A COMPUTER-BASED LEARNING PACKAGE FOR TEACHING BIOINFORMATICS

This work was part funded by the Centre for Bioscience's Teaching Development Fund and this article is taken from: Computer Simulations Improve University Instructional Laboratories, Nicola J. Gibbons, Chris Evans, Annette Payne, Kavita Shah and Darren K. Griffin.

Cell Biology Education Articles, Volume 3 Winter 2004
http://www.cellbioed.org/article.cfm?ArticleID=130

DESCRIPTION OF STUDY

Laboratory classes are a feature of most degree programs in university biological science departments. Indeed they are considered an essential part of most biological degrees, particularly for those students wanting to continue their careers in science. They can, however, be cumbersome and unreliable in producing the required data that, in turn, places a drain on staff time and resources. Coupled with the increasing number of students admitted to universities, this can put a great amount of pressure on department budgets.

Computer-based simulations of student practical classes ("virtual laboratories") can provide a cheaper and time-saving alternative to traditional practical classes. In this study, we test the hypothesis that, in certain situations, computer simulations can provide an improvement in student learning compared with real, or traditional, laboratory classes. For the purposes of this study, improvement is measured objectively either as a decrease in the time taken for students to study to a given level of performance (efficiency) or by an increase in the marks they achieve in assessment (effectiveness). To test this hypothesis, a simulation in bioinformatics (genome analysis) was developed and tested. Skills that students need to develop included accessing existing Human Genome Mapping Project databases and answering a variety of biological questions directly at the computer terminal.

Traditionally these classes are taught by didactic lectures and practical computer laboratories. A tutor would take the class through each stage in selected examples. In this study, we test the hypothesis that students learn more effectively in a bioinformatics class that involves a set of computer-based lectures and computer simulations of database navigation compared with the traditional approach.

The virtual laboratory for bioinformatics was written in 'authorware'. In this case the virtual laboratory consisted of 'virtual lectures' (Evans and Fan, 2002) on the subject material (which included the use of NCBI and NIX databases), followed by an exercise in genome database searching. The exercise involved a simulation of the appropriate databases with relevant instruction of how to perform a series of example operations (e.g., searching for the alkaline phosphatase gene).

This compares with the traditional approach in which students are given an oral lecture by the tutor and then asked to perform the same exercise on the real databases overseen by the tutor. Specifically, students were given instructions on how to perform the various analyses and how to identify CpG islands, definitions of specific terms such as STS and clones, and the use of different NCBI databases such as Map Viewer, Locus Link, and Unigene.

In both 'real' and 'virtual' modes, the subject matter was the same. The use of a simulation of a database rather than a real database has the advantage that it is possible to trap mistakes made by the student before the consequences have a drastic effect on the whole experiment. This is much like the early spotting of a mistake in the use of physical equipment in a real laboratory. In this study, a cohort of level-two undergraduates in the Department of Biological Sciences at Brunel University were recruited. These students were randomly assigned into one of two test groups (A and B). The bioinformatics teaching material and exercises were divided into two topics (1 and 2). In this case the time taken was roughly the same for both real and virtual exercises. That is, the students were given one hour to complete each of the virtual lectures and a three-hour session for each of the practical exercises.

ASSESSMENT MARKS

A total of 30 students took part. Topic 1 was studied and assessed one week before topic 2. The number of students in each group and their mean marks are given in Table 1. Collapsing the groups (and removing students who did not take both tests for direct comparisons on the same students) gives a mean score of 59.5% for students doing the virtual lectures and simulation and 58.0% for students receiving a real lecture and traditional laboratory session. However this difference is not statistically significant (paired samples t-test, $t(24) = 0.25$, one-tailed $p = 0.40$). Results are similar if the three students who took topic 2 but not topic 1 are included.

The experimental design allows for a possible interaction between the topic studied and the delivery (real or virtual); therefore, we should also consider the uncollapsed results.

Table 1. Assessment marks for Bioinformatics module

Topic	Topic 1		Topic 2	
Group/delivery	Group A (virtual)	Group B (real)	Group A (real)	Group B (virtual)
N	13	14	16	14
Mean	53.0%	45.6%	69.7%	59.7%
Standard deviation	10.6	10.9	23.7	27.6

For topic 1, the mean score was 7.4% higher in the virtual mode compared with the real mode. This result is statistically significant (unpaired samples t-test, $t(25) = 1.78$, one-tailed $p = 0.04$)

For topic 2, by contrast, the mean score was 9.9% lower in the virtual mode compared with the real mode. This result is not, however, statistically significant (unpaired samples t-test, $t(28) = 1.04$, one-tailed $p = 0.15$).

The study indicates that, in certain circumstances, virtual laboratories can improve the performance of students in assessment (by over 7% for topic 1). Thus virtual laboratories can be significantly more effective learning mechanisms than real ones in this subject area also. This result appears to be, however, dependent on the nature of the material presented because topic 2 showed no significant difference in student marks. The reader will note that the mean marks for topic 1 were substantially lower than for topic 2 (by 15%). One possible interpretation of this is that the subject matter of topic 1 was harder to learn than that of topic 2. This is consistent with the subjective evaluation of the subject material made by most bioinformatics lecturers. This would suggest that the benefits of virtual laboratories are greatest when the level of difficulty of the material is not too low. This is consistent with studies that have indicated that multimedia and computer-based learning are most effective when the media is presented to learners with low prior knowledge or aptitude (Najjar, 1996), although these attribute their results to the knowledge of the students rather than level of the material. Another explanation of course is that the exploration of topic 1 provided the students with the skills that enabled them to perform better on topic 2.

This study investigated the effect of short-term learning but did not address the issue of whether learning practical exercises via multimedia reinforces long-term student learning compared with traditional approaches. Previous research, however, suggests that computer-based packages show a significant improvement in both the short term and long term for deep learning, as shown with transfer tests (Mayer et al., 2003). To the best of our knowledge, the effect of multimedia-based approaches on long-term learning has yet to be tested in the context of simulations of student practical classes, and this will form the basis of future studies in our group.

Finally it is important to note that, although the main advantages of the use of virtual laboratories are for the students and their learning, there are also important benefits for lecturers. The time spent marking assessments can be almost eliminated by integrated computer assessment, and the time spent lecturing can be considerably reduced by the provision of virtual lectures.

We suggest that the results presented in this study provide evidence of the advantages of computer-based practical classes over traditional ones, at least in the subject areas presented. Combined with the advantages they offer in terms of flexibility in time, location, pace, and process, they can offer a potentially more efficient mode of teaching for lecturers and a more effective and efficient mode of learning for students. Further studies will establish examples of other practical class scenarios to which this pertains.

ACKNOWLEDGMENTS

The work for this paper was partially supported by a grant from the Learning and Teaching Development Unit at Brunel University and partially by the Brunel Enterprise Centre. Annette Payne was a recipient of a Teaching Development Fund grant from the Centre for Bioscience, The Higher Education Academy, UK. The work presented here was carried out under the auspices of the Virtual University Project at Brunel University. We are grateful to the staff of the clinical cytogenetics unit, University of Newcastle, for providing the chromosome images.

REFERENCES

Evans, C., and Fan, J. (2002) Lifelong learning through the Virtual University. *Journal of Campus Wide Information Systems*. 19(4), 127–134.

Najjar, L. (1996) Multimedia information and learning. *Journal of Educational Multimedia and Hypermedia 5* 129–150.

Mayer, R.E., Dow, G.T., and Mayer, S. (2003) Multimedia learning in an interactive self-explaining environment: what works best in the design of agent based microworlds? *Journal for Educational Psychology*. 95(4), 806–813.

Dr Annette Payne
Brunel University
annette.payne@brunel.ac.uk

DEPARTMENTAL TEACHING ENHANCEMENT SCHEME

This is a reminder that the deadline for applications is **31 March 2006**. The scheme provides bioscience schools and departments with the opportunity to bid for additional funds (up to £15,000) to develop and implement some aspect of practice that will lead to an improved learning experience for students in their department. Collaborative projects across departments/institutions are very welcome. Project funds must be used to effect change across entire department(s) rather than within a single module or one individual's teaching practice.

Further details: *http://www.bioscience.heacademy.ac.uk/opportunities/deptgrant.htm*