A cognitive model to promote excellence in web-supported learning

J W Fresen
Department of Telematic Learning and Education Innovation
University of Pretoria
Pretoria
South Africa
jill.fresen@up.ac.za

J C Cronjé
Department of Curriculum Studies
University of Pretoria
Pretoria
South Africa
johannes.cronje@up.ac.za

Abstract

The term *e-learning* embraces the use of a variety of electronic delivery media to facilitate and enhance learning. Examples of various delivery media are online (web-supported), stand-alone multimedia, interactive television, virtual classrooms, video conferencing, etc. This paper focuses on *web-supported learning (WSL)*, as a subset of *e-learning.* The term *web-supported learning* is preferred over *web-based learning (WBL)* or *online* learning, since the learning model under consideration is a blended one, including varying components of contact time and electronic learning opportunities.

Although the domains of quality assurance in higher education and web-supported learning are extremely topical, they seldom overlap (Reid, 2003). The purpose of this study was to investigate factors to promote excellence in web-supported learning (WSL) in higher education institutions. The outcome is a taxonomy of critical success factors, as well as a mapping of the taxonomy onto a cognitive model in the field of Information Science.

In the field of Information Science, Ingwersen's (1996) cognitive model of information retrieval (IR) interaction is well known. It represents the way that individual users may interact with an interface in order to assimilate and interpret sources of information within their social and organisational environments. The taxonomy of critical success factors was mapped onto Ingwersen's model, in order to provide a cognitive and visual interpretation of the categories in the taxonomy. This offers a unique application of information science theory to the field of web-supported learning.

Keywords:
Web-supported learning, critical success factors, information retrieval, human-computer interaction

List of acronyms:

ADDIE	analysis, design, development, implementation, evaluation model of ID
HCI	human-computer interaction
ET	educational technology
ICT	information and communication technology
ID	instructional design
IR	information retrieval

IS	information science
ISO	international standards organisation
IT	information technology *or* instructional technology
QMS	quality management system
WBL	web-based learning
WSL	web-supported learning

1. Introduction

The term *e-learning* embraces a variety of electronic delivery media, for example web-supported, multimedia, interactive television, virtual classrooms, video conferencing, etc. This study focuses on *web-supported learning (WSL)*, as a subset of e-learning. The term *web-supported learning* is preferred over *web-based learning (WBL)* since the learning model under consideration in this paper is a blended one, including varying components of contact time and electronic delivery media.

The domains of quality assurance and web-supported learning are extremely topical, yet they seldom overlap (Reid, 2003). The purpose of this study was to diminish this gap by applying quality assurance principles to the ADDIE (analysis, design, development, implementation and evaluation) model of instructional design, in order to promote consistency and continuous improvement in an e-learning support unit at a higher education institution.

This investigation is based on a case study at the University of Pretoria, South Africa, in which a process-based quality management system (QMS) for web-supported learning was designed and developed in 2003 (University of Pretoria, 2003; European Quality Observatory, 2004; Fresen, 2005). In phase 1, the process-based ISO 9000 approach was applied to the instructional design *process*. This overall process was subdivided into 12 'boxes', steps or *procedures*, each with inputs, outputs, roles and responsibilities and supporting documents such as checklists, standards, policies, pro-formas etc.

The implication of phase 1 was that such an in-depth self-evaluation exercise (i.e. 'improving the way we do things around here') should lead to improved web-supported learning opportunities (*products)* for students. However, for various reasons such as time constraints, workload, complexity of contributions of other team members, it is not always possible to streamline practice according to documented procedures. Therefore phase 2, reported in this paper, investigated teaching, learning and support aspects of the web-supported products. The outcome was a taxonomy of critical success factors which contribute to improving the quality (effectiveness) of web-supported learning in a blended learning model.

2. Taxonomy of critical success factors for quality web-supported learning

The primary research method was a literature review which identified and analysed studies of two types: those which present classic benchmarks, indicators and principles for quality web-supported learning (IHEP, 2000; Barker, 1999; Chickering & Ehrmann, 1996), and those that identify criteria for exemplary or promising courses (Graf & Caines, 2001; Confrey, Sabelli & Sheingold, 2002). Twigg (2001) confirms that the IHEP study is particularly meaningful and useful. Yeung (2002) applied the IHEP study to investigate factors contributing to quality assurance of web-based learning in Hong Kong. In South Africa, Herman (2001) and Bezuidenhout (2004) conducted similar studies based on the IHEP study, at the University of Stellenbosch and the Central University of Technology respectively. Details of all the studies mentioned are given by Fresen (2005).

The comparative analysis produced a taxonomy of critical success factors to promote excellence in web-supported learning. The taxonomy is based on six categories: institutional, technology, lecturer, student, instructional design and pedagogical factors. Subsequently Khan (2005) published an e-learning checklist of critical dimensions of the e-learning environment, which includes pedagogical, technical, interface design, evaluation, management, resource support, ethical and institutional dimensions.

The taxonomy was corroborated and extended by additional studies published from 2000 onwards. Critical colleagues within the e-learning unit were asked to reflect on and refine the taxonomy for purposes of triangulation and verification. Various suggestions were made in terms of rewording, merging and adding to the list of factors, based on their experience.

In synthesizing such a taxonomy, it is impossible to list *all* critical success factors for quality web-supported learning. It is inevitable that other researchers will suggest additional factors. In attempting to be as comprehensive yet as succinct as possible, earlier research listed separately two types of basic factors (Fresen & Boyd, 2005):

- underlying *assumptions* which must be in place before quality web-supported learning can even be contemplated;
- *exogenous* (external) factors, which are important for quality web-supported learning, yet are beyond the control of e-learning practitioners.

The critical colleagues agreed with listing underlying assumptions and exogenous factors separately. These factors are listed in Table 1, reflecting the suggestions and consensus of the critical colleagues. The resulting refined taxonomy of critical success factors for quality web-supported learning is presented in Table 2.

Table 1: Underlying assumptions and exogenous factors forming the foundation of the taxonomy

Underlying assumptions	Exogenous factors
• ICT infrastructure; • information literacy of clients[1]; • basic computer literacy of clients; • positive attitude of lecturers; • commitment and motivation of clients; • sound advice, support and consultation to lecturers with respect to instructional design and educational practice; • sound instructional design practice; • sound teaching and learning practice; • commitment to continuous improvement.	• quality of the institutional learning management system; • stability of national telecommunications infrastructure; • class size; • work load of clients; • recognition and incentives for lecturers.

The final taxonomy presented in Table 2 should be read with the understanding that the underlying assumptions listed above are taken as given and that the exogenous factors are acknowledged.

[1] “Clients” include lecturers and students

Table 2: Refined taxonomy of factors to promote quality web-supported learning

Institutional factors	Technology factors
Technology plan Student selection and entry into courses Student consultation Institutional programme evaluation Change management Standardisation of information design and dissemination	Appropriate use of technology Reliability Availability 24/7 Accessibility (Inclusivity) System training for clients IT support for clients Appropriate bandwidth and download demands Management of student data
Lecturer factors	**Student factors**
Interaction / facilitation Frequent feedback Academic background Evaluation of teaching competence Community and empathy	Communication Time management Self directed learning Critical thinking Problem solving
Instructional design factors	**Pedagogical factors**
Usability: • Modular chunks • Use of media • Use of images, graphics, animation • Layout and presentation • Standards • Accessibility **Learning principles:** • Collaborative learning • Interactivity • Engagement • High expectations • Higher cognitive levels	Learning outcomes, goals, expectations Flexible learning package Assessment strategies Learning styles Learner-centered learning environment Content and learning resources: relevance, accuracy, currency Adaptable, sustainable, scaleable, reusable Self reflection

Various new factors were suggested by the critical colleagues, for example the importance of standardised dissemination of information, on an institution-wide basis. This factor refers to the importance of standardising the *information design* of all applications that influence web-supported learning, for example the user interface of campus portals, access to library reference pages etc. Another suggestion was to subdivide the instructional design factors into two subsections, *usability* and *learning principles*.

Further modifications agreed upon were that the term *inclusivity* should be re-worded as *accessibility* and moved to *technology* factors. The current connotation of the word *accessibility* includes access to technology for persons with learning and/or physical disabilities (Brown, 2004). Similarly *diversity* was reworded as *learning styles*, which is intended to include equity issues as well as social, cultural and gender sensitivity. The term *organisational change* was replaced with *change management*, a term more widely used in the field of education innovation.

One of the critical colleagues suggested that the taxonomy could be meaningfully mapped onto Ingwersen’s (1996) cognitive model of information retrieval (IR) interaction, in order to provide a visual synthesis and interpretation of the taxonomy (Figures 1 and 2). This mapping is explored in section 4, after considering the benefits and extent of an interdisciplinary approach to theory construction in e-learning.

3. Interdisciplinary approach

De Wet and Smith (1998) analysed 796 articles in the South African Journal of Education (1981 to 1996) and concluded (*inter alia*) that a lack of cooperation is evident in theory construction in education. They found that 86% of the articles were from the single part perspective of education and other perspectives or disciplines were not taken into consideration. In a higher education environment, it is imperative that the theoretical foundations of both the effective use of technology and the dissemination of information be considered. The current emphasis on social constructivism (Amory, 2004) and the social aspects of learning (Magondo, 2004) further underlines the imperative of an interdisciplinary approach.

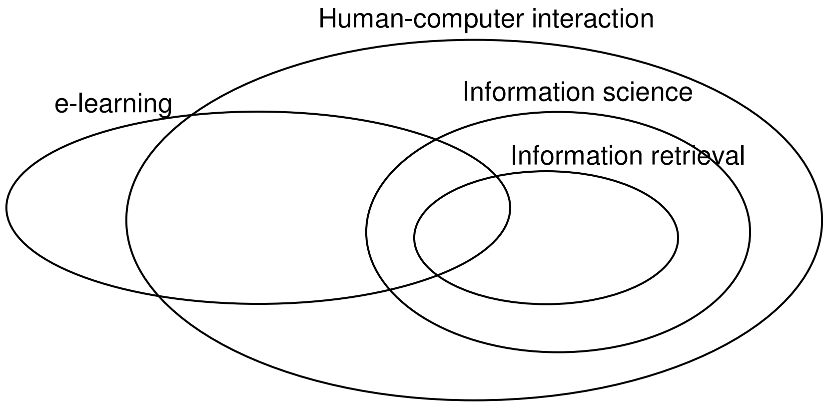
Such an interdisciplinary approach encompasses the fields of information science (IS), information retrieval (IR), instructional technology (IT) and human-computer interaction (HCI), amongst others. Let us investigate possible definitions of these disciplines.

Information retrieval may be defined as “the processes involved in the representation, storage, searching, finding, filtering, and presentation of information *relevant* to a requirement for information desired by a human user” (Ingwersen, 2004). The *cognitive view* of IR emphasizes that the communication channel is a dual one, i.e. there may be a human user or a machine (system) on either end of the communication channel and the generation and reception of information may occur in both directions. This cognitive view is aligned with a socio-hermeneutic approach to information transfer, knowledge communication and human-computer interaction (Ingwesen, 1996). The user’s situational context is considered including sociological, psychological and physical factors.

Human-computer interaction is the study of interaction between people (users) and computers (Wikipedia, 2005). Interaction between the user and the computer occurs at the user interface, which includes both hardware and software. In the taxonomy (Table 2), the *usability* section reflects principles of HCI.

Both information retrieval and human-computer interaction appear to overlap noticeably with the field of *instructional technology*, sometimes referred to as *educational technology*, or more recently *e-learning*. In all these disciplines, there is an emphasis on interaction, communication, information processing, information retrieval, information transfer and the cognitive state, prior knowledge and skills as well as the world view of the user (see *learning styles* in the taxonomy). Figure 1 is one possible representation of the overlap between these disciplines.

Figure 1: Overlaps between various disciplines sharing commonalities with e-learning[2]



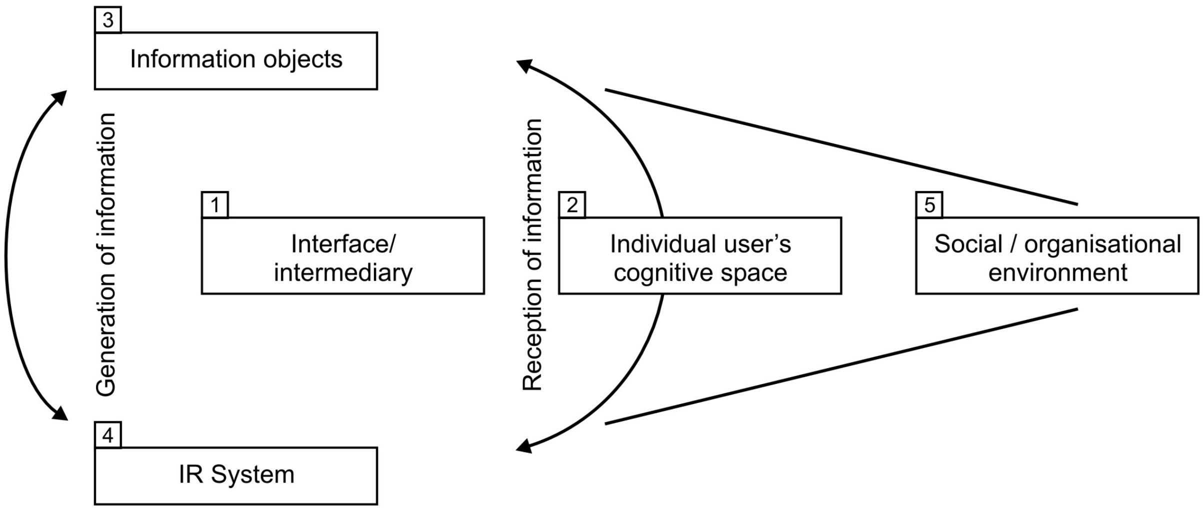
Certainly there are overlaps with many more interrelated disciplines, such as computer science, cognitive psychology, information design[3], information architecture, linguistics, semiotics and librarianship, just to mention a few. The *web of learning* is indeed complex and interrelated with many other human endeavours. The interesting inference is that the cognitive state of the human user, together with his social and physical context, is critical for the effective retrieval and processing of information, as well as for effective technology-enhanced learning to take place.

It was this inference that led to the attempt to map the taxonomy of critical success factors to Ingwersen's (1996) cognitive model of information retrieval. The benefit of such a mapping is that it provides a practical and holistic interpretation of the complex issues involved in synthesizing factors to promote excellence in web-supported learning.

4. Ingwersen's (1996) Cognitive Model of Information Retrieval

Ingwersen's (1996) model is presented in a simplified form in Figure 2 and discussed below the figure. The mapping of the categories in the taxonomy (Table 2) onto Ingwersen's model is given in Figure 3.

Figure 2: Simplification of Ingwersen's (1996) cognitive model of IR interaction.



[2] The shapes in Figure 1 are not intended to portray relative size, extent or proportions of the various disciplines.
[3] In the taxonomy (Table 2), *information design* is included under *institutional factors*.

The details of Ingwersen's model, such as particular items in each section and the flow of transformation, influence, interaction and communication between items are excluded from Figure 2, in order to simplify the concepts and to enable a mapping with the taxonomy.

In Figure 2, the interface, or intermediary (1) may be human or a computer. In the context of this paper, it would be the computer providing access to web-supported courses (this maps onto *technology factors* in the taxonomy). The individual user (2) is the client, namely the student or lecturer participating in web-supported teaching and learning situations (this maps onto the *lecturer* and *student factors*). The information objects (3) are the web-supported learning products that the student is engaging with, including content, resources, learning activities etc. These learning opportunities are based on the *instructional design* and *pedagogical factors* that need to be considered in designing and developing quality web-supported learning products. The information retrieval system (4) is the *institutional infrastructure* to enable either information retrieval or in this case, web-supported learning. The social or organizational environment (5) includes institutional and exogenous factors, as well as the underlying assumptions that are required for quality web-supported learning. For example, underlying assumptions such as positive attitudes, motivation, class size and incentives for lecturers are part of the social and organisational environment.

Figure 3*:* Graphic interpretation of the taxonomy for quality web-supported learning, mapped onto Ingwersen's (1996) cognitive model of IR

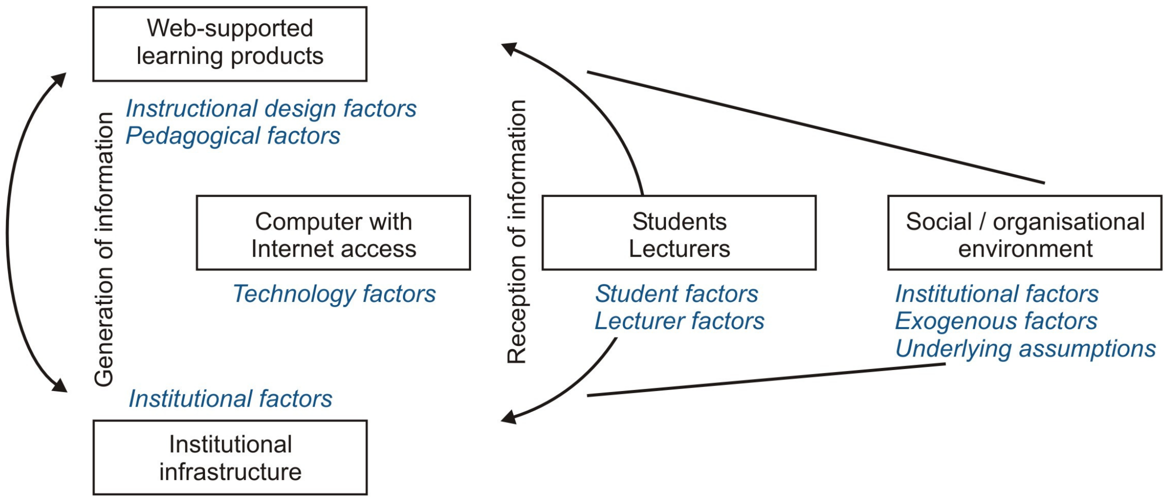


Figure 3 presents the categories of the taxonomy for quality web-supported learning mapped onto Ingwersen's (1996) cognitive model for IR, as interpreted in the foregoing discussion. In Figure 3, the categories of the taxonomy are indicated in italic text. *Institutional factors* appear twice, since they appear to map naturally onto both the *institutional infrastructure* and onto the *organisational environment*. Note the central importance of the users, situated within their social and organisational environment.

Thus this study provides guidelines to promote excellence in web-supported learning in the form of the *taxonomy of critical success factors for quality web-supported learning*, which has three components:

- underlying assumptions and exogenous factors (Table 1);
- taxonomy of factors, in six categories (Table 2);
- cognitive model providing a graphic interpretation (Figure 3).

5. Implications and future research

This paper presents a taxonomy of critical success factors to enhance the quality of web-supported learning opportunities in a blended learning environment in higher education. The taxonomy of factors is organized in six categories: institutional, technology, lecturer, student, instructional design and pedagogical factors. Many of the factors are well established having been synthesized directly or indirectly from the literature, for example, better communication channels between students and lecturers (Chickering & Ehrmann, 1996) and classic instructional design theory (Gagné, 1985; Gery, 1987; Reeves, 1993).

Additional factors were identified from more recent studies, for example usability, currency of content and resources, re-usability of learning objects and technical issues such as appropriate bandwidth and download demands[4] (Herrington, Herrington, Oliver, Stoney & Willis, 2001; Oliver, 2001). Undoubtedly there are more such studies and more factors to enhance web-supported learning. However, few studies appear to present a holistic approach to quality in web-supported learning, by applying standard quality assurance practice to products, process and client satisfaction measures (see Fresen, 2005). Phases 1 and 2 of this study attempted to diminish the gap between quality assurance and online learning practices (identified by Reid, 2003). In order to enhance its generalisability, this study is registered with the European Quality Observatory (2004).

Another fresh approach in this study was to apply principles of information retrieval (IR) and other related disciplines, by mapping the categories in the taxonomy onto Ingwersen's (1996) cognitive model of IR interaction (Figure 3). This presents a practical, holistic, graphic interpretation of the taxonomy of critical success factors and emphasizes the centrality of the user (or learner) and their cognitive state.

An opportunity for further research is to test the taxonomy of factors for quality web-supported learning empirically. Instructional designers and project managers need to modify the categories and factors proposed to assure quality in the learning experiences they design and implement in their own particular situations.

6. Conclusion

The web medium offers increased convenience and alternative methods of communication and assessment. There are changing roles for both lecturers and students in learning how to make optimum use of electronic media in order to enhance the learning process. Issues such as change management, accessibility, learner-centered environments and technology access and reliability have an impact on the quality of web-supported learning products. The taxonomy and cognitive mapping presented in this paper attempt to provide a holistic, theoretical basis from which to pursue excellence in web-supported learning.

7. References

Amory, A. Open content, open access, open source? In: *Proceedings of the 6th ZA-WWW2004 Conference*, September 2004. South Africa: Johannesburg. [Online]. Available WWW: http://ingedej.ukzn.ac.za/ (Accessed 16 May 2005).

[4] This study does not make recommendations for particular technical specifications regarding the provision of high speed internet access. The implication is simply that designs should take existing technical constraints into account.

Barker, K. (1999). Quality guidelines for technology-assisted distance education. [Online]. Available WWW: http://futured.com/pdf/distance.pdf (Accessed 28 June 2004).

Bezuidenhout, J. (2004). *An androgogical framework for benchmarking e-learning at Technikon Free State (TFS).* Unpublished D.Tech. thesis, Central University of Technology, Bloemfontein, South Africa.

Brown, A.J.V. Increasing throughput – online course design for the learning disabled. In: *Proceedings of the 6th ZA-WWW2004 conference,* September 2004. South Africa: Johannesburg. [Online]. Available WWW: http://general.rau.ac.za/infosci/www2004/fulltext/brown6.pdf. (Accessed 16 May 2005).

Chickering, A.W., & Ehrmann, S.C. (1996). Implementing the Seven Principles: Technology as Lever. *AAHE Bulletin,* 49(2), 3-6. [Online]. Available WWW: http://aahebulletin.com/public/archive/sevenprinciples.asp (Accessed 10 June 2004).

Confrey, J., Sabelli, N., & Sheingold, K. (2002). A framework for quality in educational technology programs. *Educational Technology*, 42(3), 7-20.

De Wet & Smith (1998) Die stand van teorievorming soos weerspieël in artikels gepubliseer in die Suid-Afrikaanse tydskrif vir opvoedkunde, 1981-1996. *South African Journal of Education,* 18(3), 175-182.

European Quality Observatory (2004). An analysis and description of the phase 1 quality management system for web-supported learning (use the search term 'QMS'). [Online]. Available WWW: http://www.eqo.info/index.cfm.

Fresen, J.W. (2005). *Quality assurance practice in online (web-supported) learning in higher education: An exploratory study.* Unpublished PhD thesis, University of Pretoria, Pretoria, South Africa. [Online]. Available WWW: http://upetd.up.ac.za/thesis/available/etd-02172005-134301. (Accessed 16 May 2005).

Fresen, J.W. & Boyd, L.G. (2005). Caught in the web of quality. *International Journal of Educational Development,* 25(3), 317-331.

Gagné, R.M. (1985). *The conditions of learning* (4th ed.). New York: Holt, Rinehart & Winston.

Gery, G. (1987). *Making CBT happen: prescriptions for successful implementation of computer-based training in your organization.* Boston: Weingarten.

Graf, D. & Caines, M. (2001). *WebCT Exemplary Course Project.* In: Proceedings of the WebCT User Conference, Vancouver, Canada. [Online]. Available WWW: http://www.webct.com/exemplary/home (Accessed 28 June 2004).

Herman, N. (2001). *The applicability of international benchmarks to an Internet-based distance education programme at the University of Stellenbosch.* Unpublished M.Phil. thesis, University of Stellenbosch, South Africa.

Herrington, A., Herrington, J., Oliver, R., Stoney, S. & Willis, J. (2001). Quality guidelines for online courses: the development of an instrument to audit online units. *Proceedings of* *the 18th annual Australian Society for Computers in Learning in Tertiary Education 2001* conference, Melbourne, Australia.

Institute for Higher Education Policy (IHEP). (2000). *Quality on the Line. Benchmarks for success in internet-based distance education.* Washington: The Institute for Higher Education Policy. [Online]. Available WWW: http://www.ihep.com/pubs/pdf/quality.pdf (Accessed 28 June 2004).

Ingwersen, P. (1996). Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. *Journal of Documentation,* 52(1), 3-50.

Ingwersen, P. (2004). *IR research approaches and models.* Presentation at the University of Pretoria, 25 October 2004.

Khan, B.H. (2005) *E-learning quick checklist.* Hershey: Information Science Publishing.

Magondo, M. Emerging web technologies. In: *Proceedings of the 6th ZA-WWW2004 Conference*, September 2004. South Africa: Johannesburg.

Oliver, R. (2001). Assuring the quality of online learning in Australian higher education. In M. Wallace, A. Ellis & D. Newton (Eds.). *Proceedings of the Moving Online II Conference.* Lismore: Southern Cross University.

Reeves, T.C. (1993). Evaluating technology-based learning. In G.M. Piskurich (Ed.), *The ASTD* h*andbook of instructional technology*. New York: McGraw-Hill.

Reid, I.C. (2003). Quality online education – new research agendas. *Academic Exchange Quarterly,* 7(1), 17-23.

Twigg, C.A. (2001). *Quality assurance for whom? Providers and consumers in today's distributed learning environment.* Troy, NY : The Pew Learning and Technology Program. [Online]. Available WWW : http://www.center.rpi.edu/PewSym/Mono3.pdf (Accessed 16 August 2004.

University of Pretoria. (2003). Quality management system for web-supported learning. [Online]. Available WWW: http://www.up.ac.za/telematic/quality/quality.htm. (Use Internet Explorer version 5 or higher and enable java script.)

Wikipedia (2005). The free encyclopedia. [Online]. Available WWW: http://en.wikipedia.org/wiki (Accessed 12 May 2005).

Yeung, D. (2002). Toward an effective quality assurance model of web-based learning: the perspective of academic staff. *Online Journal of Distance Learning Administration,* 5(2), 1-18.

Acknowledgements

I would like to thank my critical colleagues, Alta Marx, Gaby Pretorius and Detken Scheepers, who participated in refining and reviewing the taxonomy. In particular I would like to acknowledge Alta's contribution in introducing me to Ingwersen's (1996) model and suggesting that it may be applied in this study.

I would also like to thank my co-author and PhD supervisor, Professor Johannes Cronje, who enthusiastically supported the interdisciplinary approach and in particular the application of Ingwersen's (1996) model. Interestingly enough I met Professor Ingwersen in person when he visited the Department of Information Science at the University of Pretoria in 2004.