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Interactive e-Assessments

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ABSTRACT

It is useful for teachers to reflect on the future formats that will be necessary for assessment tasks. There is currently much discussion concerning the need for immersive and authentic learning environments. Teachers will need to investigate assessments that mix real and virtual environments, testing declarative knowledge and also conditional and procedural capabilities. Teachers will need to contemplate using assessments that measure approaches to problem solving and student responses in terms of efficiency, ethical considerations and the involvement of others.

This image of assessment is still sometime away, but will be within reach in the short term. Are academic staff ready to use this framework for assessment? e-Assessment tasks provide opportunities for academic staff to move beyond the type of question traditionally presented in a paper format. Interactivity is possible in e-assessments so that students are more engaged with the prescribed task and permit assessment to become a genuine learning and teaching tool, rather than just a summative evaluation.

Java applets and browser plugins enable teachers to create assessment tasks that encourage active participation and the use of real world data or professional tools, to show the extent of student learning. The interactivity inherent in this type of assessment allows students to explore, or make errors, and often seek their own solutions to the assessment tasks. Many java applets are freely available on the web and teachers may use them as stand alone tools within the e-assessment task. The science discipline areas such chemistry, biology, geology, physics, mathematics and statistics are well represented, with other discipline areas such as music, business, economics and commerce having some tools available.

INTRODUCTION

e-Learning has become more sophisticated as the required technology improves, as the hardware and software becomes easier for non-specialists to use, and as teachers and academic developers increase their understanding of effective e-learning designs (Koper and Tattersal, 2005). e-Assessment has lagged behind in terms of the development and application of sophisticated design principles (Parshall, Davey and Pashley, 2000). e-Assessment offers new possibilities for an immersive and responsive educational environment, moving beyond the static environment of pen and paper (Ridgway and McCusker, 2003). e-Assessment has the potential to facilitate enhanced social interactions and ultimately to provide authentic environments that resemble more the real world in which students will be required to operate. Alternative modes of presenting assessment tasks are now possible, ones that are more adapted to the diversity in cognitive, social and physical abilities of students (Boyle, 2005). e-Assessment can begin to resemble games that involve role-playing and real world scenarios; they can incorporate consequences that will evolve from the student responses. The present paper-based examination system sees significant time and resources channelled into assessments, the outcome for which is usually a grade with the paper-based responses being kept for a short time and then destroyed. By digitally capturing responses to more authentic e-assessment problems there exists a possibility to harness a significant cognitive resource. It would not be possible to prepare every assessment task along this

design principle, but units of declarative knowledge could be incorporated into scenarios if compliance with particular outcomes or minimum standards was required.

What would a student consider to be an authentic assessment task? Should it simply be a task that is related to the objectives for a program, or should it also use tools and resources that will be relevant to later employment? If students can perform assessment tasks that use tools that develop their transferable capabilities and not only require stored content to be reiterated, they are engaging in productive activity that will be useful after temporarily 'cached' content is forgotten. Allowing students to engage in 'what if' scenarios is a powerful learning strategy because they have some level of control over the learning context. Using interactive tools allows student to 'break the rules' and observe the resulting consequences, rather than just following predetermined response rules. Interactive e-assessments allow students the opportunity to make 'errors', and provide the means for them to construct alternative solutions.

Interactivity is a popular concept in the online environment. What precisely do we mean by interactivity in the context of online education? Evans and Sabry (2003), have discussed a simple model for online interactivity, involving three-way interactions between a learner and a computer; interactivity in this model involves the components of initiation, response and feedback (Figure 1). An initiation involves the computer presenting either information or a task to the learner that results in a learner response that subsequently generates either specific or generic feedback from the computer. These three actions are common to most interactions involving a learner and a computer, and give rise to an iterative interactivity cycle. These three actions are typically encountered when a student undertakes a multiple-choice question (MCQ) test; the computer presents the question to the student (initiation), the student answers the question (response) and the computer marks the response according to a preprogrammed algorithm and provides various forms of feedback (ranging from a mark or grade, through to detailed commentary on the particular learner choices to the questions). Evans and Sabry (2003) used this general framework to present nine heuristics for the evaluation of online interactivity and the common issues encountered by students.

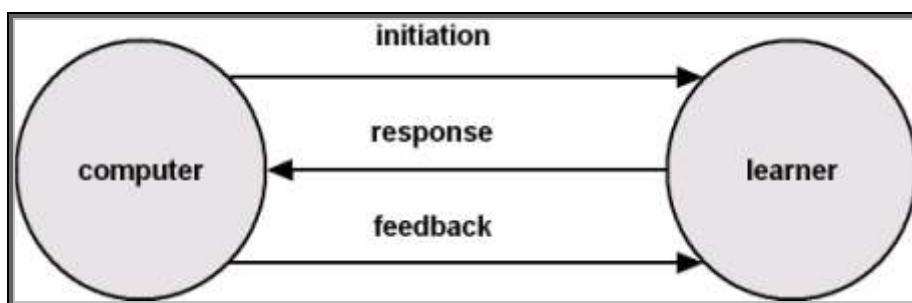


Figure 1. Three-way model of interactivity in the online environment (Evans and Sabry, 2003)

The means by which specific interactivity is integrated into e-assessments is often dependent on the software used for the assessment task. Some of the of more versatile formats for introducing interactive tasks are those that are packaged as java applets or IMS content packages (IMS), since these objects may reside on a remote server and can be incorporated readily into most standard web-based applications using simple HTML. The usefulness of these objects is that they are separate from the actual assessment, and may be used as a learning object or as an interactive tool in a variety of e-assessments. The particular questions used for a specific e-assessment may be constructed separately from the interactive object and so the difficulty level may be set to match the particular class level. The assessment questions will be marked by the actual e-assessment tool being used, not by the reusable java applet or IMS content package. Any feedback to the student will be determined by the teacher, who may recommend to the student that she/he view additional resources, or allow them to use the interactive object to improve their learning. The total integration of the simulation and the e-assessment would allow information about the student use

of the simulation to be passed to the e-assessment tool, but this is not commonly available (Thomas, Ashton, Austin, Beevers, Edwards and Milligan; 2004).

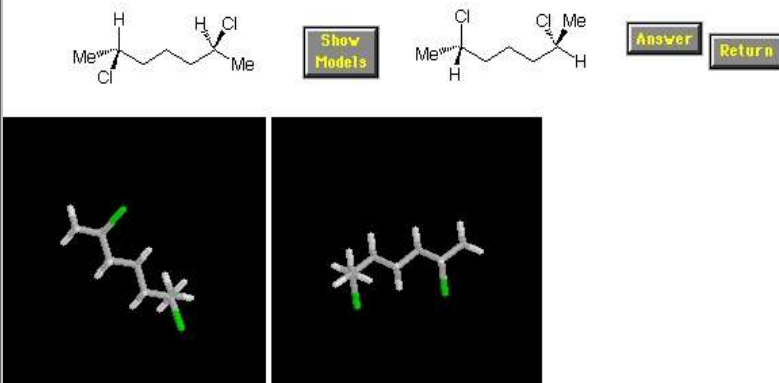
BROWSER PLUGINS AND JAVA APPLETS IN E-ASSESSMENT

A browser plugin is a software application that adds a specific service or feature to standard browser software such as Internet Explorer, Mozilla, Netscape, Opera, Safari, etc. Most people who search the Internet using a standard web browser would be aware of plugins such as Acrobat Reader from Adobe Systems, Flash and Shockwave Players from Macromedia, Java from Sun Microsystems and Quicktime from Apple Computers or Windows Media Player from Microsoft. These plugins allow the browser to play particular file types within the web environment. They also offer the potential for interactivity in e-assessment.

The Chime plugin from MDL® (MDL) is a versatile tool for allowing chemistry students to manipulate three dimensional representations of a chemical structure within a web browser. An example of how this can assist students in an e-assessment is illustrated in Figure 2, where the task is to compare two chemical structures and decide if they are identical or isomeric. If this type of question is presented to students in a static paper-based format, then they must either have a set of models that will allow them to construct a physical representation of both molecules, or they must visualize in their minds the three dimensional arrangement of the atoms in the molecule. By using the Chime plugin, students are able to rotate the digital representations of both molecules so that they are able to make a comparison, and so answer the question with more confidence. The plugin allows a more useful format to be used for the question, instead of a simple MCQ.

The MDL® Chime plugin may also be used to present interactive spectra to students. In the example illustrated in Figure 3, the infrared spectrum on the left can be expanded and the frequencies of the various absorptions observed. In addition, the specific molecular vibrations associated with a particular frequency can be observed on the structure on the right as an animation. In addition, this plugin provides functionality such as the ability to measure bond angles and bond lengths, thus providing students with the ability to relate structure to activity. Teachers can set multistructural or relational question types; they are not restricted to unistructural types.

Compare the following two molecules and determine if they are identical, enantiomers, diastereomers, constitutional isomers, or non-isomers. Try to do this using conventional methods. However, if you get stuck, click on the "show models" button to view them. Then click-drag on one of the molecules to manipulate it.



MDL MDL

Figure 2 Rotation of three dimensional chemistry models using MDL® Chime plugin (Example from <http://www.colby.edu/chemistry/OChem/>)

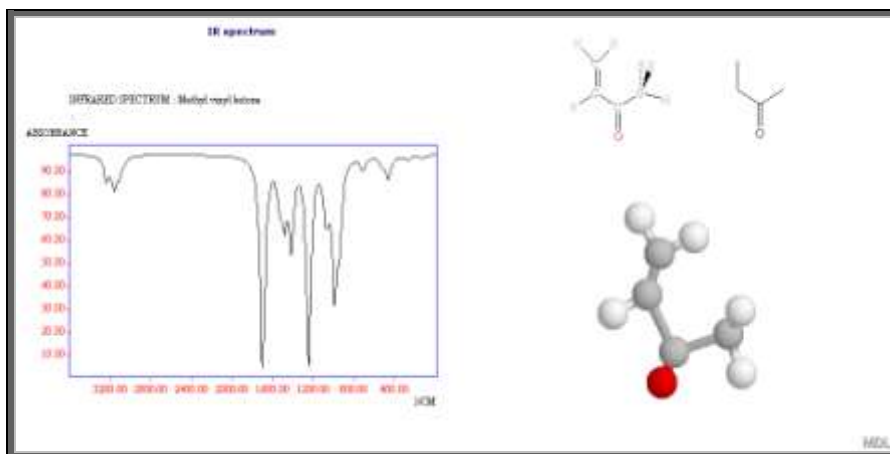


Figure 3 Relationship between frequencies in spectra and molecular vibrations using Chime plugin (Example from http://www.hull.ac.uk/chemistry/spectroscopy/infrared_spectrum.php)

The ability to provide sophisticated tools for students to use during an e-assessment means that students can explore various possibilities during the assessment. Since plugins allow files to be called from a remote central server, the object being manipulated is independent of the particular software used for the e-assessment, the plugin adds more flexibility to the type of question that may be asked in particular e-assessment packages. This means that the same files may be used for different assessments, and the questions can be set to match the students' ability. It also permits comparative question types, and reduces the dependence on memory of declarative knowledge, since the data is always available. Students can concentrate on constructing responses rather than reiterating them.

Other examples of plugins that are useful for presenting sophisticated files for student use during e-assessments include the Virtual Reality Modeling Language (VRML) and Apple's Quicktime VR, both providing opportunities for the manipulation of three-dimensional objects through a web browser. Figure 4 illustrates a section from a high resolution Quicktime VR image of sculptures by Rodin in a formal garden. This image, when incorporated into an e-assessment, allows students to examine each sculpture closely, and the relative positions of the various pieces with respect to their surroundings. Students can identify visual elements and prepare multistructural and relational responses to questions of design, structure and form. This presentation format for the question moves beyond a static photograph as the image can be rotated in three dimensions. It is a more immersive experience for students as they can experience the actual 'feeling' of being at the location.



Figure 4 QuickTime VR images of Rodin sculptures in garden setting (Example from <http://www.virtualparks.org/scenes/ZbS-38hFbx6RB3DD30tLHqg.html>)

GeoVRML is a variation of VRML that allows the presentation of geographical data as a three dimensional representation over the web, and students are able to manipulate maps and terrain

models through a web browser, as illustrated in Figure 5 (GeoVRML). Students may use this application to construct complex responses to questions requiring multiple perspectives of the situation.

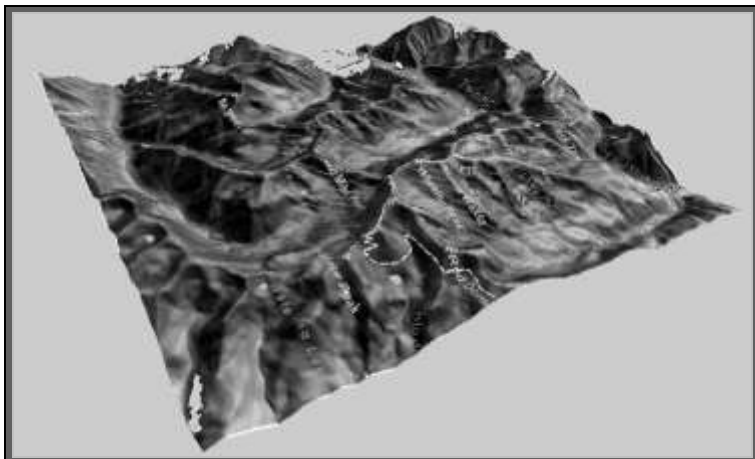


Figure 5 GeoVRML example of three dimensional terrain maps
(Example from <http://www.geovrml.org/examples/>)

Java applets are small applications written in the Java™ code; they can be used with various media formats (text, graphics, animation and sound) and can be complemented with JavaScript and VRML. Many examples of the use of interactive java applets are available on the web (Baker, 2002; Rojiani, Kim and Kapania, 2000; Cartwright, Gopalam, Liu, Yuan, Tang and Wie, 2000; Drogenik and Kolar 2002).

Educational java applets are learning objects that can be called from a remote server or stored and used on a local server. The applet itself is encountered as a *.class or *.jar file and can be called from the server by inserting a few lines of HTML code into the web page for the e-assessment. The action of calling the applet is independent of the software used to deliver the e-assessment; commercial systems such as WebCT or Blackboard can be used for the assessment, as well as open source systems such as Moodle or Sakai. An example of HTML code for the java applet illustrated in Figure 5 would be:

```
<applet code="JME.class" name="JME" archive="http://name_of_your_server/directory/JME.jar"
width=360 height=335><param name="options" value="list of keywords">
Enable Java in your browser ! </applet>
```

The use of java applets and browser plugins in assessment encourages teachers to access the higher levels of the SOLO taxonomy. The tools themselves provide a framework for alternative forms of questions other than traditional MCQ formats. The java applet illustrated in Figure 6 allows students to draw chemical structures within the web browser environment. Students are required to master the ability to draw visual representations of molecules that highlight the three-dimensional nature of the object. This is the simplest level of use for the applet, as students can also use the extended features of the application to explore physical and biological properties of the molecule they draw. Teachers can set assessment tasks that require students to explore the relationship between structure and activity, and students can provide unexpected answers to set problems within this context.

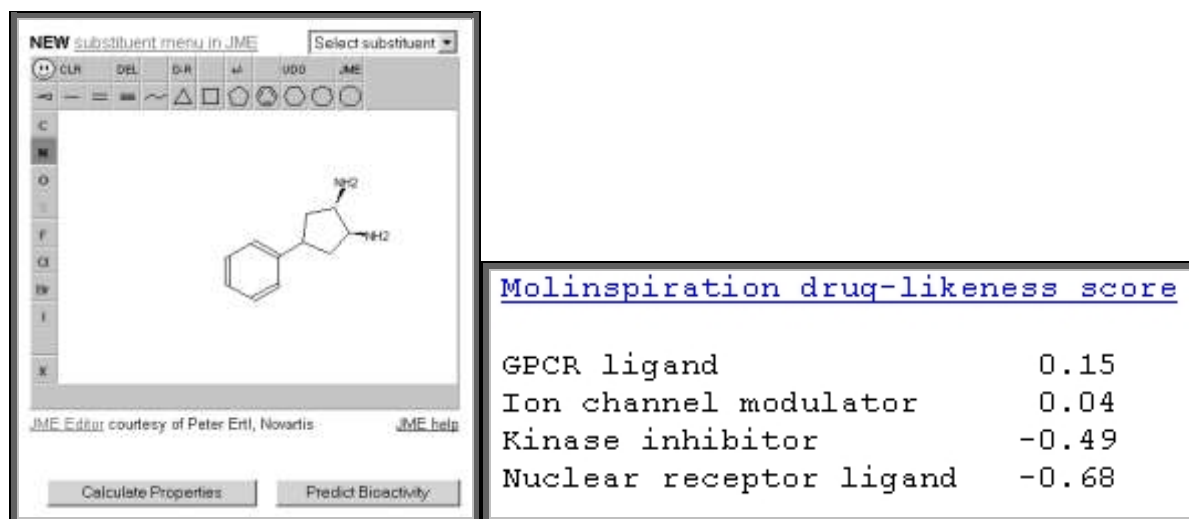


Figure 6 Chemical structure drawing applet
(Example from <http://www.molinspiration.com/cgi-bin/properties>)

Tools such as that illustrated in Figure 5 encourage students to create new knowledge, and not simply reiterate known content. Clearly this approach would not be suitable for all assessment tasks, as declarative knowledge is still important for students to master, but conditional and procedural capabilities can be tested using these types of additional resources. Since java applets can be made to open in a second browser window, students may have a number of resources available to them during an assessment, and may move freely between them as required. Allowing students to have access to information and resources during an assessment provides opportunities to explore relational and extended abstract responses. The java applets and browser plugins may be used effectively with simple MCQ questions that are marked automatically by the assessment software, but this does not have to be the only framework for e-assessment. Students can be required to write extended responses that are marked by teachers or by moderated group processes. This naturally adds an additional marking burden on teachers, but may be considered important for the objectives for the program.

Not all java applets will be suited to e-assessment tasks, and it is certainly the present situation that the science and mathematics disciplines have considerably more objects available for use. It is also the case that simply incorporating a java applet or a browser plugin into an e-assessment can cause significant problems for students if sufficient time has not been allocated for their use in the assessment activity. Many of these applications require practice in their use, and students would need to be very familiar with them before incorporating them into a high stakes summative assessment task. The use of applets in assessments may be made more efficacious if their use is coupled with appropriate learning and assessment design principles. Tools that are relatively simple to use, but not simplistic, will be beneficial from the point of view of time efficiency and capability development. If students require many hours to learn how to use a particular tool, but are required to spend only a short time using it, then the benefits would be minimal for the time invested.

Electrophoresis is a common technique used to separate mixtures of biological macromolecules. The java applet illustrated in Figure 7 is an example of a tool that allows students to explore the consequences of changes in electric field strength, size of the macromolecule and the separation medium on the separation of a mixture of macromolecules. Different questions can be designed around the use of this tool, covering many of the main concepts associated with electrophoresis. This is a very practical example as students would use these concepts and tools based on this applet, in their professional work.

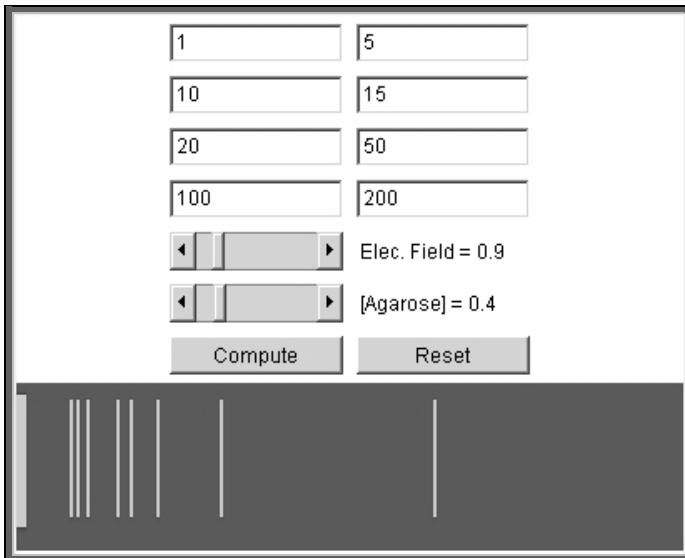


Figure 7 Java applet for exploring variables in the separation of macromolecules (Example from <http://webphysics.davidson.edu/applets/biogel/biogel.html>)

The well established methodologies associated with science-based research, and the use of physical and digital tools to assist in scientific investigations, has encouraged the use of digital resources in science-based teaching (Bryan, 2006). The disciplines of physics, engineering and mathematics are well represented in the availability of numerous java applets (Physlets, engApplets, ManipulaMath). Conceptual learning gains can be more readily determined if students are required to prepare responses that are multistructural and relational, rather than unistructural. The simple optics example illustrated in Figure 8 allows unistructural responses, such as whether a light beam is refracted by a certain amount, or whether total internal reflection will occur under given conditions; these questions would cover simple understanding of Snell's Law. The applet may also be used to explore more sophisticated applications of reflection and refraction using the relative light intensities resulting from the calculations. Teachers could set different scenarios that combined relational understanding with declarative knowledge, and so test higher level conceptual understanding. Figure 9 illustrates a java applet that enables students to explore the photoelectric effect; this applet allows students to experiment with different parameters and presents teachers with new opportunities to test students' conceptual understanding by exploring the consequences of non-standard experiments.

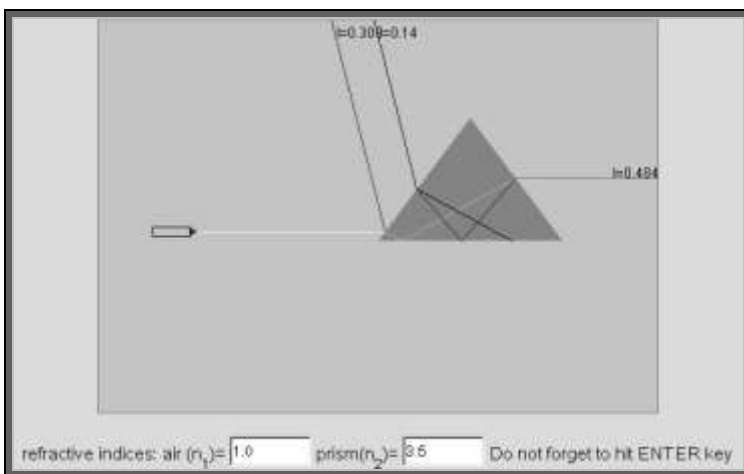


Figure 8 Java applet exploring applications of Snell's Law (Example from <http://www.phy.ntnu.edu.tw/ntnujava/>)

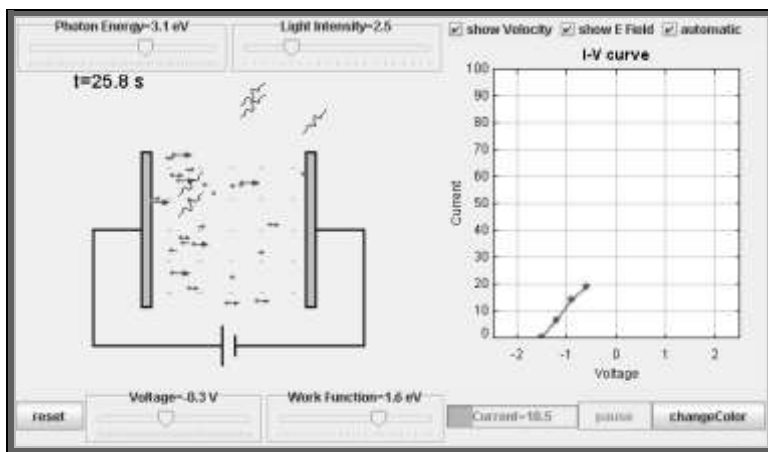


Figure 9 Java applet exploring the Photoelectric Effect (Example from <http://www.phy.ntnu.edu.tw/ntnujava/>)

Chemistry students are required to use the relative positions of elements on the Periodic Table to predict properties such as ionization energies and electron affinities. There are numerous interactive Periodic Tables available, and an example is illustrated in Figure 10, where the student has access to information on the individual elements and also the trends in the properties of the elements. Once again, questions can be set that require only a unistructural response, such as reading information directly from the Periodic Table, or alternatively, relational response questions can be set that require students to explore trends and construct an argument based on these trends. This applet is capable of being used at different levels, ranging from high school to university students. The same applet can be called for numerous assessments, depending on the objectives and SOLO level required. Teachers would use this tool in their classes, and also require students to interact with it during the learning process, so that the interface becomes familiar.

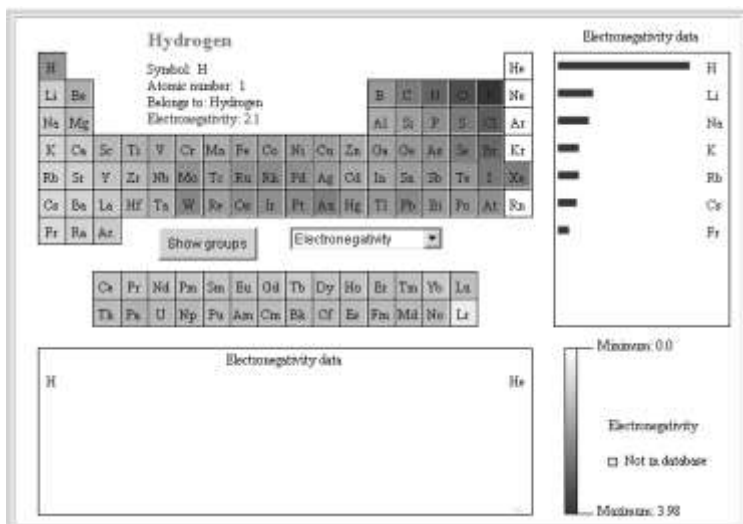


Figure 10 Interactive Periodic Table of the Elements (Example from <http://chemmac1.usc.edu/java/ptable/ptable.html>)

JeLSIM (Java eLearning SIMulations, JeLSIM) provides a simple toolkit for the preparation of simulations that can be packaged as java applets (Thomas and Milligan, 2004). JeLSIM uses a set of standard visualization objects such as graphs, tables, digital inputs and outputs that allows teachers with limited technical experience to prepare pedagogically useful simulations. Figure 11 illustrates an example of a series of practical experiments in chemical kinetics. Students may be set a series of experiments to undertake, and the assessment questions can cover simple declarative knowledge, procedural knowledge about experimental techniques, as well as relational questions that require conditional understanding. The student is required to think through the consequences of certain actions, and is given tools to explore what might happen by following the

expected path, but also what might happen if an unexpected path was taken. This allows a more extended range of questions to be used in the assessment.

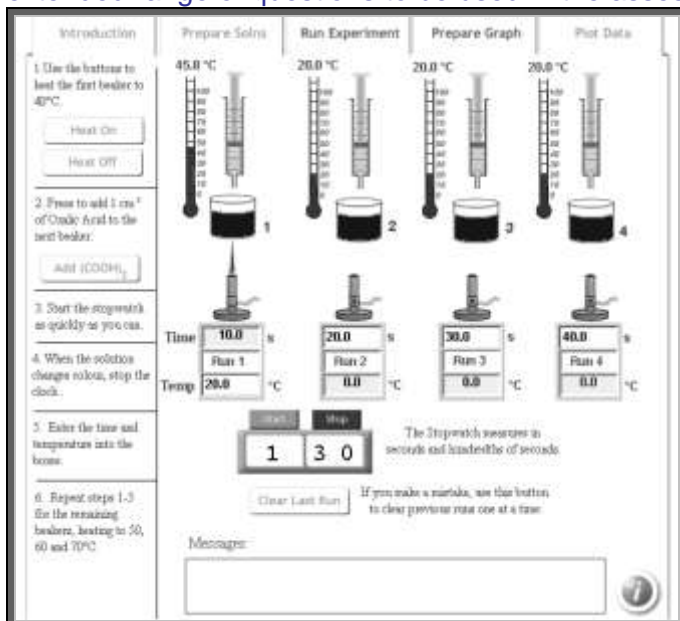


Figure 11 Example of JeLSIM simulation for chemistry practical exercise (Example from <http://www.scrolla.hw.ac.uk/talks/shock03/chemweb/sqa-ucles/ppa2/sqappa2.html>)

CONCLUSIONS

Interactive e-assessments allow students to respond not only in the 'expected' or predetermined way, but also in an unexpected, but sometimes equally valid, way. Providing students with interactive tools allows for the possibility for them to explore existing knowledge from a different perspective. Rather than attempt to mimic paper-based assessments, e-assessments should offer authentic problems that require students to manipulate authentic tools in order to respond to a question. The tools described in this paper provide new opportunities for teachers and students to move beyond the traditional question types associated with assessments. The ability to access well defined digital resources that are educationally appropriate has led to much interest in the establishment of digital repositories (Gupta, 2006). This will be critical to the widespread use of objects such as the java applets and browser plugins discussed in this paper.

It is essential for teachers to provide educational scaffolds that allow students to improve their learning outcomes through diagnostic and formative assessment coupled with appropriate feedback. The ability to provide tools that can enrich the assessment environment and allow exploration of the concepts under investigation should assist in improve student learning. As interactivity is paramount to engaging students, e-assessments should be designed so as to provide students with an opportunity to show capability development as well as content recall.

Although more research is clearly needed in this area, a review of the impact on students and teachers of the use of ICT for the assessment of creative and critical thinking skills has indicated a positive relationship between the use of computers for assessment and the development of critical thinking skills (EPPI, 2003).

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