The challenge of measuring E-learning quality:
some ideas from HCI

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Abstract: This paper discusses the concept of e-learning quality, critically reviews current practice in measuring e-learning quality and suggests several Human-Computer Interaction (HCI) methods that can be used to measure the usability of e-learning. Usability evaluation and user-centred design are seen as essential to ensure e-learning quality. Several of these methods were used to evaluate the quality of a web design tutorial developed at the University of Port Elizabeth (UPE).

Key words: E-learning, quality, web-based learning, usability, usability evaluation.

1. INTRODUCTION

E-learning is the delivery of instruction to learners by electronic means (Cross 2001) and has become the dominant presentation mode for distance education, encompassing terms like computer assisted learning (CAL), just-in-time learning (JITL) and Web-based learning (WBL).

Much e-learning material currently available on the WWW is of poor to moderate quality, largely because of low interactivity. The objective of this paper is to review current practice in measuring e-learning quality, especially WBL, and to suggest several methods from HCI that can be used to measure e-learning quality. The use of these methods will be illustrated by a case study to evaluate the usability of a web-based tutorial developed at UPE.

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2. WEB-BASED LEARNING AND USABILITY

The rapid growth and integration of e-learning has prompted experts, authors and researchers to question how best to evaluate e-learning (NCSA 2002). Many questions regarding the effectiveness of e-learning have been raised. One of the most common is simply *How effective is it?* Measuring the effectiveness of e-learning requires a multilevel evaluation approach that requires systematic analysis of different sources and types of information. Typical measures include learner satisfaction, technology satisfaction, measuring learning outcomes and cost effectiveness (NCSA 2002).

Henke (1997) maintains that a critical factor for the success of WBL is the incorporation of usability design into the development process. Usability issues which have a significant impact on learner experience and level of satisfaction in the design of WBL include interface design, the learning environment, navigation, level of participation and interaction and the amount of feedback provided (NCSA 2002, Henke 1997).

A recent eLearn Magazine feature revealed that most major producers of e-learning are not doing substantial usability testing (Feldstein 2002). According to Feldstein, *'learnability is one of the most important measures of usability in e-learning'* (Feldstein 2002).. This definition emphasizes that learnability is only one aspect of e-learning. Thus usability in e-learning refers to both the way the content is presented as well as the content itself.

Henke (1997) agrees that many educators take user interface design for granted or are ill-prepared to create computer-based training material. The emphasis on user interface design is motivated since a WBL course can be considered as both a software application and a web site. Storey, et al. conducted a study to compare two commercially available WBL tools (Storey et al 2000). Based on their results, they conclude that web-based course supplements are widely accepted as part of the students' educational experience. They recommend, however, that if the WBL tools are not professionally developed, they can have a negative impact on the students' perceived learning.

3. E-LEARNING DESIGN PRINCIPLES

The beginning of quality lies in good e-learning courseware design. Quality must be designed into the content and the planned interactions of e-learning courseware (Wesson 2002). Design must be learner-centred, participative (involving learners as co-designers), model-based (based on an instructional design model) and make use of an iterative cycle of evaluation and design. Quinn states that that a major problem with existing e-learning

interfaces is that these are not user-centred (Quinn 2001). He maintains that in order to develop user-centred interfaces and thus improve product quality, e-learning producers must adopt a usability strategy that involves keeping key usability considerations in mind during product development.

Human-Computer Interaction (HCI) has proved useful in the development process of good quality interactive software systems and can offer the same benefits for e-learning (Wesson 2002). From the HCI perspective, the quality of an e-learning artefact depends on the interaction between the users of the artefact and the artefact. Quality has two major aspects: *usability* and *utility.* An artefact (e.g. an e-learning course) is usable if it is *effective* (allowing the user to achieve specified goals), *efficient* (not requiring too much effort from the user) and *satisfying* (invoking positive feelings and lasting acceptance by the user) (ISO 1997). An artefact has utility if it serves a useful purpose for its users (e.g. an e-learning course that teaches a learner how to design web pages).

Visual layout, navigation and interaction are very important design issues that are essential for a sound user experience. The materials produced must emphasise learner activity, cater for individual learning styles and should facilitate the social construction of knowledge. Design must be grounded in our knowledge of human learning (e.g. the fourteen learner-centred psychological principles) (APA 1997)), and effective teaching (e.g. the seven principles of effective teaching (NCSA 2002)).

4. MEASURING E-LEARNING QUALITY

Kirkpatrick's four-level evaluation model (PrimeLearning 2001) has been used to measure e-learning quality, as follows:

- Level 1 Reaction: involves measuring how participants react or feel about a training program.
- Level 2 Learning: measures the extent to which participant's knowledge, skills and attitudes change as a result of training.
- Level 3 Behaviour: examines the extent to which change in behaviour has occurred because of training.
- Level 4 Results: can be defined as the final results that occurred because participants attended training.

While Kirkpatricks' model is commonly accepted it is rarely implemented (NCSA 2002). Other methods used to evaluate the effectiveness of e-learning include quality evaluation models based on checklists. An example of this is the e-learning evaluation checklist complied by Sage Learning Systems (2002). This checklist identifies 17

major categories and 105 separate evaluation criteria. Typical categories include course structure, navigation, screen design, interactivity, feedback and content. These checklists are aimed to assist with the selection and evaluation of existing e-learning material. They do not, however, provide any assistance with design.

The model for design and development of instructional multimedia as proposed by Alessi and Trollip (2001) includes an iterative process of evaluation and design. The only evaluation technique discussed, however, is the use of an evaluation form. Within the field of Human-Computer Interaction (HCI), several standard techniques exist for user-centred design (ISO 13407) and usability evaluation (Faulkner 2000, Shneidermann 1998).

5. HCI EVALUATION TECHNIQUES

Within the field of HCI, usability evaluation is used both as a formative and as a summative evaluation tool during the user-centred design process (ISO 1999). Formative evaluation can be done during design to detect potential usability problems. Summative evaluation can be done after implementation to determine if the system meets its user requirements.

Different evaluation techniques are available to support these different types of evaluation. Analytical evaluation techniques are typically used by design experts to determine usability problems during design (Faulkner 2000). These techniques include heuristic evaluation, cognitive walkthrough and keystroke-level analysis evaluation (Shneidermann 1998). Heuristic evaluation involves using a set of design heuristics or principles to evaluate the design and determine any possible usability problems. Several such lists of design heuristics exist, although the one most commonly used is the set of ten design principles as initially proposed by Nielsen (1994). The outcome from a heuristic evaluation consists of a list of design problems, the severity of these problems and suggestions for design improvements.

A heuristic evaluation may also be used to determine any potential usability problems in WBL. Smulders (2001) showed how, with some adjustments, Nielsen's original eight design principles can be used to evaluate WBL environments (Table 1). Henke also used a heuristic evaluation to assess the usability of WBL (Henke 1997), based on two set of metrics: Nielsen's Top Ten Web Design Mistakes and Jones' and Okey's Interface Design for computer-based learning environments.

Cognitive walkthrough is an analytical technique that is used to assess the ease of learning and use of a system. A detailed task analysis is undertaken of the key tasks supported by the system. For each task, four questions are asked to predict the ease of use of the system. These questions

are: *Is the goal clear at this stage? Is the appropriate action obvious? Is it clear that the appropriate action leads to the goal? What problems are there in performing the action?* (Faulkner 2000). This technique may be especially useful for determining the learnability of the WBL environment.

Table 1 Summary of heuristics to evaluate WBL environments (Smulders 2001)

No.	Heuristic	Description
1.	Indicate site status	Give users a visible indication of where they are within a website. Provide means of determining how users got to current location and how to access other pages.
2.	Match content to audience	Understand your target audience. Use learner profiles to determine instructional design, style and tone.
3.	Give learners control of navigation	Allow learners to find their own way around the web environment. Provide a navigation bar, index and search functions for large websites.
4.	Be consistent and follow standards	Create a standard look and feel for the course by using a consistent colour scheme, font sizes and styles.
5.	Build flexible and efficient web pages	Address accessibility issues for your target audience.
6.	Consider using a minimalist design	Make use of a clean, clear design. Develop an information architecture for the site; keep it simple and avoid clutter and excessive use of features like banners and flashing images.
7.	Prevent errors	Strive to be error-free, up-to-date and relevant.
8.	Help users recognise, diagnose and recover from errors	Provide documentation, troubleshooting advice, links to technical support and contact information.

Within HCI, empirical evaluation techniques are used to determine actual measures of efficiency, effectiveness and satisfaction (Faulkner 2000). The available techniques include informal user testing, observations, interviews, questionnaires and formal usability testing. Empirical methods involve working with actual users and gathering data that has to be analysed. Empirical methods may involve substantially more time and money than analytical methods but can yield quantitative data on the actual usability of the system.

With reference to e-learning, empirical evaluation techniques could also be used to determine actual measures of learner satisfaction, efficiency and effectiveness (Storey et al 2000). Standard HCI questionnaires could be used to evaluate user satisfaction, such as the Software Usability Measurement Inventory (SUMI 2002). Formal usability testing can also be used to identify any usability problems that learners may have with specific aspects of the WBL material (Wesson 18).

6. CASE STUDY: EVALUATION OF WEBWORKS

The Department of Computer Science and Information Systems at UPE introduced a Web Technology course in 2001. A web-based tutorial, called WebWorks, was developed in 2002 to support this course. This tutorial consists of lesson topics, lessons, examples, quizzes and interactive lessons on web page design. The lesson structure is based on web design principles and includes a summary of design principles as well as examples of good and bad practice.

The evaluation of WebWorks was conducted using standard HCI techniques (Section 5). After development of an initial prototype, a cognitive walkthrough was conducted to determine if any usability problems existed with respect to ease of learning. This walkthrough resulted in minor changes to the layout and content of the user interface design. Informal user testing was also done using a standard set of heuristics and a task list (Table 2).

Table 2. Task list for user testing of WebWorks

Please do the following tasks:
1. Open the WebWorks tutorial:
• Open Internet Explorer
• Open the file C:\WebWorks\webworks.aam
2. Read the **Introduction** to the tutorial.
3. Work through the **Home Pages** lesson. This can be found under the topic **Page Design**.
4. Do the **Exercises** for the Home Pages lesson.
5. Read the **Summary Principles** for Page Design.
6. When you have finished, close the browser window.

This evaluation revealed several usability problems. These are summarised in Table 3 below.

Table 3. List of usability problems identified in WebWorks

1. Window does not resize dynamically
2. Too much text on some lesson pages and too many lesson pages
3. Scroll bar on example where text does not scroll is confusing
4. Thumbs Down symbol in example does not stand out as much as Thumbs Up
5. System must not crash when user clicks browser Back button
6. Quiz login: not immediately obvious that user must press Enter; would prefer to use mouse
7. Option to print lesson is needed
8. Make summary of lesson available throughout lesson
9. Separate the exercises into Quiz (multiple-choice questions) and Exercises
10. Option required to go back to Quiz instructions
11. Option required to leave Quiz to look something up in the lesson, then resume Quiz

A new design for lesson pages was suggested to solve several of these problems and encourage user interaction. For example, to address the problem of too much text (Problem 2), the lesson content was redesigned to include buttons for **Why? How?** and **More Examples** (Figure 1). On placing the mouse over these buttons, the user can now obtain information in pop-up windows on the rationale for the principle, how to implement this principle and access to further examples. In addition to reducing the amount of text per page and the total number of pages, this design creates more interactivity and makes better use of the presentation medium.

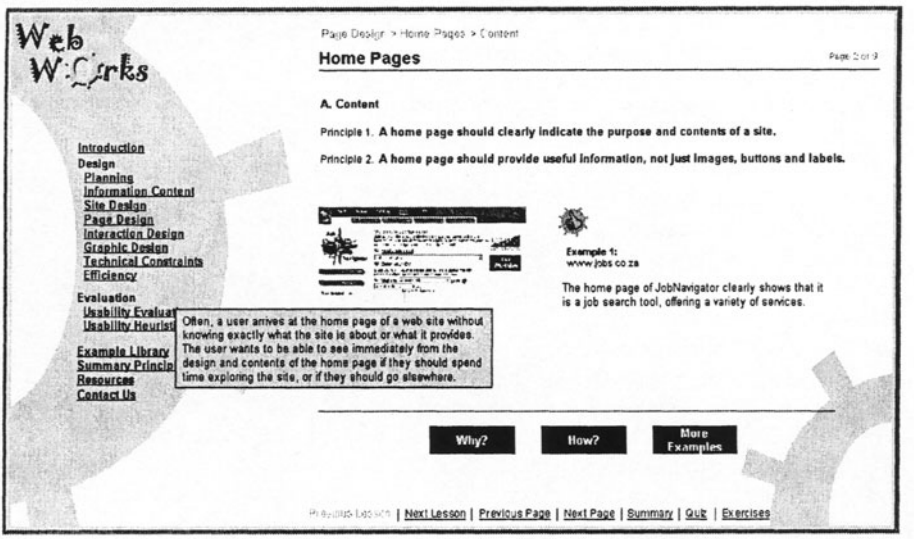

Figure 1. The new design for a lesson page in WebWorks

Due to a lack of time, further empirical testing has not yet been conducted on WebWorks. Additional lesson content also needs to be created, although a framework has been created for the entire tutorial. Once this has been completed, learner satisfaction will be evaluated using the SUMI questionnaire. Further research is needed to determine if this tutorial is effective in helping students to achieve the intended learning outcomes.

7. CONCLUSIONS

There is no doubt that usability is an essential aspect of the quality of e-learning and especially WBL. Determining the quality of e-learning will thus involve evaluating the usability of e-learning which will include measures of the effectiveness, efficiency and user satisfaction of the e-learning material. Standard HCI usability evaluation techniques like heuristic evaluation,

cognitive walkthrough and user testing can be used to evaluate e-learning material and inform design. More research is needed, however, to define a standard set of heuristics for WBL and develop specific questionnaires to determine learner satisfaction and assess learning effectiveness.

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