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INTERACTIVE E-ASSESSMENT - PRACTICAL APPROACHES TO CONSTRUCTING MORE SOPHISTICATED ONLINE TASKS

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Abstract
This paper will explore some of the practical options that are available to teachers as we move towards Assessment 2.0. Assessment 2.0 describes an environment in which the teacher sets tasks that allow students to use more dynamic, immersive and interactive environments for exploring and creating responses to sophisticated assessment tasks. Assessments will become more like sophisticated games incorporating role-playing and scenarios; they will replicate many of the complexities of the real world, allowing students to explore and describe the consequences associated with their responses. This paper looks at how teachers can begin this journey through the use of simple interactive tools incorporated into familiar question types available in common learning management systems.

Keywords
e-assessment, higher order skills, interactivity, sophisticated assessment

Introduction

Assessment tasks in higher education must satisfy a diverse range of needs for a variety of stakeholders, including students, staff, institutions and future employers. Designing an assessment task is easy, however designing a meaningful assessment task that adds value for each of the stakeholders above is a time-consuming process and involves “planning, discussion, consensus building, reflection, measuring, analyzing, and improving based on the data and artefacts gathered about a learning objective” (Ramakishnan &Ramadoss, 2009). For teachers to be able to construct a variety of assessment tasks that will meet the needs of various stakeholders, they will likely have to devote significant time that will take them away from other activities, such as discipline research. So the temptation for time-poor teachers is to design assessment tasks that can be prepared quickly and that require student responses that can be marked efficiently. Meaningful assessment tasks that had an intrinsic worth beyond the immediate requirement for a mark or grade and which engaged students in an authentic activity would provide much deeper insights, for both the student and the teacher, about the capabilities that the student had developed.

E-assessments have traditionally been used for tasks that focus on testing the acquisition of declarative knowledge, or knowing “what” (Bull & McKenna, 200; Northcote, 2003); such tasks have required students to select a predetermined response based on factual recall, for example the familiar multiple-choice (MCQ) and short answer question type. Such questions have been popular because they are quick to write and are easily constructed in common learning management systems used in higher education institutions; teachers do not need significant training to be able to write and deliver such assessments. Although MCQs can be quick to write, valid and reliable MCQs require considerable expertise to construct (Considine, Botti, & Thomas, 2005; Johnstone, 2003). More recently, innovative e-assessment formats have been developed, including drag-anddrop, hotspot, matrix or extended matching questions, voice responses, as well as the use of certainty-based marking to capture the students' confidence in their level of understanding (http://www.ucl.ac.uk/lapt). Although these more innovative question types are becoming more commonly available in learning management systems, the predominant question type used is still the MCQ.

MCQs are typical selected response questions; students are provided with options from which they make a choice. Such questions are typically associated with convergent responses, that is, every student is expected to make the same choice – there is no ambiguity about the expected response. Another way of referring to these questions is to define them as testing non-contestable knowledge, or the currently held truths in a discipline. In higher education there is clearly a body of knowledge associated with each discipline, and students are expected to become familiar with this knowledge over the course of their studies. However, higher education is also concerned with contestable knowledge or contestable ways of thinking and even what is non-contestable today is often contested over time as our understanding of a particular discipline becomes more refined. Why discuss this in a paper about assessment? This paper is concerned with sophisticated assessment tasks, in particular those undertaken using a computer and the web. In order to test higher order capabilities we need to design sophisticated assessment tasks, but the workload in designing such tasks is considerable. So this paper is proposing a design strategy for interactive e-assessments that uses many of the question types that teachers are familiar with and which are constructed using any of the common learning management systems. The difference is to include an additional digital tool within the question to provide teachers with the opportunity to ask more sophisticated questions and students with the opportunity demonstrate higher order capability development. For the purposes of this paper we have not distinguished between the different types of assessment, namely diagnostic, formative and summative. From the perspective of designing sophisticated e-assessment tasks it makes no difference whether the task is designed for current or future learning, or to provide a mark or grade for progression or completion of a program.

General characteristics of sophisticated e-assessment tasks

So what is a sophisticated e-assessment task? Boyle and Hutchison (2009) have described sophisticated e-assessment tasks as having the following characteristics:

- should contain media-rich stimulus material (whether graphical, sound, video or animation)
- the test taker should be required to interact with the stimulus material in a variety of ways
- tend to be expensive and slow to develop, and not easily written by a non-specialist teacher

Boyle and Hutchinson also pointed out that many sophisticated e-assessment tasks tend to generate a relatively large quantity of data about what the student did during the task, often making interpretation and the assigning of a mark or grade difficult for teachers. Boyle and Hutchinson provided two examples of sophisticated e-assessment tasks using purposely built software systems; the Tripartite Interactive Assessment Development system (TRIADs), work carried out at the University of Derby (http://www.i4learn.co.uk) and World Class Tests taken by gifted and talented teenagers in the United Kingdom (World Class Arena, 2004). Neither of these systems is incorporated into common learning management system (LMS), and teachers would be confronted with a significant learning curve themselves if they wished to construct e-assessment tasks using these packages. They do offer good examples of the type of sophisticated tasks that could be devised for students in the online environment. This provides actual examples of what could be done, but no real practical way for discipline teachers to use these systems without first investing considerable amounts of time becoming proficient in the use of the software.

Currently, sophisticated e-assessment tasks are expensive and slow to construct, and frequently out of reach for discipline academics in universities. The technology is limiting a more widespread adoption of sophisticated e-assessment, so what is required is a design process that makes use of the current skills of teachers, or at least skills that that they can readily develop, and utilizes existing LMSs and tools that are readily available, versatile, easy to use and reuse, and that teachers do not have to build.

Assessment 2.0

In the constructivist approach to learning, students are expected to make decisions and reflect on the consequences of those decisions (Rust, O'Donovan, & Price, 2005). A constructivist learning environment provides students with access to information and authentic learning tools. These same tools and information sources should be available for students to use when they undertake assessment tasks in order for students to demonstrate the development of higher order capabilities. One of the ways we can render e-assessment tasks more sophisticated is to provide students with tools that they can use to construct non-text responses, analyse data, interact with digital objects, or interrogate objects within an assessment task. Assessment 2.0 is an emerging term (Elliot, 2008) used to describe tasks that are aligned with the characteristics of the Web 2.0 environment; these are tool-assisted tasks that provide students with opportunities for solving authentic and personalised problems; they facilitate deep approaches to learning as the tasks require an understanding of how to use a tool to assist with the construction of the response.

Allowing students to manipulate data, to examine the consequences of their responses and to make informed decisions about potential solutions are all consistent with the higher education ideals of assessing advanced skill development in students, as described by the higher levels of the SOLO taxonomy (Biggs, &Tang, 2007) or the Bloom's taxonomy (Thomas, Ashton, Austin, Beevers, Edwards, & Milligan, 2004). Table 1 provides a summary of descriptors for sophisticated e-assessment tasks, using terms that are common in current assessment rubrics. Simulations and sophisticated digital tools allow students to construct multistructural and relational responses to questions. Sophisticated e-assessment tasks are not meant to replicate paper-based assessments; they are designed to make use of the characteristics of the new digital educational environment, namely interactivity.

Table 1. *Descriptors for sophisticated e-assessment tasks using digital tools (using modified Bloom's taxonomy, Thomas et al., 2004)*

Assessing Understanding	Exemplify	students generate response data by using the tool
	Predict	students use the tool to predict what will happen
	Compare	students use the tool to compare data for two scenarios
	Explain	students use the tool to match selected response options in extended response questions type
Assessing Application	Complete	students use the tool to process a dataset and generate a result as a response to the question
	Implement	students use the tool to make a decision or draw a conclusion to an unknown situation
Assessing Analysis	Differentiate	students are presented with a case study and use the tool to test a number of potential explanations
	Determine coherence	students find relationships between information they have using the tool
Assessing Evaluation	Rationalise	students use a dataset within a case study to justify trends or conclusions
	Critique	students use the tool to look for inconsistencies in a dataset, scenario, or case study
Assessing Creativity	Exploring solutions	students use the tool to assist them construct a hypothesis
	Planning and refining	students use the tool to test a hypothesis and refine it

By providing students with tools that they must use to generate responses to questions, we are able to document the development of competencies and attributes that support current and future learning; students are actually developing meta-cognitive strategies for learning. One of the issues with many current assessment designs is that they foster a dependency in students on the teacher; this dependency is related to students believing they cannot make judgements about their own learning or performance level without input from the teacher. Clearly teachers have a pivotal role in defining standards and making judgements about assessment responses, but students should also be provided with opportunities to develop skills in judging their own learning and performance levels (Boud, & Falchikov, 2007). The ability of students to assess their own learning is critical to developing effective approaches to future learning. The difficult part for many teachers is designing appropriate learning activities that scaffold the development of these meta-cognitive self analysis skills and then to construct assessment tasks that are aligned with these learning activities. Although authors such as Shute, Ventura, Bauer, and Zapata-Rivera (2009) have proposed elegant models for measuring skills such as self-regulation or self-explanation, these tools have not been translated to a format suitable for use by discipline academics, nor have they been incorporated into common LMSs. Using sophisticated e-assessment tasks created through a common LMS should provide a more accessible pathway for discipline academics to design tasks that facilitate the testing of higher order capabilities and also provide students with access to tools that enable them to make judgements about their own learning or performance level.

So how do we provide teachers with a design strategy for sophisticated e-assessment tasks that makes use of existing LMSs and does not increase their workload significantly? If we separate the interactive tool that the student will use to assist them in generating their response from the actual question by incorporating a web link (URL) to the tool within the question, the question and any feedback given by the teacher can be constructed in any quiz tool in any LMS (Figure 1). This design principle also requires only one copy of the interactive tool to exist on an institutional server and so it can be used many times for different purposes or with different groups of students.

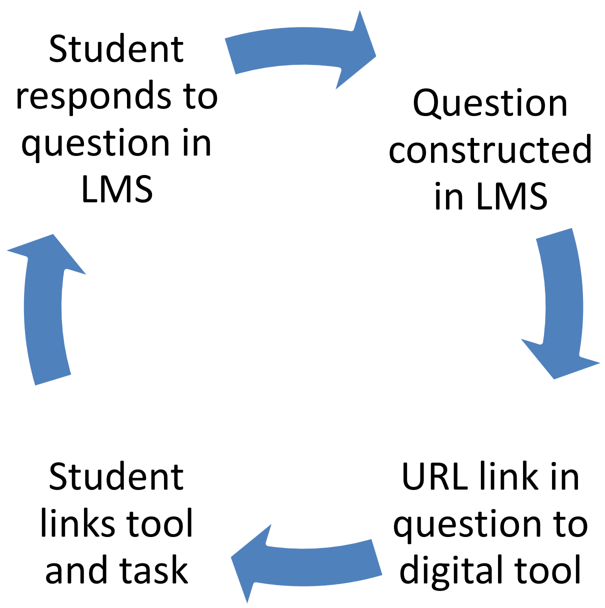

Figure 1. Design model for sophisticated e-assessment task

Discipline examples of sophisticated, interactive e-assessments

Not all digital tools will be suited to e-assessment tasks, nor will all discipline areas necessarily be able to find freely available resources. Nevertheless, teachers will find that there are a significant number of suitable tools for many of the fundamental science, engineering and mathematics areas. An early example of the use of interactive Java applets in learning was presented by Healy, Berger, Romero, Aberson, and Saw. (2002). A Java applet is a small computer program that is written using the Java programming language and packaged so that it will execute through a web browser. It is very convenient for teachers and students when the digital tool to be used in a sophisticated e-assessment task is available in the form of a Java applet or a Flash file as no special software, other than a web browser, is required to use the tool.

Many educational Java applets are freely available through the web and teachers can readily find and use these educational tools by either linking to the tool through an embedded URL to an external web site, or requesting a copy of the appropriate Java applet (*.jar or *.class files) for use on an institutional server. Teachers will not need to learn how to write their own Java applets, there are many suitable tools already available. The main technical task for the teacher is to embed the appropriate URL (that calls the Java applet) into an e-assessment item in their LMS. Figure 2 illustrates a typical example of a question constructed in a common LMS, incorporating a URL link to a Java applet; in this case the applet is a simulation of diffraction patterns resulting from light of different frequencies being displayed through a slit of various widths and at different angles. The Java applet is available from http://www.walter-fendt.de/ph14e or it can be downloaded (with permission from the applet creator) to an institutional server.

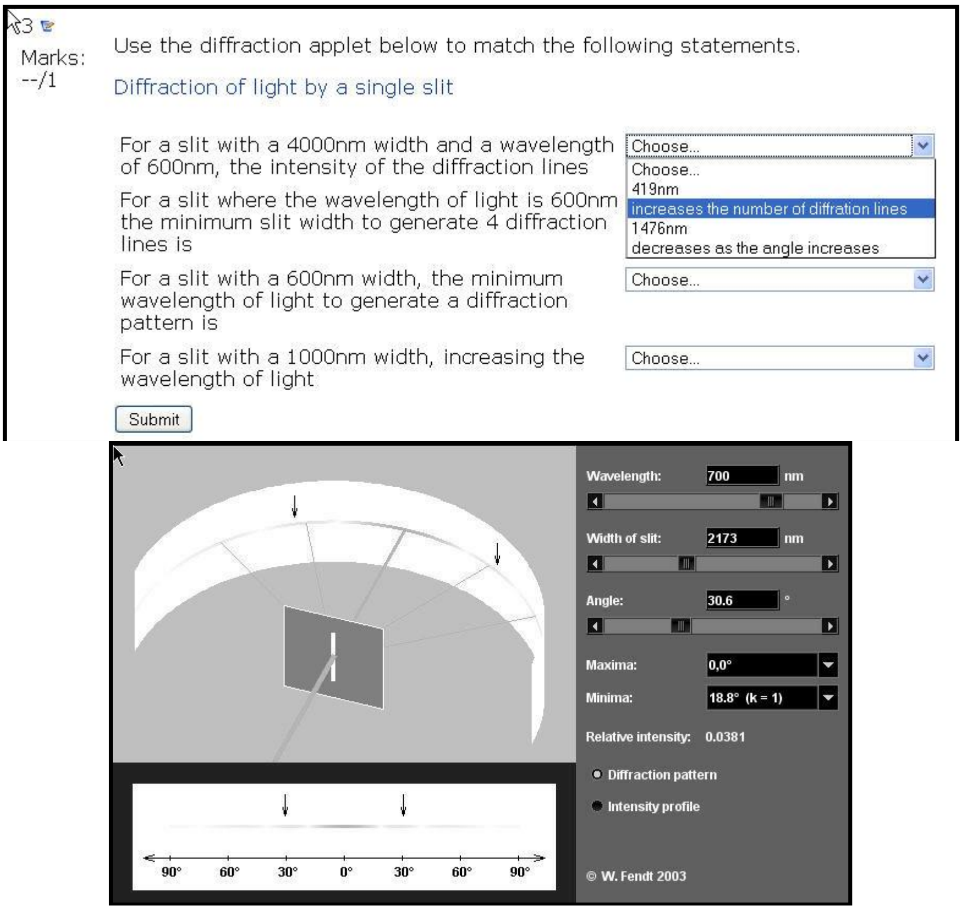

Figure 2. Example of Java applet simulation embedded in an e-assessment question

From the point of view of the student using the Java applet in an e-assessment, it makes no difference whether the tool is located on a local server within the institution or it is located on a remote server across the world. The only issue for teachers to consider is whether access to the digital tool is required for a high stakes summative task; in this case it is likely to be more reliable to locate a copy of the tool on the institutional server as access to the tool can be controlled more readily at the local level. For low stakes summative or formative assessments, ensuring access to the tool at any time will be less critical.

Table 2 provides some readily available sources for educational applets.

Table 2: *Examples of educational digital tools suitable for sophisticated e-assessment tasks*

Discipline	URL
Physics	http://webphysics.davidson.edu/Applets/Applets.html, http://www.walter-fendt.de/ph14e/ http://www.phy.ntnu.edu.tw/ntnuJava
Chemistry	http://www.chemcollective.org/applets/vlab.php http://www.chemcollective.org/applets/pertable.php http://www.molinspiration.com/jme/ http://jmol.sourceforge.net/
Biological sciences	http://wishart.biology.ualberta.ca/cgview/ http://employees.csbsju.edu/hjakubowski/Jmol/ERTamox/3ERTnew.htm http://www.physionet.org/physiotools/ecgsyn/Java/ecgsyn-Java.html http://relax.organ.su.se:8123/eurocarb/gwb/builder.action
Mathematics	http://www.analyzemath.com/ http://www.geogebra.org/cms/
Engineering	http://www.jhu.edu/virtlab/bridge/bridge.htm http://www.falstad.com/mathphysics.html http://www.engapplets.vt.edu/

Teachers should be aware that students will need to be given adequate time to become familiar with the Java applets before they can be used in an e-assessment task, as the tool is a crucial component of the assessment task. The more sophisticated the Java applet and the more options that are available for students within the applet, the more time teachers will need to allocate to learning activities that allow students to practice using the tool.

The early study by Healy et al. (2002) highlighted that the use of a digital tool *per se*, does not automatically improve student learning. It is critical that appropriate design strategies are used to ensure that any digital tool is pedagogically effective. Buzzetto-More and Alade (2006) collated examples of good practice in e-assessment and highlighted the advantages of the use of simulations as authentic activities. Simulations or digital tools that allow the analysis of datasets require students to use higher order thinking as well as the application of knowledge and skills in a potentially authentic environment. However, the use of a simulation or digital tool that is associated with a simple MCQ will rarely give any insight into the thought processes students used to determine their responses. One option that teachers can use is to construct nested selected response questions, such as those illustrated in Figure 3, where the student is provided with a series of interrelated questions, each requiring the use of the digital tool, and each aligned with a key concept, in this case the structure-activity relationship between functional groups and solubility. This example uses the traditional format of a computer-marked question format, so uses the selected response format.

The example in Figure 3 also highlights the potential of incorporating digital tools and simulations into e-assessments to radically change the type of question we can set for students. The traditional selected response format (MCQ) is associated with convergent responses, that is, all students are expected to provide the same (correct) response. This is true for the questions illustrated in Figure 3. However, as we have provided students with a tool that allows them to explore the relationship between structure and activity themselves, we could reframe this question to require a divergent response; different students could provide different, equally valid, responses. If we asked the students to design a molecule that had specific properties, for example, a TPSA value between 15 and 17, then students would need to be familiar with the relationship between structure and the property being investigated, but they are able to demonstrate that understanding by designing their own molecule. In this case, the students' responses would be assessed by a teacher, rather than the computer. Students can also test their own understanding by changing the structure of the molecule and examining the effect on physical or biological properties. This activity would facilitate the development of self-review skills in students; by providing students with tools to test their own levels of understanding we would be reducing their dependency on teachers, and having to wait to receive feedback about whether they have an adequate understanding of the key concepts.

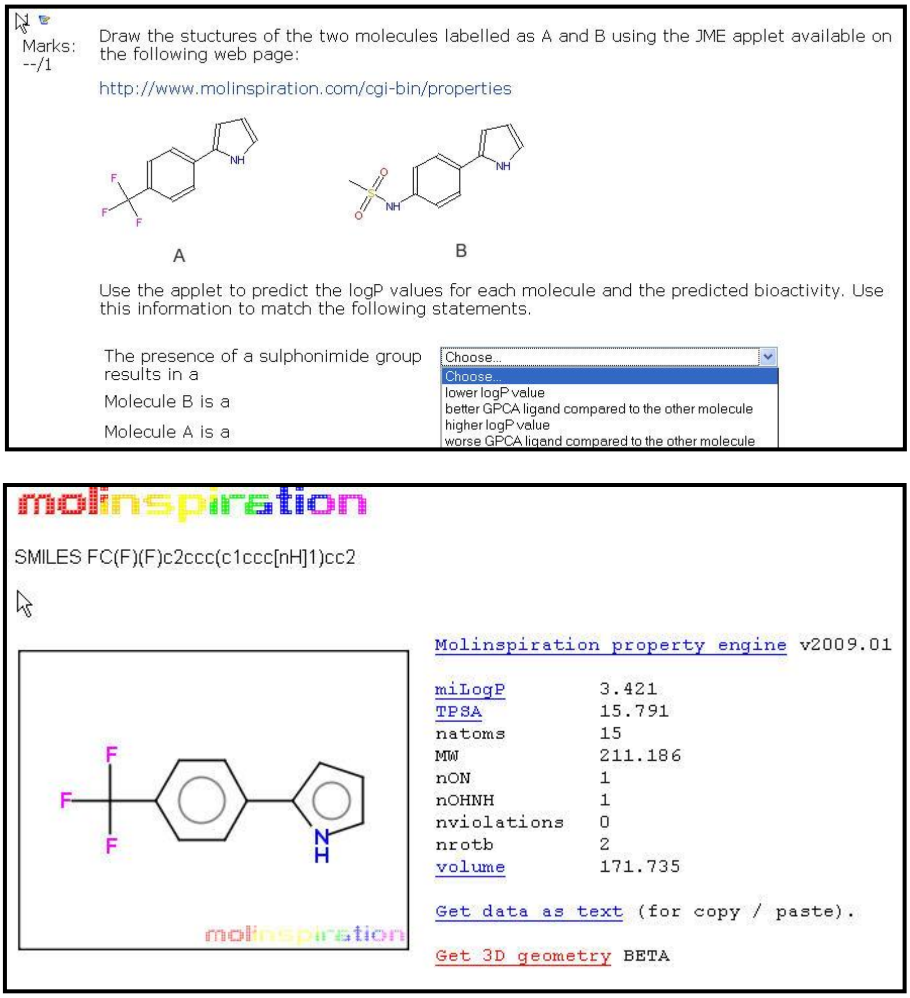

Figure 3. Example of digital tool embedded in an e-assessment question

In order to reduce the workload on teachers when they are constructing sophisticated e-assessment tasks, institutional learning designers or other support staff, could develop templates that are readily incorporated into the institutional LMS. An example is illustrated in Figure 4. A series of such templates could be made available for different question formats using a particular digital tool; this digital tool would likely be one that resides on the institutional server and used for both learning and assessment activities. This approach of developing templates for teachers has a number of benefits; it encourages a team approach to curriculum design, it reduces the need for teachers to learn technical skills before being able to generate sophisticated e-assessment tasks for their students, it also maintains the role of the teacher as the person responsible for writing the actual question and providing the appropriate feedback. Teachers will feel they are still in control of the learning environment, even if they have only basic technical skills.

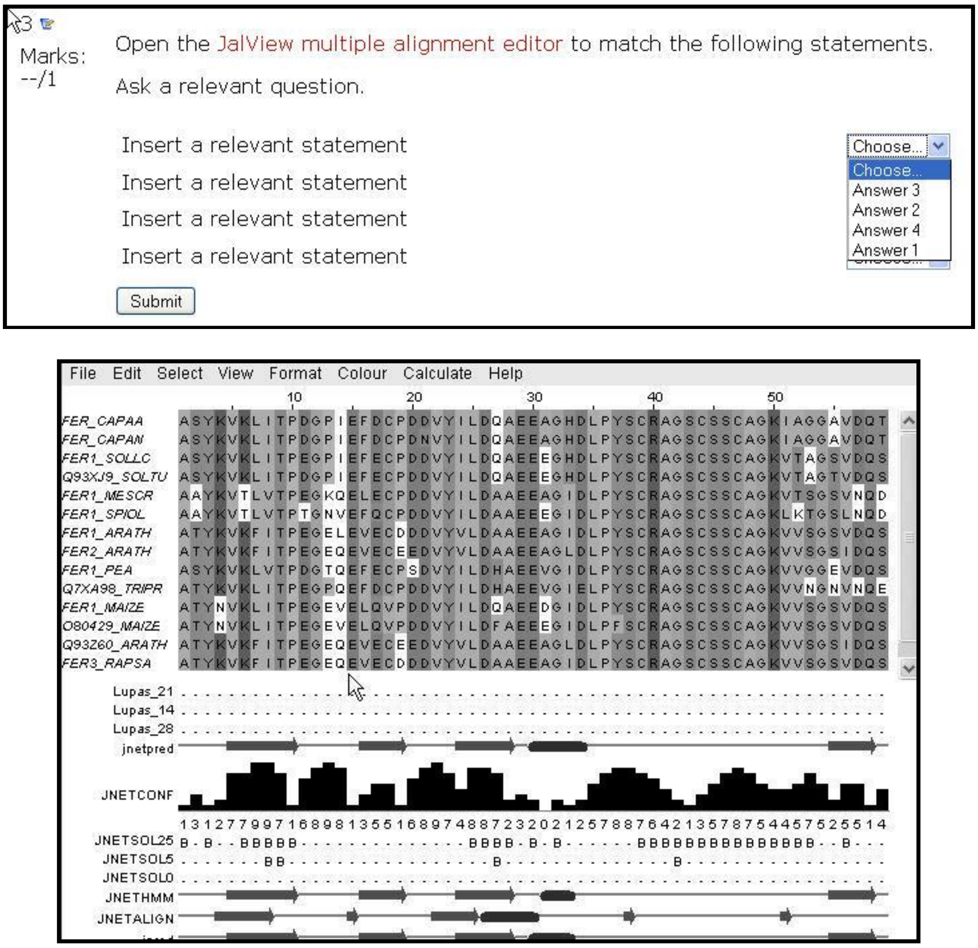

Figure 4. Example of digital tool embedded in an e-assessment question

Java applets were used to illustrate the concept of a digital tool that could facilitate the construction of sophisticated e-assessment tasks. Other examples of relevant digital tools include the use of Excel spreadsheets with embedded macros (Lim, 2006), Flash simulations and QuickTime VR images. 3D images, where students could examine the relative spatial orientations of objects within the image, would allow more sophisticated questions to be set in the online environment. An example of the use of a QuickTime VR image incorporated into a selected response question in a typical LMS is illustrated in Figure 5. Here the student is being asked to examine the volcano and identify particular geological features. Although this example is quite simple, the teacher could create a series of nested selected response questions that require the student to move around the 3D image of the volcano and identify objects that have specific spatial relationships to each other. This type of assessment task would not be possible with a static image of a site. Other examples of useful QuickTime VR images would be complex 3D images of anatomical or biological specimens, molecular structures, engineering sites, archaeological sites, museums, landscape features or architectural plans for buildings.

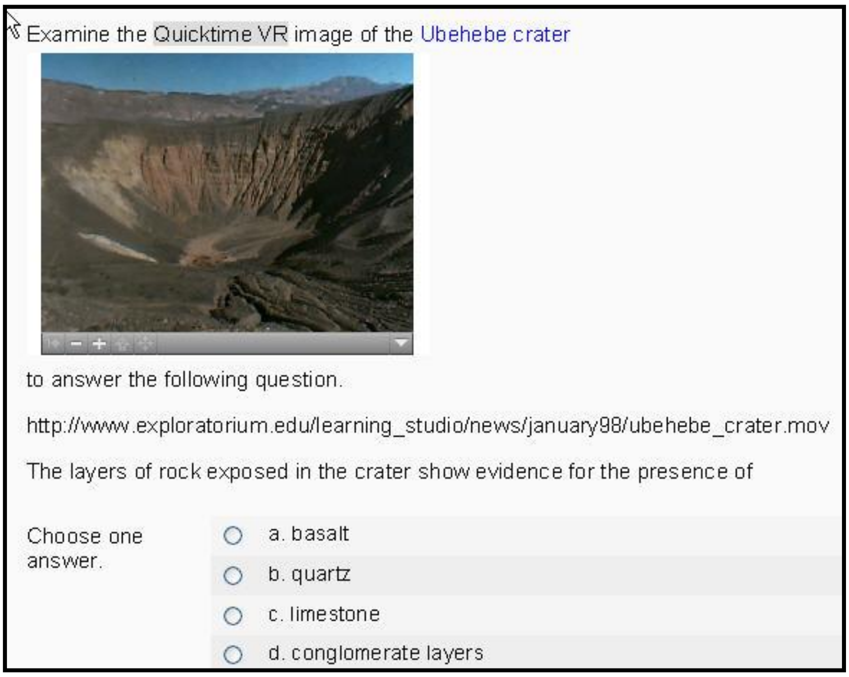

Figure 5. Example of QuickTime VR image embedded in an e-assessment question

Conclusion

This paper has proposed an e-assessment design model based on the incorporation of a URL link to a digital tool within questions developed using quiz tools in common learning management systems. The design allows teachers with minimal technical skills to construct sophisticated e-assessment tasks and to test higher order skills. Providing students with access to digital tools within assessment tasks also facilitates the development of self-analysis skills in students and reduces their dependence on teachers for affirmation of whether a response is appropriate or not. The modular nature of the design principle also allows the development of templates that teachers could use, further reducing the workload required to build online assessments.

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