within a large class, assisted by a computer program). However students found the messaging system in 'Top Class' did not suit their purposes in this project and this framework did not allow us to provide the forms of feedback that we considered desirable.

In 2000, students undertook Group projects in both Semester 1 and 2. The rest of the report will discuss these implementations which were structured around cost-efficient web-delivered tasks that incorporated re-usable interactive web components which stored student responses in a server database. This is OCCA - On-line Courseware Component Architecture, described earlier (Fritze et al, 2000) and in another report at this conference, (Kavnoudias, Fritze et al, 2001). These components also provided opportunities for group discussion, self-assessment, reflection on learning and peer review. 'Facilitutors' were then able to contribute timely feedback using efficient templates for reviewing and annotating student work.

Students (360) originally worked in groups of 3-6 with a computer in 1999, but now groups of 3 are preferred after student surveys and evaluation of group dynamics showed that large groups had significant problems in sharing workloads. The classes of 40 are repeated several times each week, in a collaborative learning laboratory with 15 computers. Although the project is cross-platform, we chose iMacs because of their reliability and ease of use in delivering computer assisted learning classes.

Students worked on their semester projects in the last 30 minutes of the 2 hours of scheduled weekly collaborative computer assisted learning sessions, described in Kemm et al, 2000a It was not an optional activity and counted towards student's final assessment in the respective semester long courses. Assessment was based in participation, collaboration and effective use of the processes and less on the quality of the final submission.

Appearance to the students:
Student groups organised their own members and registered themselves on the project Web site. Each week, activities presented on the different Web pages posted corresponding records to the OCCA database for that group. Web pages could contain interactive objects and references to stored records that were dynamically updated on delivery. Each student group was provided with one of four real-world problems to work on.
Problems in Semester 1 were introductory, dealing with simple concept analysis.
Problems in Semester 2 used the same process on a shorter time scale, but with more complex and topical issues. (e.g. " What are the physiological effects of human growth hormone and why would Olympic organisors consider its administration to be performance enhancing?)

Students' activities involve preparation of material in their workbook combined with progressively submitting their work on Web pages.

The first week task: was performed individually by students reading around the topic to see what were perceived as the crucial issues. They submitted this by email to their 'facilitutor' and also had it available to share with the other members of the group in the following week.

The second week tasks illustrate activities that students might expect to undertake in the project over several weeks.

?? Brainstorm around the issues and write and submit several sentences that covered what the group thought was important. They could progressively review their work and add sentences, but once submitted they could not be modified.

?? Identify what they thought were the key phrases (or keywords) using their first writings which were made available on a new web page

?? Prioritise these key phrases by dragging them up and down their list.

?? Report on the level of consensus in their group decisions

?? Classify whether each of the listed items was of major or minor importance

?? Indicate how confident they were that their efforts addressed the problem.

The essence of the subsequent weeks' activities was for students to:

?? Learn to appreciate and interpret physiological information and to communicate effectively within a collaborative peer learning environment.

?? Use web-based interactive help that progressively revealed issues for consideration that students could consider in their later drafts.

?? Reflect and review their own work using guidelines provided. This was important to stress the importance of the various processes they undertook if they were to be confident with the quality of their work to submit it for peer review by another group.

?? Review the work of peers using several suggested criteria and justifying each of their ratings.

?? Respond to their peer reviewers' comments, professionally and without emotion, and change their final submission if it was warranted.

The students work was progressively stored in their groups learning portfolio. Additionally, electronic communication was used to exchange information amongst student group members, 'facilitutors' and academics responsible for the project's development.

Appearance to Staff

Various Web page templates were used to give assessors appropriate views that:

?? Summarised each group's activities in a particular week

?? Showed a group's final submissions, the peer review, and their responses to the review

?? Provided views that compared different groups' approaches to specific tasks

'Facilitutors' could use entry boxes on these templates to provide simplified and timely feedback to students on their progression through the problem. Such feedback was saved as records in the database and made visible on appropriate pages accessed by the group. Thus relative assessment of group activities was continual and seamless within the scaffolding, being made easier by being able to scan all class responses for an issue on one template page. The summary templates were also crucial in the final assessment by supervising staff, who were able to bring together the students efforts, together with the 'facilitutors' reports and ranking of each group.

4. Approaches to Evaluation:

General Approach:

A number of evaluation strategies have been used to collect data in 1998, 1999 and 2000. These are part of our overall action research strategy for dealing with global learning outcomes from collaborative computer assisted learning and focussed evaluation of additional standalone learning modules. -

We required human ethics approval for our surveys and logging of student activities in the computer tutorials, since we wanted to be able to correlate individual student's responses to several questionnaires, their exam results, as well as their 'facilitutors' comments and assessments. Such approval required a student's enrolment number to be replaced by a randomised 'research number', with original records identifying students stored in a secure location and only available under strict guidelines to researchers who were not examiners.

Student Questionnaires
Questionnaires specific to the CLE were used to survey students' attitudes to various aspects of the CAL tutorials and the CLE sessions, in consultation with our educational advisors. These instruments were developed in consultation with out educational advisors.

The student questionnaires had approximately 80 questions designed to reveal students' attitudes and use of the CLE, covering aspects such their pattern of work with the CLE, development of independent learning skills, relevance of the CLE to their learning compared with lectures, and their attitudes to group work. Approximately half the questions focussed on issues pertinent to the Group Project. Most questions required students to rank their responses on a 5-point scale, supplemented by several open-ended questions. In addition we investigated students' self-assessment of their approaches to learning. We used a modified study process questionnaire to extend the investigation of deep, achieving and surface learning-approaches (Biggs, 1987) so it included additional learner characteristics. Its use is discussed in application to one of standalone interactive tutorials (Kemm et al, 1997) and will be correlated here with other evaluations. We found that students cooperate well with questionnaires and interviews if they are fully informed about their purpose and that the results have been acted upon each year.

'Facilitutors' play a key role in the implementation of the program so their impressions of the course are most relevant to understanding student reactions. They made observations and kept records of students' work and participation in the CLE sessions. Formative evaluation continued throughout with regular formal meetings between the main developer and tutors, as well as many informal interactions amongst the students, tutors and the academic developers whose nearby location enabled and encouraged this latter process. In the recent semester, we provided additional training for tutors to be able to better facilitate group learning processes and make better judgements about students' contributions.

5. Results

The highlights of the questionnaire responses in Semester 2, 2000, with numerical data being on a scale of 5 - with 3 being a neutral response, are as follows: students rated ease of use and feedback on the OCCA-based web pages highly (>3.9). They were neutral/disagreed that the project was a waste or time (2.8). They rated group work as useful, enjoyable and an important part of their development (>3.5). They did not think that the group project increased their knowledge much, but this single exercise was not designed for that purpose. In open-ended questions, most important comments emphasised working with people and discussing problems, researching and clarifying issues. Many students (45%) thought that they should be left alone as they already had the required scientific reading and concise reporting skills, although a formative assessment assignment and exam answers show that they are misled about their own abilities.

As a formative assessment assignment, a written short one hour test for the students was individually given as an open book assignment that required them to transfer these skills to a separate task. It required students to follow exactly the same format as they had undertaken collectively in their group. Only those students who went through the same process they learned in the group project were able to write concise answers. Many students wrote their answers directly and submitted answers that were either too long or made the tight word limit by writing generalities with little scientific content.

As an initial summative evaluation approach, we compared the examination outcomes for second year Science Physiology across 4 semesters. The "Exam result" excludes all collaborative computer aided learning assessments and is proportioned as 60% toward written answers and 40% multiple choice questions (MCQ). The student cohort was divided into high-achieving students (First year Faculty score ? 75), low-achieving students (First year Faculty score ?60), and those in between (61-74). Each group was further divided into whether students made an effort or not at their collaborative learning (? 7.0). Analysis of the data showed that collaborative learning assists students achieve significantly higher examination outcomes in the written component, but did not change the MCQ component. These results were markedly higher for all groups but the low achievers (eg 70 vs 63 for high achievers group). However, this improvement cannot be ascribed to any particular attribute of the collaborative learning environment that provides many learning opportunities.

We then analysed student results, investigating if any of our collaborative learning (CL) approaches correlated with the results of students who markedly improved their result over first year. Students were divided into *improvers*, *disappointers* and *remainder* groups. Data showed that *improvers* obtained a better CL mark. *Improvers* student cohort primarily improved their scores in questions requiring writing responses. (43 vs 34 for questions requiring written responses for the *improvers* group compared with the total student cohort).

The improved writing ability of the *improvers group* correlated only with a high score (>3.5/5) in the group project. Students performing well in the group project also did marginally better in the MCQ component of the assessment. Data indicate that those students who undertook the group project and did well, may obtain improved examination outcomes, especially to written answer questions. A good group project result however did not guarantee an improvement, but certainly the very large majority of the *disappointers* group did poorly in their written answers and they also performed poorly in the group project.

6. Discussion

The use of a customisable learning environment based on OCCA has given us significant advantages in producing some of our desired learning outcomes compared with our previous efforts to use a high level learning framework that had restricted flexibility. Generating structured collaborative exercises adds value to any high level framework, such as WebCT, while allowing academics to produce effective student-centred learning environments without specialist programmers.

The process of reasoning that has been introduced in this group project work is a first step in developing the training of critical thinking science graduates (with skills in analysis, criticism, aware of different views and with skills to manage those differences – both personally and as a consensus document). There remain some concerns that students have not been able to transfer these skills to other contexts. This issue will be addressed in 2001.

Once our collaborative learning environment is fully implemented, with strengthening of students' ability to extract and understand physiological concepts by group projects, it is envisaged that more factual material would be taught in a structured student-centred collaborative self-paced learning environment with less emphasis on lecture material..

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