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Relevant Aspects for Test Delivery Systems Evaluation

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1. INTRODUCTION

The number of educational institutions seeking solutions to the problems associated with the burden of expanded student numbers is increasing every day. Most solutions to the problems of delivering course content, supporting student learning and assessment may be found through the use of computers thanks to the continuous advances of the information technology. According to Bull (1999) using computers to perform assessment is more contentious than using them both to deliver content and to support student learning. In many papers, the terms Computer Assisted Assessment (CAA) and Computer Based Assessment (CBA) are often used interchangeably and somewhat inconsistently. The former usually covers all use of computers in assessment including reporting and marking such as in optical mark reading. The latter is often restricted to the use of computers for the entire process including delivery of the assessment and provision of feedback (Charman and Elmes, 1998). In this paper we will adopt the term Computer Based Assessment and we will discuss some issues related to the on-line assessment of students.

The interest in developing CBA tools has increased in recent years, thanks to the potential market of their applications. Many commercial products, as well as freeware and shareware tools, are the result of studies and research in this field made by companies and public institutions.

For an updated survey of course and test delivery/management systems for distance learning see Looms (2000). This site maintains a description of more then 100 products, and is constantly updated with new items.

Such a large number of assessment systems available, obviously raises the problem of identifying a set of criteria useful to an educational team wishing to select the most appropriate tool for their assessment needs. From a survey of all the material available on the net, starting from the results returned by the most common search engines, and then going to a number of sites maintaining links related to educational resources (ERIC®, 2000; TECFA, 2000; CAA Centre 2000) it appears that only two papers have been devoted to such an important topic (Freemont & Jones, 1994; Gibson et al., 1995). The major drawback shown by both papers being the unstated underlying axiom that a CBA system is a sort of monolith that must be evaluated as a single entity. This is false since the structure of a CBA system is very complex, as shown in figure 1.

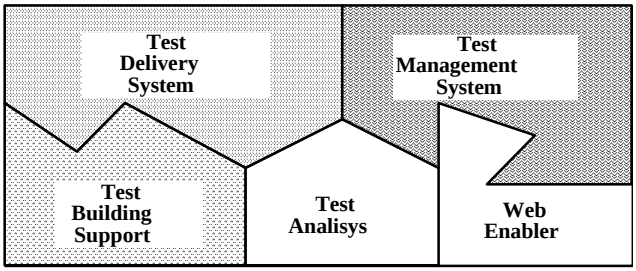

Figure 1 – The complete structure of a CBA tool

According to figure 1, a CBA system is composed by:

* A Test Management System (TMS) - i.e. a tool providing the instructor with an easy to use interface, the ability to create questions and to assemble them into tests, the possibility of grading the tests and to make some statistical evaluations of the results.
* A Test Delivery System (TDS) - i.e. a tool for the delivery of tests to the students. The tool may be used to deliver tests through paper and pencil, locally, on a LAN, or over the web.
* A Web-enabler that may be used to deliver the tests over the WWW. The web-enabler may be implemented as a separate tool. In many other cases producers distribute two different versions of the same TDS, one to deliver tests either on single computers or on LAN, and the other to deliver tests over the web. This is the policy adopted for instance by Cogent Computing Co. (2000) with CQuest-Test and CQuest-Web.
* Some utilities for Test Building Support – a set of tools that may provide the teacher help to build up both well formed questions and tests. An instance of a TBS utility is represented by "Better Testing" developed by Question Mark Computing Ltd. (2000) and sold separately with respect to the TDS/TMS application.
* Some utilities for Test Analysis – a set of tools that may be used to analyze the performances of the students individually and with respect to the class. As an example, Assessment System Co. delivers a large set of different programs both for item and test analysis. "These programs are based on classical test theory, on Rasch model analysis using the 1- 2- and 3-parameter logistic IRT model, on non-parametric IRT analysis, and on IRT analysis for attitude and preference data" (Assessment System Co, 2000).

Obviously the modules composing a CBA system may be integrated in a single application as for instance InQsit (2000) developed by the Ball State University, or may be delivered as separate applications. As an instance of this latter policy, we may cite ExaMaker & Examine developed by HitReturn (2000): in this case Examine (the TDS) is provided free of charge.

Therefore, it is very important to identify some metrics that can be used to evaluate all the modules that belong to this general structure of a CBA system.

The purpose of this paper is to present a proposal for a framework that may help to identify some guidelines for the selection of a Test Delivery System.

Three main functional modules roughly compose a Test Delivery System: a student interface, a question management unit and a test delivery unit. Therefore, we have decided to organize our framework by identifying some metrics that may support the evaluation of the functional modules, and other metrics that may support the evaluation of the system as a whole. Finally, we discovered the need of introducing some domain-specific metrics to evaluate the system with respect to the cheating issue.

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In section 2 we will present the metrics for the evaluation of a TDS at the component element; in section 3 we will discuss the metrics for the evaluation of a TDS at system level and in section 4 we will introduce some remarks on cheating and on the possible countermeasures to be adopted. Some final remarks and hints for further research will follow.

2. METRICS FOR THE EVALUATION OF A TDS AT COMPONENT LEVEL

2.1 Interface

Although there is a lot of work in the literature on the criteria to be adopted for the evaluation of a Graphical User Interface (GUI) from the point of view of usability (see for instance Nielsen & Molich, 1990 and Gilham et al., 1995), this issue seems to attain little importance when evaluating any commercial product.

We strongly believe that the evaluation of the interface is a qualifying aspect for the evaluation of a CBA system and obviously for a TDS. This becomes dramatically true, if we take into account the fact that neither the teacher nor the students involved in the use of a TDS necessarily has a degree in computer science, nor may be interested in acquiring skills in this field.

In the following, we will list some well-known guidelines that may be used to evaluate a GUI. As Nielsen & Molich (1990) simply proposed, the interface must be easy to learn, efficient to use, easy to remember, error free and subjectively pleasing.

Some of the criteria that may be adopted to evaluate the usability of a GUI are summarized in the following list:

* speak the users' language (multilinguality & multiculturality)

With respect to this point, it is worth remembering that the European Union (EU) comprises eleven official languages plus a large number of national specific versions and of regional languages. Additional language requirements are issued by the European Free Trade Association involving four more countries and by Eastern Europe.

It is obvious that the assessment process of users with different languages should be done according a chosen language and in a familiar cultural environment (meaning for instance taking into consideration the cultural bias or acceptability of icons, key words, etc.).

The availability of features that allow switching among different languages, yet maintaining the same assessment capabilities would be very valuable. This aspect may be very interesting for educational institutions providing cross-countries learning material. (CEN/ISSS WS/LT, 2000)

* be accessible

Accessibility is used in this context as the usability of information systems by persons who cannot use the standard text and image based computer interaction.

The United Nations estimates that approximately ten percent of the population of a country has some sort of disability (impairment). These data vary considerably from country to country, rising up to 25% of the population whenever moderate forms of sight and hearing losses are taken into account. With respect to the accessibility issue, the EU promotes a cross-programme theme in the fifth framework programme for research.

Obviously the availability of tools able to improve the accessibility of a TDS may be of great importance for any educational institution. (CEN/ISSS WS/LT, 2000)

* provide feedback

This item is related to ability to provide information to the student once the answer to a given question has been entered. Feedback will be discussed in some more detail in the next section.

* provide clearly marked exits

According to King (1998) who conducted an evaluation questionnaire on the CAA examination process at the University of Portsmouth – UK, about 6% of students providing adverse comments (7 out of 112) addressed the problem of obtaining and end-screen to be sure of having answered to all questions.

2.2 Question Management

Among the issues to be taken into account to evaluate the Question Management unit of a TDS the ability to provide multiple attempts at solving a question, the ability to provide feedback and tutorials on the topic covered by the questions, and the capability of including multimedia in questions have been selected.

Retries

This item is related to the ability to allow multiple attempts in answering a question. Obviously, this ability may be of great importance for self-assessment, since it may be useful to improve the knowledge of the student whilst reducing the need of providing feedback and or tutoring.

On the other hand, the impossibility to change the answer to a question during an examination is often perceived as unfair by the students. According to a study conducted by King (1998) on the evaluation of a CAA protocol, about 34% of the students providing adverse comments needed the ability of repeating/retrying responses. It is worth outlining that allowing multiple attempts at question answering may affect the use of adaptive systems whenever item presentation depends on previous responses.

On the other side, retries may represent a vehicle for cheating as will be shown in section 4 of this paper.

Feedback & Tutorials

This item is related to the ability to provide information to the student once the answer to a given question has been entered. The feedback may be provided after each question (this solution being preferable for self-assessment), after a set of questions covering a given topic or at the end of the test and can be based on the overall performance. Furthermore, the feedback may be used to indicate the correctness of the answer, to correct mis-conceptions or to deliver additional material for deepening and/or broadening the coverage of the topic assessed by the question. Tutorials represent an extended approach to provide additional information to the students. The existence of some facility for ease inclusion of tutorials in the TDS represents an important feedback aid. As an example, Perception provides explanation-type questions that may be used for "information screens, title pages, or to display large bodies of text" (Question Mark Co., 2000).

Multimedia

The use of questions incorporating multimedia, such as sound and video clips or images, may improve the level of knowledge evaluation. This aspect may be of great importance for example in language assessment, where the comprehension of a talk or a movie can be assessed by recurring to multimedia only.

The use of multimedia can raise issues related to portability and interoperability since it may require special hardware and software, both for the server delivering the questions and for the client used by the students. Furthermore it may raise the costs for the adopted solution. These issues may not represent a problem whenever a Web-enabled TDS is selected, since the nature of the WWW is inherently multimedial. In this case, the choice of standard plug-ins for the most common browsers may reduce risks of portability and of interoperability. Since most plug-ins used to grant access to

multimedia sources are usually free of charge, their use may not interfere with cost problems.

2.3 Test Management

Among the issues taken into account to evaluate the Test Management unit of a TDS we have identified the ability to provide help and hints, the ability to made tests available at a given time, and the capability of grading the tests.

Help and Hints

This item concerns the capability of the system to provide directions about the completion of the test and hints that usually are related to the contents of the questions. This item representing a further measure of the ease of use of the application from the student's point of view.

Restricted Availability

Tests can be made available at a specified date and time. They can also be made unavailable at a different date and time. This allows test designers to specify exactly when people can access a test.

It should be possible to leave out either or both of the restrictions to provide maximum flexibility. This lends itself nicely to the computer lab setting where students are required to complete an on-line test during a specified time frame on a specified day.

Restricted availability may raise some concerns with respect to the policies for handling borderline situations that will be discussed in section 4.1 of this paper.

Grading

Obviously, any software for assessment should be able to compute student grades. Furthermore, grades must be delivered as feedback to the course coordinator, to the instructor and to the students. Each of these categories of users needs to obtain a different kind of feedback on the grades associated with a test. For instance, a student needs to know where she stands with respect to other students and to the class average besides her own individual and cumulative grades. This need raises obvious concerns about privacy that may be faced through the security facilities provided with the assessment tool.

3. METRICS FOR THE EVALUATION OF A TDS AT SYSTEM LEVEL

Among the issues taken into account to evaluate a TDS from a systemic point of view, we have identified security, survivability and communication with other software.

Security

There is a wide range of security issues related to the use of TDSs. Among these issues, it should be outlined that there are a lot of concerns on the security of the availability of the test material, of the HTML code that implements testing, of the identification of the user (both instructors and students) and so on. In the next paragraphs we will discuss some issues related to security.

With respect to security concerns about the test material and its HTML code it must be outlined that, while commercial programs usually implement encrypting approaches, a lot of issues should be taken into account for freewares. In fact, most freeware applications rely either on Perl/CGI or on JavaScript. From the point of view of security, the use of CGI-based application may raise an important problem: since a CGI program is executable, it is basically the equivalent of letting the world run a program on the server side, which is not the safest thing to do. Therefore, there are some security precautions that need to be implemented when it comes to using CGI based applications. The one that will probably affect the typical Web user is the fact that CGI programs need to reside in a special directory, so that the server knows to execute the program rather than just display it to the browser. This directory is usually under direct control of the webmaster, prohibiting the average user from creating CGI programs.

On the other hand, since the JavaScript code runs on the client side of the application, the obvious drawback of this approach is that the assessment program cannot be completely hidden, and a "smart" student can access the source discovering the right answer associated to each question. In any case, some sophisticated techniques can be used to partially overcome the problem, which can be reduced to a minimum (Cucchiarelli, 2000).

Survivability

The complexity of an information system is determined partly by its functionality (what the system does) and partly by global (non-functional) requirements on its development costs, performance, reliability, robustness and the like. According to the current literature on Software Engineering formal definition or a complete list of non-functional requirements do not exist. Among the non-functional requirements identified in a report by the Rome Air Development Center (Bowen et al, 1985) survivability, i.e. the ability of a system to perform under adverse conditions, may be of great importance for a Test Delivery System. In particular it is self-evident that no termination procedures should result in any loss of data. To ensure this, both student and system files should be update after each transaction, so that no data is lost if the test is terminated because of machine or power failure (Ring, 1994). With respect to this aspect of survivability a TDS should collect the following data for each test: student identifier, question identifier and the student's response at minimum.

The possibility of providing examination printouts may further enforce the survivability of the system.

Finally, after a crash the system should be able to restart from the point of termination with all aspects of the original status unchanged, including the answers already given and the clock still displaying the time remaining.

Heard, Chapman and Heath (1997) have provided a very useful protocol for the implementation of summative computer-assisted assessment examinations. Recommendations are made that when booking examinations spare capacity should be allowed both in numbers of PCs and time allocation and that a server be dedicated for examination use. Tasks are identified for staff from both the academic department and the service provider and these need to work closely together before, during and after examinations. Any institution should draw up similar procedures then seek agreement from its authoritative bodies before adopting TDSs.

Communication

Communication with other existing software may be very useful both for exporting answers and for calling external applications. Exporting answers is usually performed through test files and data conversion utilities. This may be useful to customize the reports generated by the application or whenever an analysis more detailed than that allowed by the assessment tool is needed to evaluate the results obtained.

Furthermore, many available tools enable the calling of a program as a block within a question. The called program returns a score in points that may be added to the test score. This may be useful for assessing abilities that cannot be evaluated through the basic question-answer paradigm of most assessment tools.

Some tools allow external applications to be called at the very end of the test phase for printing certificates for all users who pass the test; for the electronic submission of the answer file to a central location for analysis and evaluation; for the storage of the results in a file to be accessed by a user program (Question Mark Co., 2000).

Finally, communication with other software is required in order to allow the integration with TMSs distributed by different commercial producers.

4. CHEATING

The term cheating is used to address dishonest practices that students may pursue in order to gain better grades. Copying from books and assignments set in previous years, collusion amongst students in preparing assignments, getting help from relatives, using illegal notes in tests, sending colleagues to take one's place in assessment and copying during classroom tests are just some examples of school assessment dishonesty.

According to literature on academic dishonesty, it appears that cheating is practiced by students at all level of schooling, ranging from "approximately 40% in the upper primary year to nearly 80% in the latter years of secondary school falling to approximately 40% again in tertiary institutions" (Godfrey and Waugh, 1998). This old problem has new life with the widespread use of Computer and Web Based Assessment. Many researchers suggest that this phenomenon can be discouraged, although not entirely prevented, by using certain simple practices such as informing students of the penalties for cheating and enforcing those penalties; ensuring that seating arrangements in examination and testing centres are adequate to prevent cheating; and being aware that cheating seems more likely to occur in larger classes than in smaller classes. Teachers can also assist in the discouragement of cheating by being aware of the high frequency of the phenomena and acknowledging the pressures under which many of these students are working. They must be patient and caring in their approach and make certain that students know that they can come to them for help or assistance and that some students may require more attention at times than others. Parents, of course, can assist in discouraging cheating by ensuring that their children are not overly pressured in their academic endeavours. (Godfrey & Waugh, 1998)

In this section we will discuss cheating control from the technical point of view, presenting some requirements that should be satisfied either at component or at system level of a TDS. More in detail, we will discuss how an attempt at controlling cheating may affect the interface, the question management and the test management functional blocks of a TDS. Then we shall discuss some remarks of the effects of cheating control on the security of a TDS.

4.1 Cheating countermeasures at component level

Any system should attempt to ensure that any given student takes the right test at the right time and that the right student takes the test. The latter task may be solved only through organizational countermeasures, and will be discussed at the end of this section. The former task is not difficult and is usually handled by asking students for their name and/or an identification number.

The previous remark implies that the interface of a TDS should be designed so that access control could be enforced. This implication becomes less trivial than how it may appear at a first glance, if we take into account the fact that access control should be enforced by the teacher too, in order to avoid unauthorized access to tests before they are administered. Most systems actually on the market allow three classes of users to access the system: Student, Teachers and Administrators, each with different privileges and allowed functions.

Another issue affecting the interface of a TDS is linked to the possibility of copying tests from the workstations. Printing and saving browser information on a disk is done through their caching feature. By disabling the cache system it is possible to prevent students from making unauthorized copies of tests they are taking. Implementing the «kiosk» mode available for most major browsers prevents copying the text from the browser, using email or accessing any other applications.

Some TDSs are designed to hand the test in for marking via e-mail. This raises "the concern that students may catch on to the format of the results email and attempt to create a fake one (naturally with very good overall results). It is possible to detect such email messages by paying close attention to things such as the user-id, when, and where it was emailed from, etc., however, that requires a lot of awareness from those administering the test. To prevent this situation, the test designer can specify a verification code, or secret code, to be used with each test. The code is only included in the email message that is sent to the administrator. It is impossible for students to find out what this code is as long as the problem files are not accessible to the general public" (WebTest, 1996).

From the point of view of Question Management, some TDSs provide the ability of scrambling the answers, so that the same question is never submitted in the same examination with the answers in the same position. In order to obtain well formed questions, answers like "None of the above" or "All of the above" should be avoided in multiple choice questions as suggested in the literature (Gronlund, 1985). Obviously the previous considerations are valid for multiple choice and for multiple answer questions only, while they do not make sense for short answers, essays or hot-spot questions.

Another aspect that may affect cheating from the point of view of Question Management, is the possibility of attempting multiple responses to the same question that we addressed as the "retries issue" in the previous section of this paper. In fact, students may try to access all the hints provided to questions, and then backtrack through the pages only to proceed again as if they have never seen them (and thus not losing any marks for seeing them). In order to avoid this drawback, the test designers of WebTest (1996) were provided with the ability to disable backtracking. This solution raised a number of problems (as for instance the need of appropriate warning messages to be issued to inform the user not to click Back or Reload), including the fact that clicking the Reload button has the same effect as moving backward and forward thus corrupting the test again.

From the point of view of Test Management, most TDSs provide the ability of scrambling the position of questions inside a test. This obviously may raise the concern that questions related to the same topic may be spanned around, thus implicitly increasing the level of difficulty of the test, and therefore representing a sort of unfairness to students. Furthermore, it must be taken into account the fact that question scrambling may interfere with adaptive testing where the set of items that constitute the exam is not predefined and depends on the students' performance level.

As discussed earlier in this paper, restricted availability of the tests may prove useful to ensure that a given student takes the right test at the right time. Obviously, constraining the time limits for the execution of test imposes both functional and non-functional requirements on the architecture of the TDS. As an instance of the former class of requirements we may cite, both the possibility of displaying a clock with the residual time available and the existence of appropriate warning messages as the time limit ap-

proaches. As an instance of the latter class of requirements, we may mention the existence of policies for handling "border-line" situations e.g.: what should happen to the student who does not complete the test on time? Should a student's test terminate and be handed in automatically? Or should the student be allowed to finish the test and hand it in himself under the assumption that the test-administrator will eventually make her leave?

4.2 Cheating countermeasures at system level

The existence of features for locking out the access to the operating system may be very useful to prevent cheating if the Test Delivery System is running locally or over a LAN. Obviously this becomes impossible and/or useless whenever the test is taken over the Internet. With relatively common technical knowledge and tools the students may intercept IP packets and read them. Tests transmitted by the TDS could thus be stolen. A possible solution to avoid this problem may require adding data encryption-decryption features to the TDS.

Ensuring that the right student takes the test cannot be handled in a cost-effective way without human intervention. Therefore, the following discussion is independent from the software adopted but is related to the organizational aspects of Computer Based Assessment. For students doing the test on site and under supervision, the procedures are the same as for a conventional test. If students are taking the tests at remote locations some form of human supervision is normally required. Most educational organizations address this issue by asking students to arrange for their tests to be proctored by an approved education agency and thus paying any proctoring fees. Approved agencies include a college testing center or the office of a public or private school administrator. Working with small classes is referenced in the literature as a good starting point for reducing cheating (Davis et al, 1992).

Using alternative assessment methods that do not rely on multiple choice questions can further discourage cheating. For example short answers or filling the blanks question types seem to be less subject to cheating. Furthermore, assigning each assessment worth only a few points can be a good countermeasure for controlling the pressure to cheat.

Godfrey and Waughn (1998) discuss a list of other issues that should be taken in account to reduce/prevent cheating.

5. FINAL REMARKS

In this paper we have discussed a framework that may be useful in assisting an educational team in the selection of a Test Delivery System. The framework has been obtained by modifying and extending existing work on the field (Freemont and Jones, 1994; Gibson et al. 1995). Three main functional modules roughly compose a Test Delivery System: a student interface, a question management unit and a test delivery unit. Therefore, we have decided to organize our framework by identifying some metrics to support the evaluation of the functional modules, and other metrics to support the evaluation of the system as a whole. Finally, we have discovered the need of introducing some domain-specific metrics, to help evaluate the system with respect to the cheating issue.

The next step in our research will be the integration of this framework with the one devised by Valenti et al (2000) for Test Management Systems, in order to identify a general framework for the evaluation of a Computer Based Assessment System.

At the same time our research effort is aimed at reviewing the commercial and freeware applications referenced in Looms (2000) using the metrics identified.

The resulting framework has been summarized in table 1.

Issue		Metrics
Component level	Interface	▪ Friendly GUI
	Question Management	▪ Types of questions ▪ Question Structure: (retries, tutorial building)
	Test Management	▪ Help & Hints ▪ Restricted Availability ▪ Grading
System Level		▪ Security ▪ Survivability ▪ Communication
Cheating		

Table 1– Metrics for the evaluation of a TDS

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