Usability and Learning: A Framework for Evaluation of Web-Based e-Learning Applications

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Abstract: With rapid advances in information and communication technology, e-learning is playing a major role in education and training. Aspects of usability, as well as learning issues, need to be considered in the development and evaluation of e-learning applications. This paper proposes a framework for evaluation of web-based e-learning applications that narrows the gap between the fields of educational computing and Human Computer Interaction. A literature study was undertaken to synthesise the framework, which comprises three categories – general interface design, web-site specific design, and instructional design. The categories contain sets of criteria and subcriteria that relate to aspects of learning and usability. In an evaluation study, a learner-survey was conducted of a course website, *Info3Net*, to determine the effectiveness of the evaluation framework. The criteria served well in identifying deficiencies in the application with regard to its usability and support for learning.

Introduction

The prevalence of the World Wide Web (WWW) as an information and communication technology has resulted in its widespread use as an educational medium for both distance and face-to-face learning (Vrasidas, 2004). Consequently, Web-based e-learning applications are in high demand in educational institutions and in corporations that use them to train their employees in workplace skills (Feinberg & Murphy, 2000).

While there are established traditions of research and development both in educational computing and in Human Computer Interaction (HCI), there is a need for better communication by practitioners in these fields (Squires, 1999). There is a danger that the usability features of web-based e-learning applications may be considered at the expense of educational issues, while the converse is equally true (Jones et al., 1999). One of the reasons for the latter is that usability evaluation can be difficult, time consuming and expensive (Kjeldskov et al., 2004). The International Standards Organisation (ISO) defines usability as: *"The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context"* (ISO, 1998). Usability is a key issue in HCI since it is the aspect that commonly refers to quality of the user interface (Parlangeli et al., 1999). Usability evaluation is concerned with gathering information about the usability or potential usability of a system, in order either to assess it or to improve its interface by identifying problems and suggesting improvements (Preece, 1993). To ensure system usability, usability evaluation should be performed, ideally, during development (Granic et al., 2004). Usability is essential in order for web-based e-learning environments to be effective. The interface should be virtually invisible to the learner (Veldof, 2003). Costabile et al. (2005) point out that when systems are not easily usable, learners might spend excessive time trying to understand the system itself, rather than engaging with the content. They advise that evaluations of educational software should investigate both *pedagogical effectiveness* and *usability* aspects. In fact, there should be a synergy between the learning process and the interaction with the application (Ardito et al., 2006). In identifying criteria for evaluating such applications, the peculiarity of e-learning must be considered, namely, that its primary goal is to support learners in learning the didactic content material in such a way that they devote minimal effort to the actual interaction with the application, and apply a concerted effort in engaging with the learning content (Ardito et al., 2004). The integration of usability and learning should therefore address usability features that are important for the achievement of educational goals (Squires & Preece, 1996).

General system interface evaluation criteria can be applied to evaluate e-learning applications. However, problems arise from applying generic principles to a wide range of systems (Ardito et al., 2006). Specific criteria are required to evaluate the usability of e-learning systems. This paper can be viewed as a response to that call as it presents, and describes the use of, an integrated set of evaluation criteria which address both the usability and educational aspects of e-learning.

Aim

This paper reports on an investigation with two aims:

- To present an evaluation framework of synthesised criteria suitable for evaluating web-based e-learning applications in the context of higher education (HE); and
- To apply the framework in an evaluation study, so as to determine the effectiveness of the framework.

Method

In order to identify appropriate evaluation criteria for evaluating web-based e-learning, literature surveys – using books, journals articles, Internet articles and conference proceedings – were conducted in the following domains:

- Theories and models of e-learning, particularly web-based learning (WBL); and
- Human computer interaction, specifically the areas of usability and usability evaluation methods.

Molich and Nielsen (1990) advocate that sets of general principles, so-called 'heuristics', be used in usability evaluation of computer interfaces. This approach was adopted, using material that emerged from the literature survey as a basis for the synthesis of appropriate sets of criteria/heuristics for the framework. These criteria, along with further additions, were then used to design a questionnaire for an end-user evaluation of *Info3Net*, a website for teaching Information Systems to 3rd-level learners at Walter Sisulu University in South Africa.

Literature Study

E-learning is a form of teaching and learning that includes instruction delivered via a broad variety of electronic media including the Internet/intranets/extranets, satellite broadcasts, video/audio tape, interactive TV, and CD-ROM (Govindasamy, 2002). An important aspect of e-learning is the need for careful consideration of the underlying pedagogy and recognised learning theories, i.e. how learning takes place (De Villiers, 2005; Govindasamy, 2002). Behaviourism, cognitivism and constructivism, are currently the three main learning theories (Alessi and Trollip, 2001; De Villiers, 2005). In contrast with the other two theories, which insist that the world follows real and consistent rules and that learning involves being able to understand and apply those rules, constructivism maintains that the individual's interpretation of the world is of prime importance and that each individual constructs his/her own view of reality. Constructivism views learners as active creators of knowledge, who learn by observing, manipulating, and interpreting the world around them. It has emerged as the dominant current approach to learning (Ben-Ari, 1998) and it is particularly relevant as an underlying paradigm for contemporary e-learning.

The Framework

Following literature studies on learning theories, web-based learning, and usability, relevant concepts were integrated to form a set of criteria and subcriteria for usability evaluation of web-based e-learning applications. The framework in Table 1 shows twenty resulting criteria/heuristics, and for each, the associated guidelines or subcriteria synthesised in this study. The framework was compiled by synthesising and integrating the works of various authors, with some new additions. A number of sources were consulted in the compilation process. However, the main foundations of the set come from the "general interface" heuristics of Jakob Nielsen and Rolf Molich (Nielsen, 1994:30); "golden guidelines" (Shneiderman & Plaisant, 2005:74); Squires' & Preece's (1999:479) "learning with software" heuristics; and Albion's (1999) "educational design" heuristics. As stated in the *Introduction* of this paper, evaluation of e-learning should

address both pedagogic effectiveness and usability aspects (Costabile et al., 2005). Similarly Masemola and De Villiers (2006) believe that the learning content and learning functionality of an e-learning product are related to usability and should be addressed in usability evaluation. The framework presented here is in line with these persuasions.

The twenty criteria and their subcriteria are classified within three categories in the framework:

- Category 1 – General interface design criteria: These are based on Nielsen's heuristics, but with some extensions influenced by Squires' and Preece's (1999:479) "learning with software" heuristics, so as to focus them on educational applications. They mainly concentrate on the usability of interfaces in general, but within the context of web-based e-learning.
- Category 2 – Website-specific design criteria: Although the criteria in Category 1 are also applicable to web-based applications, there are others that are specific to websites.
- Category 3 – Learner-centred instructional design criteria: Further specific guidelines were identified as necessary and relevant for evaluation of e-learning. The criteria in this category are grounded in current learning theories and models, and aim for effective learning within educational software applications.

This approach is in line with the stance advocated by Ardito et al. (2006), namely, that specific custom-designed guidelines should be provided for the evaluation of e-learning, rather than using a small set of general criteria.

Table 1: Evaluation criteria for web-based learning - a framework

Category 1: General interface design criteria (based on Nielsen (1994))	
1	**Visibility of system status** • The website keeps the user informed about what is going on through constructive, appropriate and timely feedback. • The system responds to actions initiated by the user. There are no surprise actions by the site. or tedious sequences of data entries.
2	**Match between the system and the real world, i.e. match between designer model and user model** • Language usage, such as terms, phrases, symbols, and concepts, is similar to that used by the users in their day-to-day environment. • The metaphor usage corresponds to real-world objects or concepts. • Information is arranged in a natural and logical order.
3	**User control and freedom** • Users control the system. • Users can exit the system at any time even when they have made mistakes. • There are facilities for Undo and Redo.
4	**Consistency and adherence to standards** • The same concepts, words, symbols, situations, or actions refer to the same thing. • Common platform standards are followed.
5	**Error prevention, specifically prevention of peripheral usability-related errors** • The system is designed in such a way that the users cannot easily make serious usability errors. • When a user makes an error, the application gives an appropriate error message.
6	**Recognition rather than recall** • Objects to be manipulated, options for selection, and actions to be taken, are visible. • The user does not need to recall information from one part of a dialogue to another. • Instructions on how to use the system are visible or easily retrievable whenever appropriate. • Displays are simple and multiple page displays are minimised.
7	**Flexibility and efficiency of use** • The site caters for different levels of users, from novice to experts. • Shortcuts or accelerators, unseen by the novice users, are provided to speed up interaction and task completion by frequent users. • The system is flexible enough to enable users to adjust settings to suit themselves, i.e. to customise the system.

8	**Authenticity and minimalism in design** • Site dialogues do not contain irrelevant or rarely needed information, which could distract users as they perform tasks.
9	**Recognition, diagnosis, and recovery from errors** • Error messages are expressed in plain language. • Error messages indicate precisely what the problem is and give quick, simple, constructive, specific instructions for recovery. • If a typed command results in an error, the user does not have to retype the entire command, but rather needs only to repair the faulty part.
10	**Help and documentation** • The site has a help facility and other documentation to support the users' needs. • The information in these documents is easy to search, focused on the user's task, and lists concrete steps to be carried out to accomplish a task.
Category 2: Website-specific (educational websites) design criteria	
11	**Simplicity of site navigation, organisation and structure** • The site has a simple navigational structure. • Related information is placed together. • Information is organised hierarchically, starting with general information then specific.
12	**Relevance of site content to user** • Content is engaging, relevant, appropriate and clear to the users. • The authors of the content are of reputable authority.
Category 3: Learner-centred instructional design criteria	
13	**Clarity of goals, objectives and outcomes** • There are clear goals, objectives and outcomes for learning encounters. • The reason for inclusion of each page or document on the site is clear.
14	**Collaborative learning** • Facilities and activities are available that encourage learner-learner and learner-teacher interactions. • There are facilities for both asynchronous and synchronous communication, such as e-mail, discussion forums and chat rooms.
15	**Appropriateness of the level of learner control** • Apart from controlling the interactions with the site, learners have some freedom in directing their own learning, either individually or through collaborative experiences, and have a sense of ownership of their learning. • Individual learners can customise the site to suit their own learning strategies. • Where appropriate, learners take the initiative regarding the methods, time, place, content, and sequence of learning.
16	**Support for personally significant approaches to learning** • There are multiple representations and varying views of learning artefacts and tasks. • The site supports different strategies for learning and indicates clearly which styles it supports. • The site is used in combination with other mediums of instruction to support learning. • Metacognition on the part of learners, which is the ability for an individual to evaluate his/her own cognitive skills, is encouraged. • Learning activities are scaffolded by providing support to learners to allow them to work within existing competency while encountering meaningful chunks of knowledge.
17	**Cognitive error recognition, diagnosis and recovery** • Established strategies, such as cognitive conflict, bridging, and problem-based learning (PBL) are used to promote the recognition-diagnosis-recovery cycle for cognitive errors. (This cycle also exists for interface errors and other forms of usability errors as explained in Criterion 9.)
18	**Feedback, guidance and assessment** • Apart from the interface-feedback by the system, as described in Criterion 1, learners give and receive prompt and frequent feedback about their activities and the knowledge being constructed. • Learners are guided as they perform tasks.

	• Quantitative feedback, for example, in terms of grading learners' activities, is given so that learners are aware of their level of performance.
19	**Context meaningful to domain and learner** • Knowledge is presented within a meaningful and authentic context that supports effective learning. • Authentic, contextualised tasks are undertaken rather than abstract instruction. • The application enables context- and content-dependent knowledge construction.
20	**Motivation, creativity and active learning** • The site has features that motivate learners, and promotes creativity by engaging learners. • To promote active learning, learners are encouraged to compare, analyse or classify information, or make deductions from it. • In order to attract and retain learners, the application engages them by its content and interaction.

The criteria and their associated subcriteria are an effort to integrate usability and learning, particularly in the context of a constructivist approach. They are appropriate for the evaluation of web-based e-learning, as demonstrated by the evaluation of *Info3Net*, described in the next section. Criteria specifically for intelligent tutoring systems were excluded from the study. Application of a criterion need not adhere rigidly to the guidelines/subcriteria given, because use depends on the content and context of each application. This synthesised set of criteria can serve a further valuable purpose, namely, in their use as design principles and guidelines for the development of new applications.

Various usability evaluation methods (UEMs) exist, such as analytical, expert heuristic evaluation, observational, survey and experimental evaluations (Nielsen, 1994; Preece, 1993; Shneiderman & Plaisant, 2005). The framework given above can be used in expert heuristic evaluation and in survey evaluation. Heuristic evaluation (HE) is a usability inspection technique whereby a small set of expert evaluators, guided by a set of recognised usability principles known as heuristics (such as the 20 criteria in the framework), determine whether a user interface conforms to these principles (Nielsen, 1994). HE is the most widely used usability evaluation method for computer system interfaces, since it is effective, inexpensive, easy and fast to perform, and can result in major improvements to user interfaces (Karoulis & Pombortsis, 2003). However, in this case, the criteria were used for an evaluation via end-user survey methods. They were adapted to form sets of questions ? in terminology appropriate for the target group (learners) ? for a questionnaire survey and focus group interviews, described in the next section.

Application of the Framework

The evaluation was conducted on an application called *Info3Net*, which is the course website for *Information Systems 3* for 3rd-level learners at Walter Sisulu University (WSU) in East London in the Eastern Cape Province of South Africa. *Information Systems 3* entails a one-year programme, in which 'Advanced Databases' is done in the first semester and 'Project Management' in the second. The *Info3Net* site was designed and built early in 2005, using the *WebCT* development environment. *WebCT* is a course management system (CMS) for developing web-based e-learning applications. *Info3Net* was constructed by the first author, who is the lecturer and subject co-ordinator of *Information Systems 3* in the Department of Computer Studies at WSU. A subject co-ordinator is responsible for the preparation of all study materials, notes, tests and practical exercises for the subject.

Computer-based learning environments can be used as a supplement to face-to-face teaching/learning, or as a stand-alone tool for instruction (Jackson, 2004). In this study the former approach, known as blended learning, was used as *Info3Net* supplemented the traditional face-to-face contact sessions in 2005. About 80 learners were registered for *Information Systems 3* when the survey evaluations were conducted. They were all in their final year of the National Diploma in Information Technology or the National Diploma in Financial Information Systems. The site was used mainly in the first semester, since the Project Management module of the second semester was not electronically functional in 2005. The main phases of the survey evaluation were: questionnaire design, pilot study, main evaluation, focus group interview, and analysis of results.

Questionnaire design

According to Gillham (2000) the starting point for developing a questionnaire is to determine its broad aims and, stemming from these, to determine specific questions to be answered. In order to evaluate the application, a number of

statements, or subcriteria, were provided for each of the twenty criteria in the framework of Table 1, generating a total of 110 statements in the questionnaire. Learners were required to indicate to what extent they agreed with these, using a five-point Likert rating scale (strongly agree to strongly disagree). However, since one of the main objectives was to identify usability problems, space was provided at the end of each criterion for open-ended responses, where they could spontaneously describe specific problem/s they identified in relation to that criterion.

Pilot study

Questionnaires should be prepared, reviewed and tested with a small sample of users before carrying out a survey (Gillham, 2000; Shneiderman & Plaisant, 2005). In this study, a pilot study was conducted with five learners and was found to be very useful. For example, learners commented on issues such as the wording of certain questions and the length of the questionnaire. Some suggested that it should be reduced so as not to tire the participants. Using feedback from this pilot study, a final questionnaire was compiled for use in the actual evaluation.

Main evaluation

Sixty one learners participated in the evaluation. They logged in to the *Info3Net* site and evaluated it. They were already familiar with the application, having used it during their studies. Now they were required to evaluate it in its entirety and to identify usability problems they had encountered at any time while using it. However, they were asked to do two specific representative tasks to refresh their minds. They were required to do a short reading of part of the content, which was followed by a five-minute test based on this and on their general knowledge on the topic. These scenarios, as well as general site features such as its structure, were the specific focus of the evaluation, as participants completed the questionnaire. Reference could also be made to problems encountered in tasks done previously and this, in fact, was welcome. Because learners constantly referred to the site as they evaluated it, it took them an hour to one-and-a-half hours to perform the evaluation. Their responses were studied and a focus group interview was conducted with a group of learners as a follow-up process to clarify and expand some of the issues raised by responses to the questionnaire.

Focus group interview

Three days after the survey, a focus group interview was conducted with a representative sample of learners drawn from respondents in the questionnaire survey. Since it is recommended that six to twelve people (Maughan, 2003) form a focus group, eight learners were asked to participate. The exercise took about one-and-a-half hours. Several issues were clarified by the learners and further problems emerged.

Survey evaluation results and discussion

As stated before, the investigation of each criterion in the questionnaire concluded with a space for open-ended responses where learners could mention problems they had experienced with relation to that criterion. Sixty six (66) unique problems were identified from the problems described in these sections.

There were 110 statements in the questionnaires. These statements were phrased in a positive, rather than a negative form. On a Likert scale of 1 to 5 (strongly agree, agree, maybe, disagree, strongly disagree), the mean of these average ratings was 2.3 and the standard deviation was only 0.4. This means that most learners tended to agree with the statements given, indicating generally positive impressions of *Info3Net*. This is further confirmed by the fact that in 92 statements (84%) out of the total 110, the average rating was less than or equal to 2.5. Statements with an average rating of more than 2.5 were analysed so that if a statement was rated highly (indicating disagreement) and was not related to any of the 66 problems identified in the open-ended sections of the questionnaire, then it would be considered as an additional usability problem. One further problem was identified in this manner, raising the number of problems from 66 to 67.

During the focus group discussion, issues were clarified and further usability problems were identified. For example, some learners had stated that the background colour was not consistent. During the discussion they gave more specific responses such as "Background colour for the Home Page is blue, but that of the Calendar is white" which clarified their claims. Five new usability problems were identified in the focus group exercise and were incorporated into the students' list of problems. This raised the number of problems from 67 to 72, forming a set of 72 unique problems in I*nfo3Net*. Table 2 shows the number of problems identified for each criterion, and for each category.

Table 2: Number of problems identified for each criterion and category

Category 1: General	**Criterion**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**	**%**
	Problems	2	3	6	5	3	4	6	4	3	4	**40**	**56**
Category 2: Web	**Criterion**	**11**	**12**									**Total**	**%**
	Problems	9	2									**11**	**15**
Category 3: Educational	**Criterion**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**			**Total**	**%**
	Problems	3	2	2	2	0	8	2	2			**21**	**29**
Total												**72**	**100**

Table 2 shows that 40 problems (56%) were identified in *Info3Net* in the General category, 11 problems (15%) in the Web category and 21 problems (29%) in the Educational category. This data indicates that a high proportion of the problems, 56%, were a result of interaction- or usability-related problems. The greatest numbers of problems in this category emerged from Criteria 3 and 7, relating to User control and Flexibility respectively. The lack of flexibility and customisation identified here can possibly be attributed to limitations in the *WebCT* development environment.

A further 15% were Web-specific interaction problems. It must be noted, however, that the eleven problems in the Web category were generated from only two criteria, indicating issues – particularly in site navigation (Criterion 11) – that require serious attention.

The framework also made it possible for learners to identify 21 learning-related problems (29%), belonging to the Educational category. Some of the issues raised here relate to a desire for more interactive feedback (Criterion 18) and constructivist features. For example, there was a request for multiple forms of presentation, in line with the constructivist approach. *Info3Net*, having been created by a CMS, does not have a constructivist basis nor does it have sensitive diagnostic capabilities and personalised feedback.

The criteria in the framework were generated from theoretical foundations that, among others, advocate classic HCI concepts such as interactivity, visibility, feedback, customisation and flexibility in learning environments. The framework, with its twenty different categories, served well in supporting identification of deficiencies in *Info3Net*. These should be addressed in its future upgrades, as far as is possible within the constraints of *WebCT*. The number of problems identified from the different categories indicates that the framework was effective in evaluating *Info3Net* in terms of learning and usability.

Conclusion

Evaluation of e-learning systems should consider both pedagogical issues and usability aspects. An evaluation framework was synthesised in an effort to narrow the gap between educational computing and Human Computer Interaction, by addressing aspects of usability and of learning in the evaluation of web-based e-learning applications. In an application of the framework, a learner-survey evaluation was conducted on *Info3Net*, a website for a 3rd-level university course. Seventy two (72) learning- and usability-related problems were identified, unmasking deficiencies of the application. The result of this evaluation demonstrates, to some degree, the effectiveness of the framework. Although the application used as evaluation target was built with a course management system and holds certain inherent behaviourist tendencies, the categories and criteria in the framework deliberately have a constructivist bias and served well to identify shortcomings. In general, however, users had positive perceptions of *Info3Net*.

The evaluation framework presented is based on current learning theories and models, and usability principles. Although it is theoretically based, it provides a simple set of categories and criteria appropriate for practical usability evaluation of web-based e-learning, particularly by heuristic- and survey-evaluation methods. As an evaluation instrument, it is easily transferable and customisable to other environments and contexts, and to different forms of e-learning software. The set of criteria can also serve as design principles and guidelines in the development of new applications.

References

Albion, P.R. (1999). *Heuristic Evaluation of Multimedia: From Theory to Practice.* Retrieved May 6, 2005, from http://www.usq.edu.au/users/albion/papers/ascilite99.html

Alessi, S.M. & Trollip, S.R. (2001). *Multimedia for Learning: Methods and Development*. 3rd Ed. Massachusetts: Allyn & Bacon.

Ardito, C., Costabile, M.F., De Marsico, M., Lanzilotti, R., Levialdi, S., Plantamura, P., Roselli, T., Rossano, V. & Tersigni, M. (2004). Towards Guidelines for Usability of e-Learning Applications. In C. Stary & C. Stephanidis. (Eds), L*ecture Notes in Computer Science. Vol 3196, 2004: User-Centered Interaction Paradigms for Universal Access in the Information Society: 8th ERCIM Workshop on User Interfaces for All 2004*: 185-202. Berlin: Springer-Verlag.

Ardito, C., Costabile, M.F., De Marsico, M., Lanzilotti, R., Levialdi, S., Roselli, T. & Rossano, V. (2006). An Approach to Usability Evaluation of e-Learning Applications. *Universal Access to in the Information Society*, 4(3): 270-283.

Ben-Ari, M. (1998). Constructivism in Computer Science. In *Proceedings of SIGSCE '98*: 257-261. Atlanta: ACM Press.

Costabile, M.F, De Marsico, M., Lanzilotti, R., Plantamura, V.L. & Roselli, T. (2005). On the Usability Evaluation of E-Learning Applications. In P*roceedings of the 38th Hawaii International Conference on System Science 2005*: 1-10. Washington: IEEE Computer Society.

De Villiers, M.R. (2005). e-Learning Artefacts: Are they Based on Learning Theory? *Alternation*, 12(1b), 345-371.

Feinberg, S. & Murphy, M. (2000). Applying Cognitive Load Theory to the Design of Web-Based Instruction. In *Proceedings of IEEE Professional Communication Society International Professional Communication Conference and Proceedings of the 18th Annual ACM International Conference on Computer Documentation: Technology & Teamwork 2000*: 353-360. Cambridge: IEEE Educational Activities Department.

Gillham, B. (2000). *Developing a Questionnaire.* London: Bill Gillham.

Govindasamy, T. (2002). Successful Implementation of e-Learning Pedagogical Considerations. *The Internet and Higher Education*, 4(4), 287-299.

Granic, A., Glavinic, V. & Stankov, S. (2004). *Usability Evaluation Methods for Web-Based Educational Systems*. Retrieved September 17, 2005, from http://www.ui4all.gr/workshop2004/files/ui4all_proceedings/adjunct/evaluation/28.pdf

ISO (1998). ISO 9241: *Guidance on Usability Standards*. Retrieved May 3, 2004, from http://www.iso.ch/iso/en/CatalogueListPage.CatalogueList?ICS1=13&ICS2=180

Jackson, R.H. (2004). *Weblearning Resources*. Retrieved August 14, 2005, from http://www.knowledgeability.biz/weblearning/default.htm

Jones, A., Scanlon, E., Tosunoglu, C., Morris, E., Ross, S., Butcher, P. & Greenberg, J. (1999). Contexts for evaluating educational software. *Interacting with Computers*, 11(5), 499-516.

Kjeldskov, J., Skov, M.B. & Stage, J. (2004). Instant Data Analysis: Conducting Usability Evaluations in a Day. In: *Proceedings of the third Nordic conference on Human-Computer Interaction 2004*: 233-240. Tampere: ACM International Conference Proceeding Series.

Karoulis, A. & Pombortsis, A. (2003). Heuristic Evaluation of Web-Based ODL Programs. In C. Ghaoui. (Ed.), *Usability Evaluation of Online Learning Programs*. Hershey, P.A.: Information Science Publishing.

Masemola, S.S. & De Villiers, M.R. (2006). Towards a Framework for Usability Testing of Interactive e-Learning Applications in Cognitive Domains, Illustrated by a Case Study. In J. Bishop & D. Kourie. (Eds), *Service-Oriented Software and Systems. Proceeding of SAICSIT 2006*: 187-197. ACM International Conference Proceedings Series.

Maughan, P.D. (2003). Focus Groups. In E.A. Dupuis. (Ed.), *Developing Web-Based Instruction: Planning, Designing, Managing, and Evaluating for Results*. London: Facet Publishing.

Molich, R. & Nielsen, J. (1990). Improving a Human-Computer Dialogue. *Communications of the ACM*, 33 (3), 338-348.

Nielsen, J. (1994). Heuristic Evaluations. In J. Nielsen & R.L. Mack. (Eds), *Usability Inspection Methods*. New York: John Wiley & Sons.

Parlangeli, O., Marchingiani, E. & Bagnara, S. (1999). Multimedia in Distance Education: Effects of Usability on Learning. *Interacting with Computers*, 12(1), 37-49.

Preece, J. (1993). *A Guide to Usability: Human Factors in Computing*. The Open University: Addison-Wesley.

Shneiderman, B. & Plaisant, C. (2005). *Designing the User Interface: Strategies for Effective Human-Computer Interaction*. 4rd Ed. New York: Addison-Wesley.

Squires, D. (1999). Usability and Educational Software Design. *Interacting with Computers*, 11(5), 463-466.

Squires, D. & Preece, J. (1996). Usability and Learning: Evaluating the Potential of Educational Software. *Computers Education*, 27(1), 15-22.

Squires, D. & Preece, J. (1999). Predicting Quality in Educational Software: Evaluating for Learning, Usability and the Synergy between them. *Interacting with Computers*, 11(5), 467-483.

Veldof, J.R. (2003). Usability Tests. In E.A. Dupuis. (Ed.), *Developing Web-Based Instruction: Planning, Designing, Managing, and Evaluating for Results*. London: Facet Publishing.

Vrasidas, C. (2004). Issues of Pedagogy and Design in E-learning System. In *ACM Symposium on Online Learning 2004*: 911-915. Nicosia: ACM Press.