JeLSIM Partnership[i]: Simulating Experiments Online

This project grew out of a belief in the benefits of simulation, and a realisation that there is still some way to go if they are to achieve their full potential in online learning. We viewed this proposal as a chance to take a fresh look at the concerns raised in education literature about the use of computers in simulating practical experiments and as an opportunity to address them. We also saw the project as the first step towards addressing the issue of authentic assessment and the possibility of assessing students in the environment in which they learn.

Objectives

The objectives of this project were to demonstrate the potential of simulations by showing how they can be used to build up skills in practical activities and experimentation. Exemplar simulations have been produced, in chemical kinetics, demonstrating their use in:

- Practical experimentation (4)
- Exploratory activities (1)
- Investigative activities (1)

In producing these simulations we have reviewed and attempted to address the fears amongst many science teachers about using simulations. We have begun to build up guidelines for best practice in the field.

The nature of the JeLSIM tools[ii] means that any simulations produced are a flexible resource which can be customised by teachers to suit their teaching needs. An important part of the project was the production of training resources to allow teachers modify and tailor the exemplar simulations.

We also report on the potential for using these resources in authentic assessment and put forward a proposal for the next step in the process: the combination of simulation and assessment.

Simulations in Support of Practical Activities

The benefits of simulation in education have been recognised for some time; they can aid learning by doing, allow students to form concepts through experience and allow teachers to introduce the form of a system to their students before the mathematics. They can potentially provide an environment in reflection is encouraged, in which the learner can explore, make and test hypotheses. Used as a resource with other media, they can provide meaningful,

motivating activity in a range of educational contexts from guided learning through to open exploration.

If used to simulate practical experiments, simulations can:

- Allow access to the experiment when there is a shortage of equipment or time.
- Provide data for students to work on if it is not possible to perform an experiment, for instance due to its lengthy nature.
- Allow the performance of experiments that would not otherwise be available because they are too dangerous.
- Allow mistakes without cost or damage.

Amongst many science teachers though, there are justifiable fears about using simulations in general and for practical experiments in particular. For instance:

- It's not possible to replace real hands on experience and to mimic the dexterity required in practical work.
- Simulations often provide the perfect picture, whilst experimental procedures are usually subject to errors, the evaluation of which is important in the student's education.
- In real life it *is* possible to make mistakes. Simulated activities often provide users with a set of valid choices only.
- It's possible for students to develop misconceptions when using simulations, this may be an effect of scale (time or size) and the student cannot relate what is seen in the simulation to reality.

The Resources

We have attempted to address teachers' concerns in the resources that we have produced.

- We have not attempted to provide a computer-based equivalent of a task requiring manual dexterity, but have concentrated on giving the learner all the experimental choices they would have if the experiment were real. (What to measure, what they should plot and how they should plot it.)
- Students will not obtain the same values for the same experiment every time they run it. They can make timing and measurement errors just as in real life.
- Students can make mistakes, for instance, overheating a solution or failing to notice a solution change colour. In a simulated environment they can be given the opportunity to repeat the experiment at no cost.
- Where an experiment involves measurement of time, we have ensured that the relative times are accurate. If an event happens in 10 seconds in real life, it happens in 10 seconds in the program. However, for longer drawn out experiments time can be accelerated, but the relative differences in time between events is maintained.

Typically exemplars of practical experiments consist of a set of tabbed interfaces allowing the student to set up and run the experiment. E.g. Fig 1:

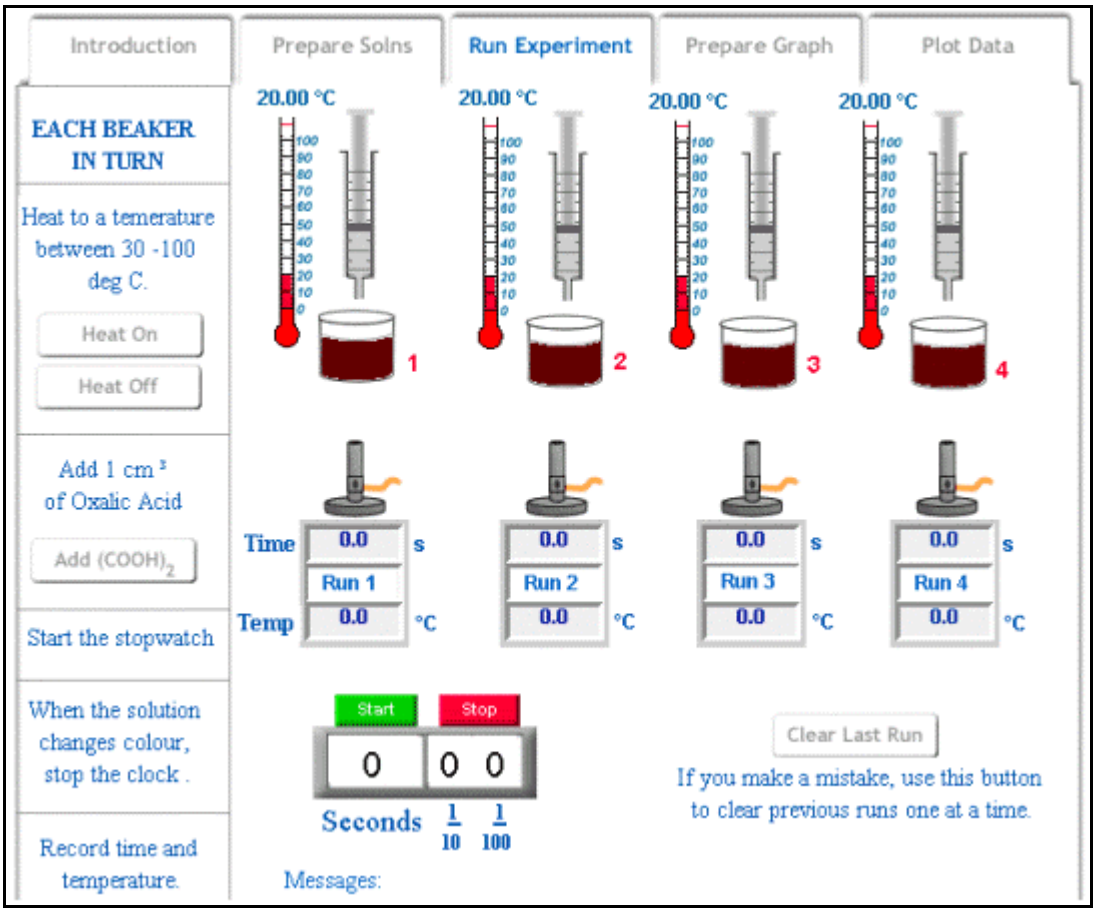

Figure 1. A screen from an experiment to determine the effect of temperature on reaction rate.

The other exemplars and related resources produced in the project can be seen at
http://www.jelsim.org/pub/chemistry/

A Flexible Resource

The nature of the JeLSIM tools make it easy to set the simulations in different contexts or amend them so these resources have potential as:

- Preparation for the student in advance of the laboratory exercise.
- A simulated experiment (or a variant of the real experiment to avoid direct replacement).
- Revision material.
- A way of providing activities in experimental design.
- A way of providing activities in experimental practice.
- General learning material in support of courseware.

These simulation resources could be used in conjunction with other resources to provide a lab pack that might also include: theory and background, information on equipment and safety, data books, formative assessment for the student to check their understanding, and summative assessment for the teacher to check the student's performance.

The Future

Simulations by their very nature give feedback to learners, any change to the simulation input results in a change to the output. However this type of feedback is towards the learner, and is not suited to assessment (either formative or summative). Integrating the functionality of an assessment engine with a simulation tool such as JeLSIM builder could create a powerful system that would provide such feedback.

Such an integrated system could provide the first step towards authentic assessment. The teacher/question setter could choose to monitor any aspect of the student's interaction with the simulation. Answers would no longer be limited to multiple choice, or text strings, but could be any combination of variables within the simulation. It would be possible to see the strategy a learner used to tackle a problem, not just the final answer.

In terms of practicals, all aspects of the student's interaction could be assessed as they used the application. Did they achieve all learning outcomes? How accurate was their information gathering? Did they plot the graph is the prescribed fashion? Do they understand units? Were they capable of planning their own experimental investigation?

In such a system it will be possible to determine where students are having problems and to gain insight into their misconceptions.

We are currently looking for funding to take such a project forward in collaboration with Professor Beevers of SCROLLA, using the CUE assessment engine.

Further Details

For further information contact Ruth Thomas rct@jelsim.org.
The material outlined in this talk is available on out website at
http://www.jelsim.org/pub/chemistry/

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[i] http://www.jelsim.org/about.html
[ii] http://www.jelsim.org/software.html