Enhancing student learning using Decision Support Tools across the curriculum

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Abstract

A sophisticated commercially available computer Decision Support Tool, *GrassGro*, has been integrated into the curriculum to enhance teaching and learning at The University of New England (UNE). This computer program permits the simulation of the climate-soil-pasture-animal-economic interactions within grazed ecosystems over long time frames in Australia. This innovation was developed under a national CUTSD-funded (Committee for University Teaching and Staff Development) project called the *GrassGro* Teaching Project (1999 2001).

The *GrassGro* software was adapted from a stand-alone application to one which is now implemented through a central server to provide for the efficient control of the software and to maximise its availability. In this way, access privileges are provided for trained staff and all students enrolled in units using the software. A total of 15 teaching staff have been trained by CSIRO in the use of *GrassGro* and modules have been developed for teaching in 16 complementary teaching units. The software can now be served out 'live' over the Internet, allowing for much broader interest and usage of such Decision Support Tools in education.

Evaluations of student and staff responses have been, and continue to be, carried out. In spite of the relatively limited exposure to this software by the time of their examination, a cohort of senior students in 2000 were found to have a somewhat greater level of understanding of complex ecosystem interactions than their counterparts in 1999, presumably due to their exposure to this project.

Surveys of staff and students were also carried out to determine in what ways the project was succeeding and to identify areas requiring improvement. The first surveys in 2000 found a generally positive response. In response to changes made based on findings in 2000, results in 2001 showed a further improvement in the level of positive response to 26 out of the 29 questions.

Those teachers who had used the software for teaching, reported favourably on its use and especially on its ability to engage students in active learning. Students also reported a substantial

level of interest and desire to learn more from the use of simulations. In spite of students' limited experience with the software to date, the survey results have confirmed the encouragement of problem solving, active learning, engagement, building on prior learning and skill development. The approach has been shown to possess many desirable attributes for enhancing student learning including a capacity to: engage and motivate students, provide realistic and interesting scenarios, be suited to experiential learning, create meaning, and enable self-directed and peer-directed learning.

Aims

Two educational goals were addressed in this project:

1. The software aimed to provide a platform for effective teaching of complex biophysical systems which reinforces more basic disciplinary teaching and thereby aims to improve student learning and facilitate improved teaching and collaboration among teachers.
2. To provide a consistent learning tool which facilitates students developing an understanding of principles and the conceptual links between disciplinary units.

Rationale

Lowe (2000) has stated that 'Much University education in technical areas is fundamentally inadequate ... It is still based on the out-dated model of transmission of a fixed body of knowledge, and so doesn't prepare graduates for the real world of rapid change'. This project has addressed this need by adopting new and relevant computer aided experiences which are effective and also highly relevant to the workplace.

Historically, a number of applied science and management degrees at UNE (like many other tertiary institutions) have introduced students to basic science and management theory and detailed mechanisms of plant, animal and ecosystem function and management. Often the units in years 1-3 have been taught somewhat in isolation with little explicit recognition of links that exist with other units and discipline areas.

As part of a teaching strategy for the applied degrees (BAgr, BRurSc, BNatRes, BEnvSc, BAgEc) this teaching platform was developed to provide links familiar to the students within and between years of the degrees to allow students to develop an understanding of the relationships between the fine detail and the 'big picture'. Such characteristics are indicative of critical thinkers and of higher level learning.

Prior to this project, individual academics teaching units throughout the School of Rural Science and Natural Resources have used a wide range of computer models and decision support systems to enhance the learning of students. Typically, the models which are available for students to interact with, have been relatively simple and cheap to purchase and therefore are not commercially significant. Also, the use of these computer aids to date has been somewhat *ad hoc* and has not provided continuity across years or between units. However the present approach facilitates at least three aspects of teaching:

a. *Links between models and teaching*. Parts of the scientific basis of the model are used as examples of principles in appropriate teaching units. By making relevant components of the model available for students as inter-related modules, they can be used to reinforce concepts in units in years 1-3 whilst a familiar platform for subsequent learning is also established.
b. *Improving the computer literacy of graduates*. This is a national priority (DETYA, now DEST, Department of Education, Science and Training); graduates in the natural resources and rural science areas are no exception. The availability of fast computing now provides a teaching medium which enables teachers to present credible evidence of the importance of interactions between a large array of factors associated with the management of natural and managed ecosystems.
c. *Need for understanding of systems*. An understanding and appreciation of the complex interactions among climate, soils, plants, livestock, markets and risk in managed and natural ecosystems is a challenging task to convey to students. This understanding is necessary in today's world, where decisions about natural resource management and agricultural production are increasingly intertwined and the implications of mismanagement can be loss of sustainable resources or production.

Description of the innovation

The use of a sophisticated computer Decision Support Tool, *GrassGro*, allows the provision of predictive outcomes (both biological and economic) from agricultural systems in a wide diversity of environments (potentially worldwide). *GrassGro* is a commercial Decision Support System (DSS), compiled by CSIRO and licensed to Horizon Agriculture Pty Ltd, that has been made available under license to UNE to incorporate into the teaching curriculum.

Figures 1 and 2 below show two screen grabs of an input and an output screen from the *GrassGro* software.

This software provides an almost infinite range of management choices to explore and is based upon an extensive published scientific knowledge base. The paper by Moore, Donnelly and Freer (1997) describing *GrassGro* and its antecedent publications directs teachers to a rich source of published literature from which to draw principles and concepts. The use of the program achieves a goal articulated by Biggs (1999) that 'University teachers should get students to tackle real non-textbook problems, as this is what they are being trained for'.

Improving student learning

The key to the improvement of student understanding by the use of *GrassGro* is the demonstrable relevance and the credibility of the simulated outcomes brought about by: i) better linkage with theory from lectures (or external teaching material); ii) the availability of the software to allow students to work through detailed scenarios in their own time; and iii) showing detailed outputs from the scenarios (*GrassGro* currently allows 49 graphical views of various parts of simulated systems).

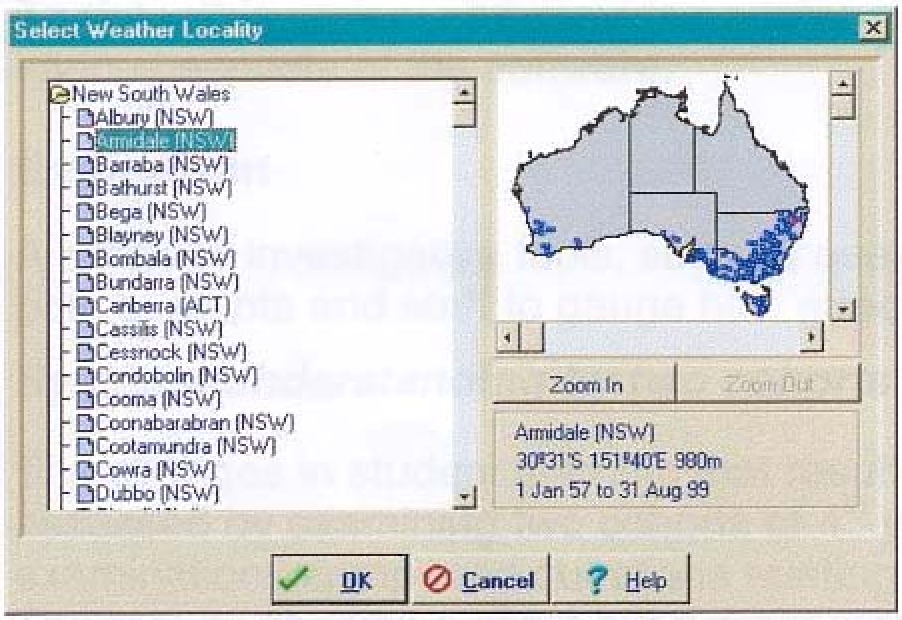

Figure 1. Location selector in *GrassGro* enabling selection of numerous sites throughout southern Australia for simulations

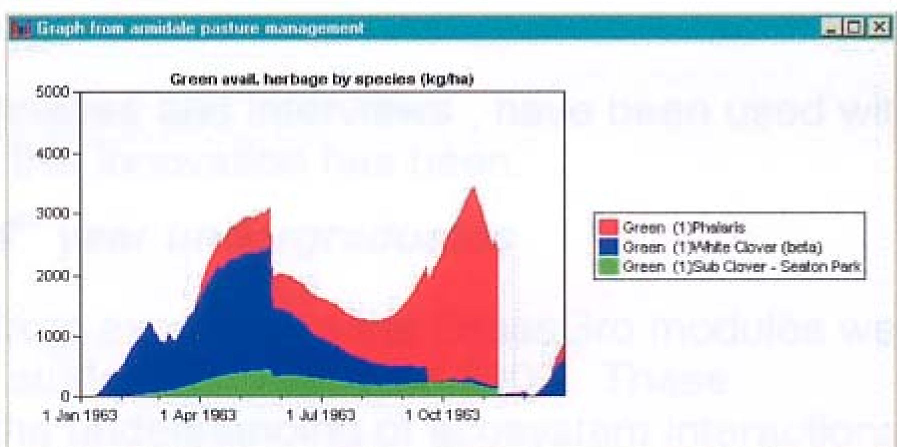

Figure 2. One of 49 possible output graphs from *GrassGro* showing the changes in available green herbage from three pasture species over a particular year for one location

To date the program has been used in practical components of 15 units including: first year units in 'Agriculture, Natural Resources and the Environment'; second year units in 'Ecology and Adaptation of Agricultural Plants', 'Animal Metabolism, Digestion and Nutrition', 'Principles of Ecology' and 'Farm and Resource Management'; third year units including 'Plant Protection', 'Crop and Pasture Management for Sustainable Agriculture', 'Animal Production Systems and Products', 'Animal Function, Health and Welfare', and 'Applied Animal Nutrition'; and fourth year units in 'Problem Solving in Farm Systems', 'Constraints to Animal Production', and

'Sustainable Land Management'. The range of learning goals adopted in each of these units has been provided in Daily et al. (2000).

Computing details and initialisation files

Control over aspects of running the model are left in the hands of the lecturer who can edit various initialisation (.ini) files to suit their purposes. This has the twin benefits of maximising the flexibility of use by the lecturer and minimising the maintenance requirements on the software provider (i.e. only one version of the software needs to be updated).

In creating a teaching scenario, a lecturer constructs a *GrassGro* work file and an initialisation file which defines the locality, soil types, pasture species, enterprise, type of simulation, date range, number of paddocks, management, livestock, and costs and prices. Students can develop and save their own unique simulations and build on them over time.

Outcomes

The key achievements of this project include:

- the training of 15 academic staff in the software, and the development of an integrated and linked plan of teaching to ensure complementary approaches by different lecturers;
- the setting up of an NT-server on which a single copy of the *GrassGro* software has been installed for multiple authorised concurrent users, the writing of initialisation files to enable constraints on the simulation to be applied for particular classroom experiences, and enabling the use of computer laboratories for teaching sessions where at least 20 simulations can be run concurrently;
- the production of a *GrassGro* Portfolio to provide basic instruction and allow students to construct their own series of *GrassGro* experiences within a logical, explicit framework;
- specific learning modules have been developed for assisting with aspects of 16 separate units which are either core or elective units for the degrees of Agriculture, Rural Science, Natural Resources, Environmental Science and/or Agricultural and Resource Economics; and
- demonstrable evidence of enhancements to teaching quality and student engagement.

To date, this project has provided a total of some 2000 student experiences in the use of various aspects of the software.

Evaluation

A range of investigative tools, such as questionnaires and interviews (complete survey results and statistical analyses for the examinations conducted are available from the author), have been used with both students and staff to gauge how effective this innovation has been.

Systems understanding by two cohorts of 4th year undergraduates

The changes in student learning that resulted from exposure to the *GrassGro* modules were assessed by examining two cohorts of 4th year students in 1999 and 2000. These examinations comprised questions relating to the understanding of ecosystem interactions. The results showed a slight but nevertheless significant trend (P=0.086) towards a better understanding from 1999 (average mark 55.2%) to 2000 (average mark 63.8%) which may be attributable to the limited exposure these students had to *GrassGro* modules (up to 3) by this stage of implementation.

Surveys of students and teachers

Surveys of students and teachers were designed in part to elicit feedback relating to principles of good teaching and learning. For example, some questions were based on Chickering and Ehrmann's (2000) seven principles important in developing technology approaches to teaching and learning whilst others explored Kolb's (1984) components of experiential learning.

An example of student feedback is given by a cohort of students (mostly mature age) who undertook Agronomy 211 in 2000 and were given one practical experience using *GrassGro* (similar to the internal students) to demonstrate the differences in adaptation between annual and perennial pasture plants in two different environments. The answers to a survey found that 100% of students found the experience to be either good or very good. Comments included 'very exciting model' and 'would have liked more time to look at a real-life scenario of how model would fit into a farming system'.

A survey was administered to 4th year Agricultural Systems 410 students in October 2000 (who had mostly experienced only 2 to 3 modules of *GrassGro* by that time) and to 3rd year Agronomy 321 students in October 2001 (who had experienced up to 5 modules in *GrassGro*). The results showed that the 2001 class ranked 26 out of 29 questions higher than the 2000 class with an overall rise in the mean Likert scale (1-5) from 3.32 to 3.64, a substantial rise within one year. The three questions which had the highest rating related to the great potential students see for this software in their degrees, the fact that it permits exploration of different ways of learning and that it develops cooperation among students.

A survey of staff in late 2000 clearly indicated the great potential that exists for this project to reap substantial teaching/learning benefits. Among the benefits, the project was thought to be generally effective in delivering most of the seven principles of using technology suggested by Chickering and Ehrmann (2000).

There was considerable agreement that the project can meet, or is meeting, the four components of experiential learning suggested by Kolb (1984) of experience, conceptualisation, reflection and active experimentation.

The teachers saw great potential for integration between units and linking theory to practice and there was agreement that the use of the software allows students to build upon prior learning, to improve their skills and knowledge, and increase their understanding of concepts and problem solving.

Portfolio

The student survey conducted during 2000 alerted us to some shortcomings of understanding of the linkages between units. This prompted us to strengthen the integration between *GrassGro* modules by developing a *GrassGro* Portfolio which has been made available to each student. This was designed to assist students and teachers in making associations between discipline areas and includes relevant literature sources. The portfolio provides a record and reference point, and a framework for students to see how various disciplines link and build on one another. It supplies much of the 'mechanics' of *GrassGro* software use, freeing lecturer and practical time for the scientific objectives of the unit.

Teaching and learning context

One of the most notable features of the use of this Decision Support Tool in teaching has been the recognition, by students and teachers, that the *GrassGro* software effectively supports problem based learning. This is important as it is through problem based learning that students get to be actively engaged in the learning process (Biggs and Moore 1993).

As noted by (Ryan 1996) graduates need to be trained to solve ill-structured problems and it is for this reason that a problem based approach is desirable. The access to this packaged 'knowledge' in the *GrassGro* DSS is important in professional disciplines relying on substantive data (in this case the interaction between climate, soils, plants, animals and financial returns).

This project has resulted in increased motivation, integration and focus, depth of learning, student/teacher interaction, and development of critical thinking skills.

Information for other Australian universities regarding this project has been made available through the detailed final report to DETYA which has been sent to all tertiary institutions teaching agricultural and environmental science subjects and via a web portal available at The University of New England (http://www.une.edu.au/dss/).

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