ENHANCING WEB-BASED LEARNING WITH COMPUTER ASSISTED ASSESSMENT:

PEDAGOGICAL AND TECHNICAL CONSIDERATIONS

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Enhancing web-based learning with computer assisted assessment: Pedagogical and technical considerations

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Abstract

Computer assisted assessment (CAA) has become increasingly popular for formal assessments such as course exams, and a number of web-based and stand-alone systems have been developed for this purpose. A primary motivation for the use of CAA in exams is efficiency, such as in the presentation of materials, collation of responses, and rapid scoring and feedback to students. However, CAA can also play a valuable role **during** the learning process. Practice questions with feedback can be integrated within other learning materials and activities to assist with consolidation of understanding during learning. This use of CAA provides learners with an opportunity to test their emergent understanding, and in particular, to quickly identify failures in assumed understanding. CAA-based identification of problem areas during the learning process has the potential to enhance the metacognitive skill of self-assessment on the part of the learner, in addition to correcting specific errors. As a result, regular self-testing and feedback during learning via CAA may significantly enhance overall learning outcomes at both discipline specific and generic levels. This is particularly appropriate for web-based learning.

This paper discusses a range of different examples of web-based learning from within higher education and corporate training contexts in Australia. It explores different types of CAA integrated with web-based learning from the perspective of both pedagogy and technology. Pedagogical models for the incorporation of CAA include self-testing embedded within learning material, end of section tests, different styles of feedback, pre-tests with advice on appropriate courses, and question bank driven final quizzes. These models are reviewed with a particular focus on consolidation of knowledge, and self-assessment of understanding. Technological models include a review of different modes for presenting CAA within learning, such as general course platform tools (eg, WebCT), dedicated CAA systems (eg, WebMCQ), authoring tools which may be adapted to present CAA (eg, Flash), and web-based programming languages which can be utilised to present CAA (eg, Java applets). In each case, advantages and disadvantages of different technical approaches (in terms of ease of use, technical proficiency, hardware/software requirements, tracking features, and costs) are discussed. It is argued that there is no single solution to integrating CAA with web-based learning, but rather that different approaches are appropriate to different developer contexts and learning outcomes.

Key words

CAA, formative assessment, learning, pedagogy, technical

Introduction

While there are a range of possible uses of computer assisted assessment (CAA) within education, summative assessment has been the predominant mode to date (Bull, 1999). There are obvious reasons for the appeal of CAA in formal testing, such as: efficiencies arising from the presentation of test materials; the centralised recording, collation and processing of responses; and the potential for immediate feedback to students concerning their performance. Immediate test performance information appears to be particularly attractive to students (Dalziel & Gazzard, 1999a), even where the results are only preliminary or subject to future scaling. The difference in waiting time for scores and feedback (eg, a month versus a few seconds) is a significant recent advance in educational efficiency which appears to have a direct outcome on student experiences of their courses (eg, O'Byrne, 1999).

Apart from summative uses of CAA, formative assessment has much to recommend it (Dalziel, 2000). While CAA, and multiple choice questions in particular, have been a target for criticism regarding their relatively low-level educational value (based on the taxonomy of Bloom, 1956), formative CAA can be used to help bridge the gap between assessment and learning. This may be achieved in part by using CAA with better-designed questions (see Haladyna, 1997), but more particularly where CAA is combined with useful feedback, and integrated within the learning process (Dalziel & Gazzard, 1999b). This approach to CAA is particularly relevant to the considerable

recent interest in web-based learning, where CAA can be used to easily add educationally useful interactivity to online courses.

The educational value of formative CAA arises largely from its ability to provide students with immediate feedback on their understanding. This feedback need not be limited to correct/incorrect responses, but can include detailed textual feedback about answers and the topic area of the question. Formative CAA can assist in consolidation of learning, and in identifying weaknesses in assumed understanding. In addition to the specific learning effects that immediate feedback has within an online course, formative assessment may have a more general effect on students by enhancing self-assessment of understanding. This metacognitive skill (of "knowing when you know something and when you don't") is considered by many to be a key feature of tertiary-level education, and it is surprising that the "lowly" multiple choice question has the potential to play a role in the development of this higher-order cognitive skill.

The current paper explores a range of pedagogical and technological models for the use of formative CAA. It attempts to provide some categorisation of both teaching and technical approaches, and identify relative advantages of each of these. To illustrate these relative advantages, five pedagogical models and four technological models for the use of formative CAA are presented. These are considered according to a range of features concerning implementing CAA within learning. This review of models and features arises from a consideration of three examples of web-based learning in which the author has been involved: (1) a range of courses concerning investor education for a stock exchange; (2) interactive materials for a financial markets training organisation, and (3) online support materials for a law course. Each of these examples (as they relate to the current topic) is briefly outlined below.

The pedagogical and technological models outlined here should not be considered as either exhaustive or definitive (and given the rapid rate of technological development, the technological review may change rapidly). However, they may provide a useful framework for considering different types of formative CAA for use within education.

Three examples of formative CAA

The first, and most comprehensive, example of the use of formative CAA considered here is a range of web-based courses developed with the Australian Stock Exchange for investor education. Each course included a pre-test which provided advice on whether a particular course was appropriate for a learner (depending on the level of understanding indicated by question scores). Embedded within each course, two types of assessment were provided: "mini-tests" embedded in some pages, which provided simple self-test questions and feedback (sometimes drawing from a bank of questions); and end of section tests, which provided questions with detailed immediate feedback (at multiple levels). At the end of each course, a summative-style quiz was provided, drawing from a larger bank of questions that encouraged multiple attempts at the quiz. At the end of a quiz, each section was scored, and feedback on the need for further

study was provided. In terms of technology, the pre-test, end of section tests and final quiz were implemented using WebMCQ, and the mini-tests were run as Java applets.

The second example is based on the development of self-test exercises and revision quizzes for a financial markets training organisation. The exercises and quizzes included true/false, multiple choice and open text-entry style questions, most with immediate feedback. All exercises were built using the "Flash" authoring tool, and had the potential to draw question data from an external source independent to the Flash files.

The third example is based on the development of several prototypes for online supporting materials for a law course. As part of preparation for classroom exercises, multiple choice questions and a discussion forum were used. The prototype was developed using several different formats based around the WebCT course platform system. These included using the "quiz tool", or alternatively the "self-test tool" in WebCT for the presentation of formative CAA material.

The three examples described above provide a context for attempting to categorise pedagogical and technological features of formative CAA. While it is not necessary to have a detailed understanding of each of these examples to appreciate the discussion below, the above information is provided as a concrete basis for attempting to make the following judgements.

Pedagogical models of using CAA for learning

As described in the Introduction, five pedagogical models of formative CAA use are outlined in this section. They arise primarily from the context of web-based learning materials, although they are applicable to other contexts. While the five models are not designed to be exhaustive, they provide an overview of different kinds of formative CAA use. The models are: (1) the use of pre-tests, taken prior to learning to assist in determining levels of existing understanding and appropriate courses for study; (2) the use of self-testing "objects" within learning (where a "mini-test" is embedded within a given page in a larger course); (3) the use of "end of section" tests, which are generally larger than mini-tests, and may focus on a greater breadth of content as part of an attempt to consolidate learning across a given content area; (4) different types of feedback, such as multi-layered feedback, option specific feedback, the ability to try again, etc; and (5) the use of final quizzes at the end of learning, particularly where these draw from a bank of questions, and hence encourage more than one attempt at a final test.

These five models can be examined for usefulness against a wide set of possible criteria. For the current purposes, four are suggested: (1) recognition of prior learning; (2) testing of understanding during learning; (3) embedding learning within the testing process, and (4) providing summative-style scoring of responses. Given these four criteria, and the five models, a matrix of usefulness can be constructed. It should be

recognised that some of the indications of usefulness presented here will change with different contexts, but for the current purposes, they provide an overview of usefulness, particularly as derived from the three examples presented above.

	Recognition of prior learning	**Testing of understanding during learning**	**Embed learning within testing**	**Provide summative-style scores**
Pre-test	High	Low	Low	Moderate
Mini-test	Moderate	High	Moderate	Moderate
End of section test	Low	High	High	Moderate/ High
Use of feedback	Moderate (if multi-layered)	Moderate	High	Low/ Moderate
Question bank final quiz	Low	Low	Moderate (if advice on study)	High

Table 1: Matrix of the usefulness of various types of computer assisted assessment for certain pedagogical objectives.

In terms of pre-tests, these have an obvious attraction for recognition of prior learning. Due to their "pre-learning" position, they have limited value for testing understanding during learning or embedding learning within testing. Pre-tests have the potential to provide summative-style scoring, although the main value of pre-tests is typically the feedback about how scores relate to appropriate courses and learning, rather than the scores themselves.

For mini-tests, these have some advantage for prior learning, in that the mini-test topic is normally quickly apparent to the learner, and hence may be skipped if the learner feels they have sufficient understanding. Mini-tests are ideal for testing understanding during the learning process, and can also be used for embedding learning within tests provided that the feedback includes an indication of the reasons for correct/incorrect answers. Like pre-tests, mini-tests have some value in terms of scoring although this is not normally their most important feature.

End of section tests are similar to mini-tests, although they have a more formal place in consolidating learning (and stand somewhere between mini-tests and final quizzes in terms of breadth of content). Due to their location, they are not normally associated with recognition of prior learning (although they can be used to assist in determining future learning topics), but like mini-tests, they are well designed for testing learning and linking learning with assessment where they provide detailed feedback. Their provision

of scoring can assist with learning, particularly where this indicates areas for further study, or future topics to study (or skip).

The use of feedback is more of a functional rather than structural aspect of the placement of formative CAA within learning. It is identified separately here to draw attention to its particular value in enhancing testing with opportunities for learning (either by way of consolidation/correction, or for new learning that extends beyond existing content). Feedback can enhance recognition of prior learning and testing of understanding during learning, particularly where this feedback is adapted to encourage understanding (such as through multi-layered feedback, where question-specific information is given at first, and then more general information is provided at a second level for those with further interest). Question-specific feedback generally plays a more limited role in summative style scoring, although the provision of feedback on specific incorrect responses following a test can target areas for remediation.

The use of a final quiz at the end of learning, particularly one that draws its items from a larger bank of questions, is useful in simulating a formal test environment. It is of limited use in recognition of prior learning, and testing understanding during the learning process due to its location in the structure of learning materials (ie, at the end). However, as discussed above, summative-style tests can provide useful feedback that may enhance learning if this is provided after the test is complete. However, by breaking the direct link between answering and immediate feedback, this approach is not as useful as mini-tests or end-of-section tests in terms of embedding learning within testing.

Technological models of using CAA for learning

In a similar way to the section above, this section describes four types of technological models for presenting formative CAA, and then relates these to five use-related criteria. The four models are: (1) using a general course platform tool for formative CAA (based on the example described above, ie, WebCT Version 3.1); (2) using a specific CAA system (in this case, WebMCQ, a system which the author has been involved in developing); (3) using an authoring tool (in this case "Flash"); and (4) using a web-based programming language (in this case "Java"). It should be noted that a range of other possible systems could have been included here, but the focus has been narrowed to the three concrete examples described. It should also be recognised that the pace of technological development may alter the descriptions presented here quite rapidly.

The five criteria used to consider the usefulness of the systems outline above are: (1) the ease of use (both from the designer's and the student's point of view); (2) the technical proficiency required by the designer to make use of the tool for formative CAA; (3) the degree of special hardware or software required to incorporate the tool into learning; (4) the ability of the tool to track performance data arising from use of the tool; and (5) the costs of using the tool to enhance learning.

	Ease of use	Technical proficiency needs	Hardware/ software needs	Tracking	Costs
Course platform tools (eg WebCT)	Moderate	Low	High (Low if ASP model)	Depends	High (Low if already available)
CAA systems (eg WebMCQ)	High	Low	High (Low if ASP model)	Yes	Moderate (Low if already available)
Authoring tools (eg Flash)	Low	Moderate	Moderate (require Plug-in)	No	Moderate
Web-based languages (eg Java)	Low	High	Low	No	Low

Table 2: Matrix of various systems for computer assisted assessment according to technical requirements.

In terms of course platform tools, the ease of use for formative CAA is generally good, although not necessarily as high as that provided by dedicated CAA systems. In the case of WebCT (V3.1) in the current context, the use of the quiz function for formative CAA is not ideal due to the lack of immediate feedback. On the other hand, the self-test tool does provide immediate feedback, but lacks tracking (a feature of the quiz function). The technical proficiency needs of formative CAA using a course platform tool are generally low, although this assumes access to a server with the software installed, hence the high hardware/software need. This can be alleviated with application service provision (ASP) models where hosting is provided by the course platform provider. Using a course platform for formative CAA alone involves high costs, but may be offset where these costs are already covered due to a broader implementation of web-based learning.

Dedicated CAA systems are generally easy to use for formative CAA due to their more narrow focus. The proficiency and hardware/software requirements are similar to course platform tools, and in the case of WebMCQ, the ASP provision of this system can assist in avoiding significant hardware needs. Tracking is generally a standard feature of CAA systems, and in some cases where these systems are linked to a more general course system, it may be possible to consolidate all course and test tracking data in a single location. The costs of CAA systems are moderate on average, but vary according to the extent of use and model of software provision (product versus ASP). As with course platform tools, the costs of using a formative CAA system may be offset if CAA is already available due to other uses (such as in summative exams).

Authoring tools can be adapted to present formative CAA, particularly for "mini-tests". However, their ease of use and technical needs from a designer perspective are not normally as attractive as course platforms or CAA systems. Authoring tools are generally attractive in terms of lack of hardware and software requirements, except that a plug-in to a web-browser may be required (and while Flash is now widely used, other less common plug-ins may present challenges to users). Current authoring systems tend not to provide options for tracking (although this may become possible in the future - but this will then require a location for tracking data to be stored). Costs are moderate, arising from the need for designers to purchase the authoring package.

Web-based languages such as Java place high technical proficiency requirements on designers, but do not require plug-ins, and generally have low costs for development. However, in the absence of an additional system for storing tracking data, they do not normally record user responses.

Conclusion

In summary, there is no one solution to the needs of formative CAA at either the level of pedagogy or technology. Each of the approaches outlined in this paper has its advantages and disadvantages, and designers will need to choose those options which are most appropriate to their development context and the needs of their learners. The combination of a range of pedagogical approaches is likely to yield the best results (provided that learners do not feel "over-tested"), but these will need to be tempered by the available technology.

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