[O3] Virtual experiments across the science curriculum

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ABSTRACT

Science is 'a branch of knowledge conducted on objective principles involving the systematized observation of and experiment with phenomena' (OED), yet the costs of providing space, time and materials for experimentation are coming under increasing scrutiny. This illustrated presentation will describe how the Open University (OU) has introduced virtual experiments into a variety of science courses that are studied at a distance; some of the virtual experiments lead on to real experiments conducted at residential school, others are stand-alone and form the basis of assignments that contribute to the student's course grade.

BACKGROUND

The question of how to encourage students to engage with the theory and practicalities of an experiment before entering a laboratory is not new. Nor is the suggestion that computer-based methods may provide a solution. 'Computer as laboratory' is one of the headings in the final report of the National Development Programme in Computer-Assisted Learning [1] that ran from 1974–77. But in this area the educational ideas ran ahead of the capabilities of the available technology of the day and the fidelity of computer-based experiments created under NDPCAL was very low.

Digital technology started to catch up with our requirements in the mid 1990s when multi-media PCs with true colour displays and the ability to play video, albeit in tiny windows, came onto the market at an affordable price and in 1998 the Open University started issuing multi-media teaching materials on CD-ROM. While some of these early multimedia developments could be viewed as modern day equivalents of the 1970s simulations with the addition of coloured, graphical, output of the results, others ventured into new fields with virtual microscopes and telescopes showing high quality still images of the very small and very large.

In the four years that followed, digital video technology made rapid advances on many fronts from the capabilities of PCs to the capacity of DVDs and all at a decreasing price. In 2002, our second level course Environmental Science became the first OU course to issue multimedia materials on DVD-ROM and perhaps for the first time, our ability to reproduce experiments with some measure of fidelity became a reality.

By 2004, DVD was established as the OU Science Faculty medium of choice for delivering multimedia materials into the home. The hybrid DVD-ROM/DVD-Video disks that we have produced allow us to integrate all of the learning materials for a course including multimedia, eBooks, TV and video programmes and self-assessment programs into one electronic environment. And gradually a bank of virtual experiments is being created for various courses across the Science Faculty.

WHY A COMPUTER?

Most experimentation is concerned with obtaining evidence from which an underlying theory can be formulated, however the time consuming nature of experiments, costs of laboratory space, equipment and consumables and, on occasion, the potential dangers lead to tightly scripted laboratory procedures that leave little space for real experimentation. The potential afforded by the computer to supply raw data based on an underlying theoretical model offers the potential for virtual experiments to be run on a much faster timescale, at no cost in laboratories, equipment or consumables or in supervision of dangerous procedures. And an incorrect choice of parameters or experimental conditions does not carry the large negative penalties associated with a real experiment that may take a day or more to complete. From this basis the computer can provide an opportunity to involve the student in understanding the underlying theory and planning the experiment that is not so readily achieved in the real laboratory.

VIRTUAL EXPERIMENTS

- allow students to spend a greater proportion of their study time on activities that involve experiential and practical learning, and students will benefit from the close linking of these activities with development of underlying theoretical concepts
- enable students to develop a wide range of skills that will prepare them for, and allow them to make more effective use of, their limited time in the lab or field
- allow students to tackle (virtual) practical work that it would be too expensive or dangerous to provide in laboratories
- encourage deeper learning by enabling a more exploratory approach than the recipe-following that characterises many undergraduate experiments
- provide a vehicle for online collaboration and discussion which will promote peer learning, increase students' motivation and their sense of being part of the student community, and improve retention
- can simulate complex models and thereby enable students with weaker maths and science backgrounds to explore, and develop an understanding of, complex systems
- are more accessible, enabling students with disabilities to engage with parts of the science curriculum that would otherwise be inaccessible to them
- when developed to sufficient quality will enhance students' interest, enjoyment and motivation, and hence improve retention and performance
- consume no chemicals, require no space or specialist equipment, are clean and are reproducible

A MODERN DAY VIRTUAL EXPERIMENT

The defining difference between modern day virtual experiments and their forerunners lies primarily in the quality of the visual imagery that can be produced and the methods that can be provided for the student to interact with these images.

These can include

- high-quality, full screen, video of laboratory equipment or a scientific site
- high-quality still images
- computer-generated images that are realistic such that the student can make choices about their experiment and the computer can simulate the results
- computer-generated 3D images

The DVDs introduced by the OU in 2002 can support all of the above in providing a much closer reproduction of the 'look and feel' of a real experiment. This in turn reintroduces the skills of interpreting how an experiment proceeds; observing, measuring and collecting data can be made more life-like and the potential for learning from incorrect experimentation no longer carries a large penalty. Indeed experimentation can be encouraged within the bounds set by the computer model or video resources.

And the approach is very suitable to individualised learning, either at a distance or in a conventional setting, because as the computer is providing the information for the student to interpret, so the computer can also perform the role of a virtual tutor who can check the observations and calculations, and where required ask the student to revisit and reinterpret certain pictorial, numerical or graphical data.

EXAMPLES FROM THE OU SCIENCE CURRICULUM

While the OU has been using experiments based on computer simulations with graphical outputs for over 20 years, since 2002 we have found that the range of experiments has spread into areas that had not previously been considered suitable. In environmental science we now have extensive virtual field trips to the Teign Valley in Devon and the Sevilleta Wildlife Refuge in New Mexico each supported by over an hour of video and extensive maps, pictures and data from local and national scientific agencies. In chemistry we have a multimedia program that deals with the separation of plutonium from uranium while our Earth scientists have taken the opportunity to bring the study of remote geological formations into students' homes, combining interactive geological maps with virtual reality video of the area. Most recently the biologists and biochemists have devised a series of experiments that are used at home prior to performing the actual experiment in a residential school.

The presentation will show excerpts from the above to convey the quality of representation that can now be achieved.

REFERENCES

1. Hooper R., Final Report of the Director, National Development Programme in Computer Assisted Learning, Council for Educational Technology, 1977.