

Final Report

e-Learning Case Study for ESD and Archaeology

A project funded by the Higher Education Academy

Summary

Based on the assertion that we can learn from past societies how human action can seriously impact on the environment, it was decided to create an e-Learning resource that demonstrates how this can be used to incorporate ESD (Education for Sustainable Development) into archaeology teaching. A web-delivered computer game is being developed that allows students to explore the relationship between environmental factors and human decision making for an early farm in the harsh environments of Iceland.

The request to make such a model as accurate and non-deterministic as possible meant that the development of the underlying ecological model was difficult and its conversion into a game complicated.

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Project Outline

The human past is full of examples whereby the actions of our ancestors had direct impact on their environment and on the future of their cultures. This is most prominently discussed in the best-selling book by Jared Diamond “*Collapse: How Societies Choose to Fail or Survive*” (2006). It is hence clear that issues of sustainability are already part of archaeology teaching, either when discussing past societies and their developments, or when looking at ecological issues under the auspices of ‘environmental archaeology’. It is the aim of this project to formalise these issues and develop an e-Learning tool that helps students in a ‘fun’ way to understand how sustainability has always been of importance to human well-being.

The project creates a model for embedding ESD explicitly into the curriculum. Rather than setting up new modules or attaching stand-alone ESD lectures, the project uses the structure and content of existing modules in Stages 1 and 2 of the Undergraduate programme, to build on students’ interests and blend ESD e-learning activities into their mainstream programme. The staff teaching team investigated how and where ESD links are currently being made and identified opportunities for enriching these aspects through this project. The material is based on existing modules related to the archaeological record of activities of past societies and their consequences for the environment and subsequent settlements. The particular example is the Viking settlement in Iceland and its anthropological impact on the environment. A computer game is created to demonstrate the impact of decisions about different parameters (e.g. requirement for food, population size, animal stocks) on the outcomes, such as land clearance, soil erosion, food production and related issues such as water supply.

Design Phase

Staff Input

The project coordinator (Dr Armin Schmidt) has taken on this role due to a keen interest in the promotion of e-Learning tools and the incorporation of ESD into the curriculum, and because of his experience in software development. However, he is not teaching modules in Environmental Archaeology, nor in World Archaeology, and relies on other colleagues to incorporate the outcome of this project into their teaching. Their close involvement from the outset was hence important.

Initial comments from them were very positive (“Looks very interesting”, “I really want to be involved with this”). However, in the Division’s Annual Teaching Day (6 November 2006) and the initial staff workshop (27 November 2006), two major concerns were presented.

- **Accuracy:** Any e-Learning tool, especially when used alongside other teaching materials, has to be based on current scientific results. Although some simplification may be acceptable, the representation of current scientific understanding has to be accurate. Given the high complexity of ecological models this is challenging for a computer game.
- **Non-Determinism:** Any teaching material that links human actions and environmental factors has to avoid environmental determinism.

These two issues are closely related. Most current lecturers have been educated under the auspices of postmodernism/post-processualism and although it is accepted that the action of humans has an influence on the environment, environmental factors are only seen as one of many possible reasons for human actions. ‘Environmental determinism’ in contrast refers to the view that actions of humans are mostly determined by their environment. It is therefore clear that a teaching tool that models people’s response to the environment has to do this at least according to sound scientific ecological research and has to avoid pseudo-scientific and oversimplified assumptions. The latter is a criticism sometimes brought forward against Diamond’s book (de Menocal *et al.* 2005).

Students' Input

A workshop with students was held on 12 December 2006 (see the transcript in Appendix 1) and after a brief outline of the project considerable student feedback was gained. Students immediately liked the idea of a game based on ecological relationships; they had discussed such relationships in a module shortly before and most had read Diamond's book. It was remarkable how many ecological and human factors were mentioned by the students that could be part of the game (*ibid.*). Their critical awareness of non-environmental issues (e.g. religion) was very high and students were certainly not prone to environmental determinism. In fact they showed a mature approach, which can be attributed to their personal level of intellectual understanding as well as the teaching and learning they experienced in the module 'Ecology and Bioarchaeology', taught by Andrew Jones.

Although this level of student awareness was heartening, as a consequence their expectations for the complexity of the implemented e-Learning tool was very high.

Background

Teaching of environmental archaeology in Bradford has a strong focus on the North Atlantic and it was hence suggested to base this e-Learning tool on two existing ecological models: *Búmodel* for Iceland and *Farmcompact* for Greenland.

- **Búmodel** was developed as a PhD project by Amanda Thomson under the supervision of Prof Ian Simpson, University of Stirling (Thomson 2003; Thomson & Simpson 2006). It is a modelling approach to farm management and vegetation degradation in pre-modern Iceland. Using an Excel spreadsheet as interface to Visual Basic code, it performs the modelling of vegetation cover based on the grazing pattern of sheep from one farm. The changing spatial distribution of the vegetation can subsequently be visualised in a GIS. The ecological relationships between various parameters were thoroughly researched and detailed in the PhD thesis. After requesting a copy of the model, it was made publicly available on the Internet http://www.sbes.stir.ac.uk/research/environmental_modelling/
- **Farmcompact** was developed by Prof Tom McGovern, City University of New York, since the 1980s and is now (Version 6) a very sophisticated set of interlinked Excel spreadsheets. It combines various roughly quantifiable factors affecting herding and community economic decisions on the scale of a community of 15-25 farms. The model is based on the Norse settlement in Greenland using archaeofaunal and architectural data available as of 1995. These data are used to provide examples for options under different levels of pasture productivity and animal stocking for farms of different scales ranging from the Episcopal 'super farm' to the tiny 'poor man's farm' like V48 (McGovern *et al.* 1988; McGovern 1995). The Information on http://xweb.geos.ed.ac.uk/~nabo/data_nabo.html is outdated and the mentioned SIMNORSE package does not seem to have been produced.

Both models are based on current anthropological observations and results from archaeological research to link environmental parameters with changes in livestock and vegetation.

The project coordinator is very grateful to the authors of these two models for having provided me with the relevant Excel spreadsheets.

The complexity of these models is high, being developed as a PhD project or over many years of research. Both require considerable computing power even for a single run and would be difficult to convert into code that can be used as a teaching tool delivered over the Internet as part of a Virtual Learning Environment (VLE).

Implementation

The project coordinator has been on Research Leave at the University of Melbourne (Australia) from February 2007 to September 2007, and from February 2008 to May 2008. Although this has made certain parts of the project more complicated (especially personal contact with staff and students at the University of Bradford), it also brought the benefit of meeting with new colleagues in Australia, who naturally have a very strong view on the interaction between

humans and their environment, and with some professionals involved in the development of multimedia teaching materials. The project coordinator is very grateful to the HEA for accommodating the delays related to these periods of Research Leave through extensions of the project deadline.

Ecological Model

When contrasting the request for accuracy in the representation of human-environment interactions in an e-Learning tool with the complexity of the available two ecological models (see above), their IT implementation and the way a game could be programmed, it became clear that the development of a simplified ecological model that is 'reasonably accurate' but can be implemented as a computer game is a major challenge. After a consultant was found to develop the computer game for the project (see below) discussions with him helped to clarify the level of complexity that could be implemented and visualised. Research into ecological modelling in general and into the two relevant models was subsequently conducted. As a result an ecological model was designed that retains various features of these models while simplifying others.

It was decided to start with Búmodel, as it is well documented in a thesis (Thomson 2003) and is based on a single farmstead in Iceland. Information about monthly temperatures, available biomass and other empirical data were extracted from the provided tables and Excel spreadsheets. Some of the functional relationships could also be used directly (e.g. annual hay yield), while others had to be simplified and some of the categories used had to be restricted in their parameter space (e.g. only four classes of land cover). The newly developed model allows to control the number of sheep grazing on the outfield as well as those fed in the byre of a farm in Iceland. Based on choices for the number of sheep in the field, in the byre and those being slaughtered, a monthly output of milk and meat is evaluated together with indications of overgrazing and resulting land loss. Random events of storms that remove soil from already overgrazed land and volcanic eruptions that destroy a month's grass crop introduce stochastic elements that make each run of the game different.

While the actions of the player (the farmer) affect the output of the ecological model (land cover, number of sheep, milk and meat production), these factors are not used to model any human behaviour (e.g. how much milk and meat is needed to maintain a family). There is hence no problem with environmental determinism.

In a future stage, the ecological model (and a game based on it) may be expanded to use the relationships in Farmcompact to link available land and food resources that are the results of the current model to the maintenance of a farmstead and hence produce a game that incorporates responses of the human population to the environment influenced by them. Based on results from the first students' workshop (see above) it is clear that this would be desirable, but the additional level of complexity would require considerable development work associated financial investment. Also the issue of environmental determinism has to be revisited.

Software Implementation

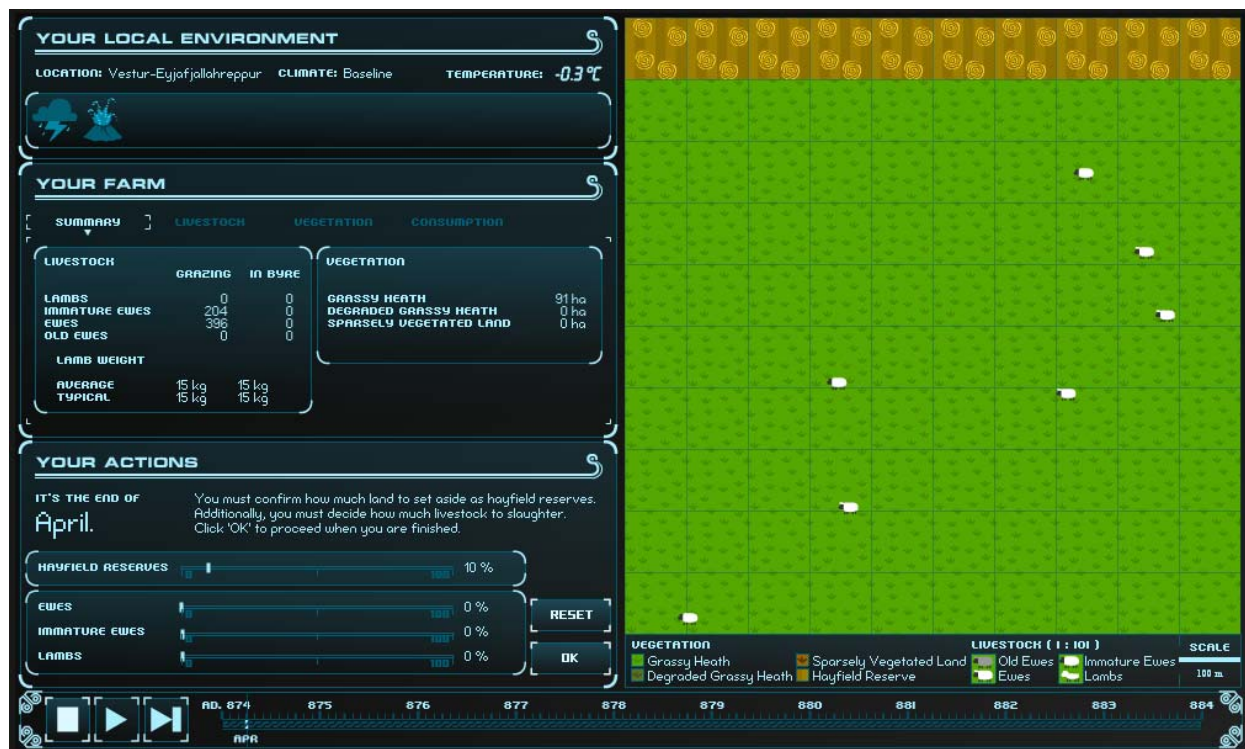
It was initially envisaged that the Multimedia Courseware Developer of the University of Bradford would programme the e-Learning tool. He had already successfully implemented another e-Learning resource for the Department of Archaeological Sciences, although this was far less complex, mainly based on if-then-else rules directly linked to user input. Unfortunately, the Multimedia Courseware Developer left the University before the completion of the ecological model. It hence became necessary to involve a consultant experienced in the development of multimedia courseware to deliver this part of the project. Through contacts at the University of Melbourne the small company *3wsonline Pty/Ltd*, Brisbane (Australia) was found and the development of the game was contracted to them. The project coordinator undertook to design the ecological model and help with its algorithmic implementation.

It was decided to create the game in two stages. First, a numerical-only version was created by the project coordinator that links the different parameters using the functional relationships of the ecological model. This allows the evaluation of the relationships, their algorithmic implementation and possible adjustment of parameters. Second, the relationships were used as the basis for a graphical visualisation that allows user interaction. The game can also be run

as a simulation with minimal user interaction and it is intended to modify it so that it can be an entirely non-interactive model. Given the randomised variables of the ecological model (see above) users can run the game several times, possibly with different start parameters, to evaluate outcomes based on these choices.

It was decided to use *Flash* animation programming to implement the computer game since this allows incorporation into web pages that can be delivered through the University's VLE (currently <http://www.brad.ac.uk/archsci/sustainability/>). An alternative solution would have been to use the free MIT software package *Scratch* (<http://scratch.mit.edu/>) that provides a relatively simple user interface for programming interactive multimedia content. However, there is no way to deliver the results directly over the Internet and a standalone installation of the software would be required on every user's machine. It would however allow students to expand the game using their own programming ideas. Given that this e-Learning resource is mainly intended for archaeology students, this positive aspect does not outweigh the problems of delivery and such implementation was not further considered.

To make the game educationally valuable, it is desirable to provide commentary that either 'pops up' when certain events occur (e.g. storm; sheep die of malnutrition) or that can be requested by the user. The implementation of this additional level of interaction was not part of this initial phase of development and should be considered in a next step.



Integration into Teaching

It has become clear that the main emphasis of this project has to be the ecological model and its implementation as a game. The resulting learning resource will hence mainly be of value in the teaching of Environmental Archaeology, a subject in which the project coordinator does not teach himself. He therefore makes this new resource available for colleagues to use in their own teaching. Given the initial enthusiasm (see above) and the general desire to incorporate ESD into the curriculum, this will be achievable.

Evaluation

A second student workshop was held (Appendix 2) to test the students' reaction to this new resource and obtain feedback on its implementation.

Students approached this resource initially very much as a computer game, especially since according to their own accounts, they were 'avid gamers'. This showed that this resource, borne out of a fairly accurate ecological model, is more tailored towards reflecting real

relationships rather than focussing on all the interactions and feedback that are built into computer games to make them exciting and interactive.

After discussing the underlying ecological model with students in more detail they appreciated the academic validity of the resource and were able to see that the aim of this game is different from those games they are normally playing (they made very useful suggestions to increase its gaming appeal). This emphasises the fact that this resource was not created to fully satisfy the need of gamers but to complement the teaching of ecological and sustainability issues with an appealing resource that can bring the 'dry' relationships to light. It is hence essential that the game is accompanied by an in-depth teaching session that explores the ecological model and explains how different parameters interact and how human behaviour and decision can change the outcome. When this is then followed up with the game students do appreciate that the academic content is visualised and are aware that the game is played with an educational purpose.

Students were able to see how issues of sustainability are covered by this resource but felt that a human dimension is essential to make it really relevant. Dying sheep alone are not enough to raise concerns about sustainability.

In summary, the following insights were gained during the running time of the project.

- Staff showed considerable interest but also reservations in terms of underlying philosophy (non-deterministic) and requested scientific accuracy of the planned product.
- Students were very supportive of the project and showed high awareness of the required level of complexity of the product.
- The development of an accurate ecological model that can nevertheless be implemented is a considerable challenge.
- The implementation of such an ecological model as a game is a considerable challenge.
- The time spent by the project coordinator working on these challenges himself proved to be much more substantial than anticipated.
- Since the project coordinator is not teaching the subject of the final product himself he has to promote the resulting resource for adoption by colleagues in their own teaching.
- The game that was created with the funding of this project is a prototype. There are various issues that should be changed in a second phase to make it more interactive (additional user input options) and to demonstrate more clearly the impact of the human farming society. Incorporating some of the Farmfact relationships could do this.

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31 May 2008

Appendix 1: Report from first Student Workshop

Report of a Seminar/Focus Group Meeting on the 12th December 2006. University of Bradford: Department of Archaeological Sciences.

Present

- Dr Armin Schmidt (University of Bradford) – Chair.
- Dr Andrew Jones (Lecturer in Bioarchaeology - University of Bradford).
- Dr Peter Hopkinson (Bradford's Director of Education for Sustainable Development).
- Mr Peter Hughes Senior Lecturer in Learning Development.
- Year 2 undergraduate archaeology students (module Ecology and Bioarchaeology; incl. Charlotte Borrett, Alex Bromley, Elizabeth Castle, Patrick Hadley, Amy Jeffrey, Rebecca Knight, Hannah Measham).
- Albert Fischer – Note taking and meeting report preparation.

Introduction

Dr Schmidt briefly outlined the project and purpose of the meeting.

The two principal objectives of the project were firstly, to consider archaeological case studies, how they are relevant in the terms of sustainability and how that approach could be introduced into the curriculum. Secondly, to develop a computer based model as an educational resource and teaching tool to achieve this; the meeting had been convened to examine the requirements of such a model and to establish ideas and suggestions for its development.

Initial thoughts envisaged that such a model would be in the form of a game as a familiar way for users to get an understanding of the causes of environmental issues and the effect of their decisions and actions over time.

It was specifically noted that the project was not an environmental determinism exercise but an archaeological examination in the context of sustainability to develop a more simplified teaching tool rather than the very complex models often utilised by environmental scientists.

The core of the group was drawn from second year undergraduate archaeology students that had undertaken the Module AR-3107D Ecology and Bioarchaeology. As this module specifically examined four relevant archaeological/historical case studies (Greenland, Easter Island, Anasazi and the Maya civilisations), the student group's views were hence particularly relevant to the discussions.

Specific points that were raised in the seminar

The following summarises the points and issues that were identified during discussion. These have been organised under a series of key headings and, where appropriate, brief explanatory notes on individual points have been included.

1. GENERAL COMMENTS AND SUGGESTIONS.

Discussions included suggestions for the interface of the computer model, suggesting:

- As an interactive, teaching resource a game format, similar to the "sim city" games was suggested as a possible model. Also an example of such an interactive approach linked to the Oxfam website had been used by one of the group.
- An opening screen in which the "game" parameters could be established. The nature of the game would require random changes to occur and these could be set within a front screen.

It was generally thought that the use of sliders could be a useful way to set any variables.

See 2 below for further detail of these model parameters.

- Use of an initial interface to “design” the culture or society that was to be modelled, predetermining various factors at the outset – religion, certain limitation responses and attitudes, monetary focus, constant growth, consumerism; these could then provide interesting interactions to other factors as they may occur during the “game”. These would be parameters, which would, to an extent, limit options that could be used by “players” later. Again slider bars could be a good way to set some of these. Would then be able to see how some inbuilt cultural factors affect the possible results. It was noted that past societies themselves might have had a view of what was success or failure was, which may well be different from ours today.

2. MODEL PARAMETERS.

The group thought that before the model was run another level of background parameters would be set which would determine various limiting factors, random events (catastrophic or cyclical) affecting a society during the period the model was run. The following were suggested as such factors:

- Physical Factors.
Soils, topography, climate, seasonality, weather cycles.
Some of these would also be related to other points and be variable over the period the model was run. For example soil or grazing could be destroyed by mismanagement.
- Changing Environmental Parameters.
Such as the regional climate, which will have an overriding influence upon what type of culture or society could be established. Although related to 1, above it was envisaged that a variable for long-term climatic change could be set. If necessary this could, through a randomising factor, introduce changes into the model as it progressed.
- Types and quantities of resources available
Both renewable and non-renewable; these would be both the natural resources and those produced by the society being modelled, e.g. crops produced for trade.
Some may need further definition, for example the grazing capacities on particular areas.
- Specific limiting factors would be crucial to the model and would need considering throughout.
- The type of culture or society that would be modelled, for example Hunter/Gatherer or Agricultural. Also could consider incorporating its change, e.g. hunter-gatherers adopting agriculture which would have environmental effects.
- The scale being examined and whether the system is open or closed, for example a limited area within a larger region or an island environment.
- Specific fixed cultural attitudes for the subject being modelled, e.g. religious beliefs and the strength of those beliefs when deciding how to respond to changes for example, would the religion itself be modified, would they accept that their extinction was the will of god or would an intensive programme of sacrifices to appease the gods be started?

3. INTERACTIVE PARAMETERS.

These are variables, which it was envisaged the user would interact with while the model was running and as such affect the final outcome. These would require the user(s) to make decisions in response to changes resulting from previous decisions and occurring due to randomised effects out of the users’ control (although there may have been set parameters at the beginning of the “game”). These would all have various long-term outcomes such as over-use of resources or over stocking destroying the resource itself. Specific examples of these parameters would include:

- Crops and animals to be used by the society or for hunters the animals hunted and numbers taken.
- Animal numbers on the land.

- Uses of the different resources and any management of those resources. Relative dependency on domesticates and wild animals.
- Nutritional factors. Can the society obtain or produce sufficient nutritional resources all the year round to sustain itself – an issue in hunter/gatherer societies in extreme environments.
- Energy requirements of the society or culture.
- Trade and exchange – use of resources, manufacturing.
- Identifying and learning skills to adapt to changing circumstances or to improve utilisation of the environment. Improving or increasing available resources by management.
- Purposeful and incidental plant and animal introductions and their effect for example rats or goats into island ecosystems and the example of the rabbit in Australia.
- Inter-species competition. Competing groups within the landscape, colonists and native populations. Interaction and conflict.
- Population levels, increasing population, population controls and movements such as emigration and immigration.

4. OTHER IDEAS AND SUGGESTIONS.

During discussions other suggestions were made, which may be worth considering further:

- That, although the model would be based on an archaeological society, there could be a modern-day comparison running on screen at the same time showing the impact of those same choices as an analogy to the model. For example, the last tree on Easter Island comparing to the last barrel of oil sometime in the future. Putting people out of work and what options there are for them in that society.
- The players have knowledge of the problems and how past societies failed; we know how it all ended. Playing the game with experience of the past such as that will affect the decisions of the players. Game parameters would have to be restricted to modern decisions, which may well have been totally unacceptable in the past.
- Response.
There would also be a situation where a past culture or society did not recognise a problem at an early stage or were unable to agree upon what to do; the culture could be described as “backward looking” and hostile to any change.
Primitive cultures/societies react differently to one that is more complex. (Civilisation is not just a western format – whole area for discussion)
- There would have been an over-riding focus to sustain your own family’s survival at any expense or consequence.
- Technological capabilities of the society as a factor to meet the stresses that arise?
- As well as being a setup parameter environmental changes scenario brought about by the culture itself could be incorporated into the model.

Appendix 2: Report from second Student Workshop

Report of a Workshop on the 30 May 2008, University of Bradford, Archaeological Sciences, Division of AGES.

Present

- Dr Armin Schmidt – chair and notes.
- Lauren Hughes (BSc Archaeology, on placement after year 2)
- Neil Willmets (BSc Archaeology, year 2)

Workshop

The game had been linked into a web page (<http://www.brad.ac.uk/archsci/sustainability/>) providing some background information, the full description of the underlying model and a DOS-based simulation.

After a brief introduction by AS into the scenario of the game and an overview of the relationships underpinning it, students were asked to start the game. In this initial run students used the slider bars and became used to the control buttons, had the program running for one cycle (i.e. 10 years) but appeared unclear as to what it all meant. This was then followed up with a more detailed explanation of the ecological model and a joint browsing through the detailed description of the model. It was clear that even this text was too long to easily digest in a short session. Following this, students were encouraged to start the DOS based simulation and they found this interesting but the lack of possibilities for interaction was felt to be a big disadvantage. After having gained this additional insight in the ecological model students turned again to the game and engaged much more thoroughly with it. They are avid 'gamers' and it was clear that they compared it with other games they know.

It was clear that two different approaches were used when exploring the game:

- "what happens if I do this ... ?"
- "can I break the game by selecting silly parameters?" (e.g. 2000 sheep on 1 ha)

While exploring the game, students provided feedback on issues arising and at the conclusion provided an overall assessment.

Students' Comments

1. It would be better to always be able to adjust the number of sheep in the byre and the number of sheep to be slaughtered, not just in specific months. This could be done by selecting a pull-down menu that provides the respective parameter controls. "This is necessary to give the player more control and to turn the game round".
2. It is good (as implemented now) to set the number of sheep fed and slaughtered as a percentage, so that even with changing stock-sizes one can keep this setting. However, for adjustment purposes it would be very useful if the absolute number were displayed as well (maybe to the right) and also adjusted as the slider is moved.
3. When selecting how many sheep to take into the byre old ewes cannot be selected, this needs to be rectified.
4. It was questioned whether all four sheep ages should be selectable for feeding and slaughter and it was felt that a single percentage for all might be sufficient, it would certainly be easier than having to adjust four.
5. It should be possible for some of the Degraded Grassy Heath to recover, otherwise one is doomed. Maybe a random percentage to recover every winter. There has to be a way for the player to regain Grassy Heath so that some control over one's fait is possible.
6. The storm could also damage the byre to have a bit more effect, since nothing happens if there isn't a lot of Degraded Grassy Heath.
7. The intro text has a heading that sounds like Star Trek

8. The player should be able to make adjustments and react to events.
9. The slider for the reproduction rate seems to have not effect.
10. It is unclear whether the 'step forward' button does the same as 'ok'.
11. When in auto-run mode (i.e. simulation) students want it to run faster to see what happens after their action.
12. The controls should not only have sliders but also input fields where exact numbers can be set.
13. There seem to be no calculations for the sheep in the byre: neither are lambs born nor do the ewes get older.
14. There needs to be more impetus to win, or to do better than a comparative scenario. Maybe also set goals to achieve, like amount of meat/milk, number of sheep etc.
15. To give the whole game more meaning it needs to go beyond just sheep. A simple human component would be to calculate the calories of mil and meat and then display how many people could be sustained by it. The human dimension is really necessary to make 'sustainability' relevant. Not just dying sheep.

Evaluation

Students approached this resource initially very much as a computer game, especially since according to their own accounts, they are avid 'gamers'. This showed that this resource, borne out of a fairly accurate ecological model, is more tailored towards reflecting real relationships rather than focussing on all the interactions and feedback that are built into computer games to make them exciting and interactive.

After discussing the underlying ecological model with students in more detail they appreciated the academic validity of the resource and were able to see that the aim of this game is different from those games they are normally playing. They were able to make very useful suggestions to increase its gaming appeal.

Students were able to see how issues of sustainability are covered by this resource but felt that a human dimension is essential to make it really relevant. Dying sheep along are not enough to raise concerns about sustainability.