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Designing mobile LMS interfaces: learners' expectations and experiences

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Abstract

Purpose – This paper aims to present findings of a study that was carried out to identify strategies of enabling learners in developing countries to fully exploit the potential of learning management systems (LMSs). The study set out to: identify the services of learning management systems that are most needed and desired by university learners in developing countries; and identify appropriate access strategies that would guide design decisions on how to effectively and satisfactorily deliver such services to the university students in developing countries.

Design/methodology/approach – A total of 144 students from two African universities participated in the study by responding to an online survey questionnaire. The questionnaire asked students: how often they accessed LMSs to obtain, create and exchange information and knowledge; their preference for the different devices used for accessing the LMS; the LMS services they are most often required to access; and the services they most desire to use.

Findings – The findings of the survey indicate that the most desired and most accessed LMS services by the students include: assignments, announcements, resources, course outlines and the chat room. At the same time, mobile phones are rated the least used devices for accessing the LMS services, mainly due to inadequate design of LMSs for mobile interaction.

Originality/value – The paper also presents mobile LMS interface designs and ideas achieved through a participatory design process for enhancing the accessibility of the most needed and desired LMS services on mobile phones.

Keywords Learning management systems (LMSs), Sakai, Moodle, Accessibility, Developing countries, Learning, Learning methods

Paper type Research paper

1. Introduction

Over the last decade, there has been a remarkable increase in the adoption of learning management systems (LMSs) in developing countries, where open source LMSs have had a clear market dominance over proprietary systems (Cavus and Ibrahim, 2007). The majority of universities in developing countries, especially in Africa, view LMSs as the most appropriate e-learning tool in blended learning environments, and they (the LMSs) are often regarded as the starting point of any web-based learning program (Akeroyd, 2005; Cavus and Ibrahim, 2007; Kakasevski *et al.*, 2008). However, our earlier research (Ssekakubo *et al.*, 2011) shows that, despite the increased adoption of LMSs by institutions in developing countries, their potential to support e-learning has not been

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fully exploited. Sife *et al.* (2007) and Saeedikiya *et al.* (2010) also noted that e-learning initiatives in general and LMSs in particular register relatively few users in developing countries, thereby not justifying the high infrastructure investment costs.

One way to attract and retain the learners on the LMSs is by identifying the LMS services that are most desired by the students, refactor the LMS and make such services more effectively and intuitively accessible by the students through various technology platforms.

In this paper, we present the findings of a survey in which we identified: the most needed and desired LMS services; how the students currently prefer accessing the LMS services; and the students' perceptions on the appropriate access strategies that would guide design decisions on how to effectively and satisfactorily deliver such services to them. The survey was carried out in two of the five universities that were involved in our earlier research entitled "Have learning management systems fulfilled their potential in developing countries?", namely University of Cape Town (UCT) and Makerere University.

Based on the findings, we then designed an alternate interface to an LMS for mobile devices, which arguably better meets user needs.

The paper has six sections. Section 1 is the introduction. Section 2 presents some related literature, including: the services of LMSs; LMS generations and standards; and the accessibility and usability of LMSs. Section 3 describes our survey approach, including: an overview of the e-survey methodology; study design; and our study population. Section 4 is the findings of the survey. In Sections 5 and 6 we present the design and implementation of a mobile LMS and conclusions, respectively.

2. Related literature

2.1 The LMS services

LMSs are web-based software application platforms that use web technologies and internet services to support: online course creation, maintenance and delivery; student enrolment and management; and education administration and student performance reporting (Dagger *et al.*, 2007; Hadjerrouit, 2010). LMSs also allow learners to use interactive features such as threaded discussions, chatrooms, discussion fora, and other methods of communication. A typical LMS, such as Sakai or Moodle, may have as many as 20 or more service components. Table I shows some of the most common service components of LMSs.

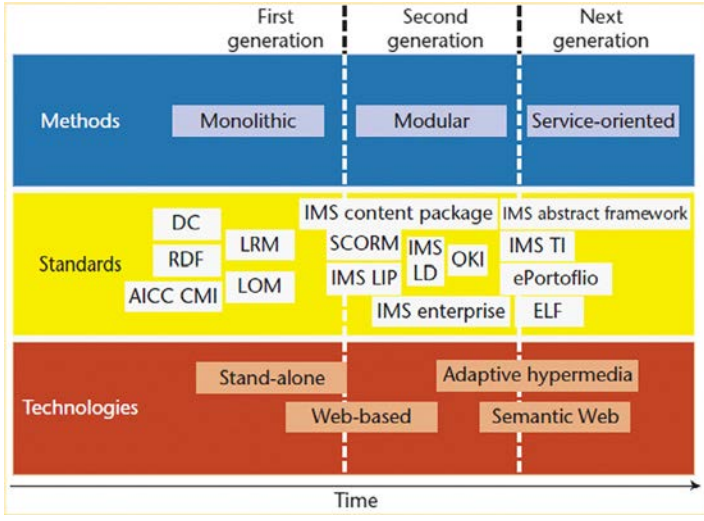
2.2 LMS generations and standards

Literature reveals three LMS generations: the first generation, the second generation and the future generation. According to Dagger *et al.* (2007), the first generation systems were monolithic and supported content-only interoperation; during this generation, a range of standards emerged, such as Dublin Core (DC), IMS Learning Resource Metadata (LRM), and IEEE Learning Object Metadata (LOM) (Figure 1). The second generation systems (which is the current generation) are largely modular, they take account of users and their associated profiles and focus not only on sharing content but also on sharing learning objects (LO) sequences of LO, and learner information (Dagger *et al.*, 2007; Leal and Queirós, 2011). The standards that have emerged during this generation include shareable content object reference model (SCORM), IMS Content Packaging, and IMS Learning Design. The next-generation

Service component	Description
Announcements	For viewing current, time critical information
Assignments	For viewing, posting and submitting assignments
Blogs	For course or project blogging or journals
Calendar	For viewing deadlines, events, etc.
Chat room	For real-time conversations in written form
Course outline	For summary outline and/or course requirements
Drop box	For private file sharing between instructor and student
Email archive	For viewing e-mails sent to the site
Forums	Displaying forums and topics of the course
Maps	For using interactive Google Maps
Messages	Displaying messages to/from course participants
News	For displaying news and updates from online sources (RSS feeds)
Participants	For viewing course participant list
Podcasts	For managing individual podcasts and podcasts feed information
Polls	For anonymous polls or voting
Q&A	For asking and answering questions
Resources	For accessing documents, URLs or other web sites
Search	For searching content within course or across courses
Slideshow	For showing and viewing slideshows of image collections from resources
Tests and quizzes	For taking online tests/quizzes
Wiki	For collaborative editing of pages and content

Source: Moodle (www.moodle.org) and Sakai (www.sakaiproject.org)

Table I.
Service components/tools of LMSs



Source: Dagger *et al.* (2007)

Figure 1.
Generations of LMSs

systems focus on targeted personalization and letting consumers choose the right combination of services for their requirements – service oriented (Figure 1).

2.3 Accessibility and usability of LMSs

Du Plessis and Koohang (2005) and Koohang *et al.* (2011) define accessibility as the ability of the LO to be accessed by learners in any location regardless of the learner experience, device or the type of platform the learner uses. LO are units of instructional content that can be used and reused on web-based e-learning systems (Leal and Queirós, 2011). In LMSs, LO are presented in the various service components, such as: announcements, assignments, resources, forums, chat rooms, course outlines and wikis.

The ISO 9241 standard 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 of use (ISO 9241-11, 1998). According to Costabile *et al.* (2005), Ardito *et al.* (2006) and Wong *et al.* (2003), usability plays a significant role towards the success of e-learning applications – if an e-learning system is not usable enough, it obstructs students' learning: the learners would spend more time learning how to use the system rather than learning the content.

Leal and Queirós (2011) contend that, despite the success in the promotion of the standardization of e-learning systems, usability and accessibility are still a major user concern with the existing systems. Earlier work by Leal and Queirós (2011) and Dagger *et al.* (2007) claims that adapting service oriented architectures (SOA) to e-learning systems so as to provide flexible learning environments for learners could improve the usability and accessibility of the services. Dagger *et al.* (2007) also argues that the current generation of LMSs embraced a significant development; the "services" principle, exposing certain aspects of their functionality externally. This means that, as designs became more modularized, it is easier for platforms to integrate new functionality as it arises. Furthermore, the LMS community has made an increased move towards separating content from tools, and the learner information has become more distinguished. However, these systems aren't entirely learner-centric; they still focus strongly on learning administration (course management) rather than on the learner (Dagger *et al.*, 2007).

This study is, however, distinct from prior research, in that our main goal is to enhance accessibility from the point of view of a specific group of LMS users constrained by poor ICT infrastructure such as electricity outages and slow internet bandwidth, rather than improving or extending the functionality of LMSs. Similar studies on LMS accessibility were carried out within the framework of the European Commission Web-edu project by Paulsen (2003) on the accessibility and satisfaction of LMSs in 113 institutions across 17 European countries. The studies revealed no major technical problems with LMSs, and the users rated accessibility to the LMS services as satisfactory. The studies also noted that in the European Nordic region and North Western Europe where internet penetration was high, it is not easy to find a university without experiences with LMSs, compared to the Southern European region where internet penetration was low. The study concludes that internet penetration determines the level of use of LMSs.

In developing countries, where internet penetration is still very low, in addition to other constraints, there is a need to identify effective ways of deploying and accessing LMSs services.

3. Study approach

3.1 The e-survey methodology

The electronic survey (e-survey) methodology was used because we wanted to reach out to more respondents in a short time without the need to travel. However, there are some concerns on the effectiveness of e-surveys, which include: access to and familiarity with technology (Thompson *et al.*, 2003); how to include incentives for completion (Couper, 2000); response quality (Couper *et al.*, 2001); invasion of privacy (Gurau, 2007); and low response rates (Kaplowitz *et al.*, 2004). In this study, the shortcomings due to such concerns were minimized by the fact that: the survey respondents were university students who were familiar with and had access to technology; no incentives were to be offered to the respondents; and the intent of the survey was well outlined in the introduction, creating a high perceived importance of the study to the respondents so as to provide genuine responses.

3.2 Study design

The study was conducted in two universities, Makerere University (implementing Moodle LMS) and the UCT (implementing Sakai LMS). The two universities were selected for this study first for convenience reasons; having carried out a closely related research meant that we had established contacts in these universities, which would benefit this study. Most importantly, however, was the fact that these universities had for long enough implemented two of the most popular open source LMSs – Moodle and Sakai, respectively. In addition, our earlier research also showed that, while there had been various attempts at LMS implementation (Blackboard, Kewl, and now Moodle) at Makerere University with relatively little success, the UCT had to a good extent successfully implemented Sakai. This contrast in success stories would also benefit our study.

An electronic questionnaire was sent out to students in the two Universities. The invitation to participate in the survey was sent to students' e-mail lists and in some cases directly to individual students' e-mail addresses by the principal investigator. The potential respondents were identified with the help of contact persons, who were faculty staff in the participating universities. Upon sending out the invitation to the students, announcements were also sent to them so as to avoid them treating the invitation to participate in the survey as spam e-mail.

The e-survey questionnaire was powered by LimeSurvey, an open source survey application. The questionnaire consisted of four sections. Section 1 focused on demographic information. Section 2 focused on the students' prior experience with LMSs and comfort level with information technology in general. Section 3 had questions that required the student to rate the different LMS access devices, to score the importance of the various LMS services (on a scale of 1-5) and to select the most desirable LMS services to them. Section 4 was the narrative response section, which allowed the students to provide additional comments or suggestions on any issues that were not addressed in the previous three sections of the questionnaire.

The survey responses were anonymous, and no incentives were offered to the respondents. However, since the survey required the use of human subjects, we had to obtain permission in the form of ethical clearance from the participating Universities.

3.3 Respondent demographics

Although the study targeted about 200 respondents (100 respondents from each University), a total of 144 valid submissions were obtained, indicating a response rate of 72 percent. The distribution of the respondents over the different participating universities is shown in Figure 2. The distribution of the respondents according to domain of study, qualification pursued by respondents and the year of study are shown in Figures 3-5, respectively.

Students from specific faculties were purposely targeted. The targeted students were those who were more actively using the LMS, and these were mainly from the disciplines of science and technology (e.g. engineering, mathematics, computing and information systems) and business and management (Figure 3). The skewed distribution of respondents according to qualification pursued (Figure 4) is explained by the fact that bachelors students are assumed to be more actively using LMSs, especially those in later years of study (second, third and fourth year) who had had more time to interact with the LMS, and so these were targeted (Figure 5).

4. Findings

4.1 Access to, and ease of use of technology

While most of the students who responded to the survey said they did not have access to computers most of the time, all of them own a mobile phone. Thus, mobile phone

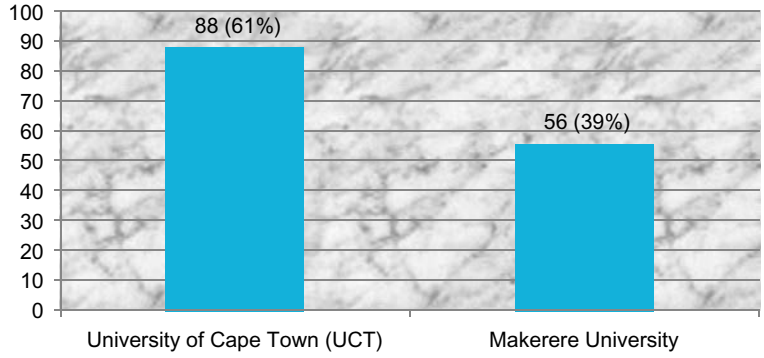


Figure 2.
Distribution of respondents according to university

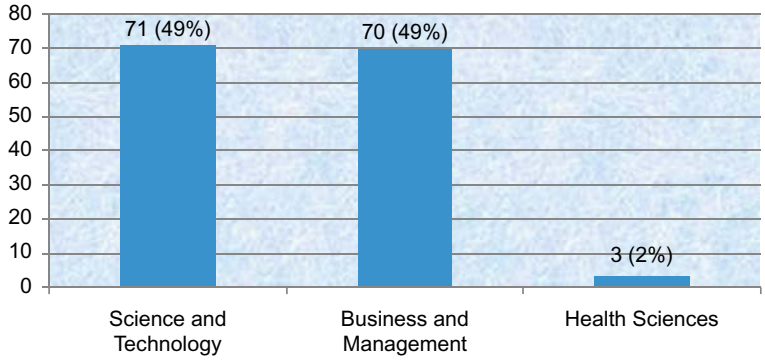


Figure 3.
Distribution of respondents according to study domain

proliferation in the surveyed is 100 percent, of which 79 percent can access the internet (Figure 6). Overall, 58 percent of the respondents had smartphones while the rest had non-smartphones.

Asked to rate themselves on their comfort levels using technology and technology applications, 67 percent said they were very comfortable while 1 percent said they were very uncomfortable (Figure 7).

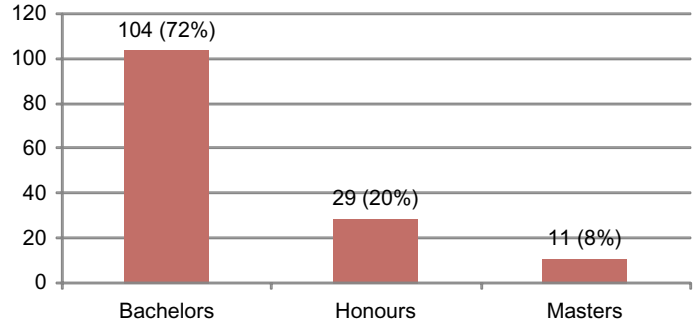


Figure 4.
Distribution of respondents according to qualification

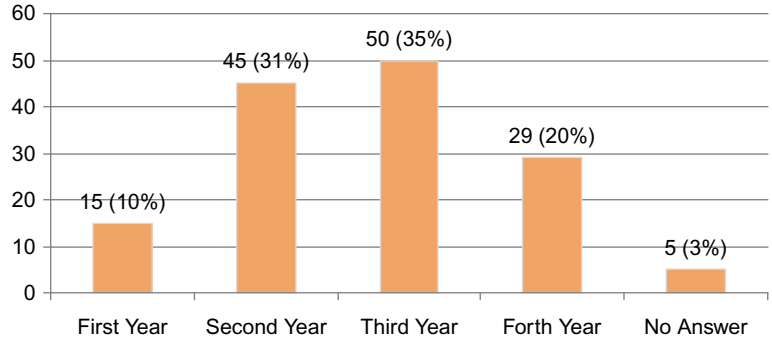


Figure 5.
Distribution of respondents according to year of study

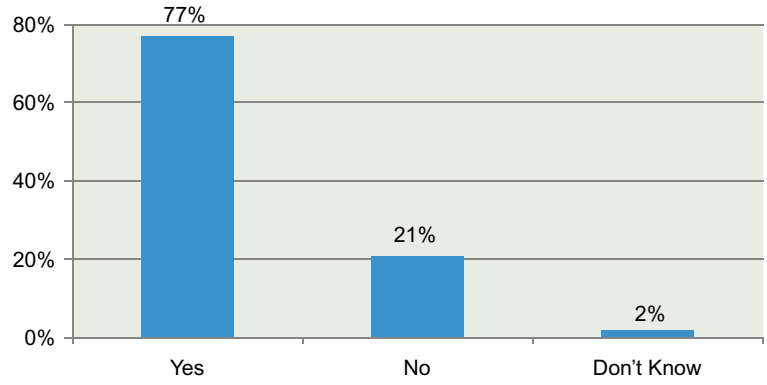


Figure 6.
Can you access internet on your phone?

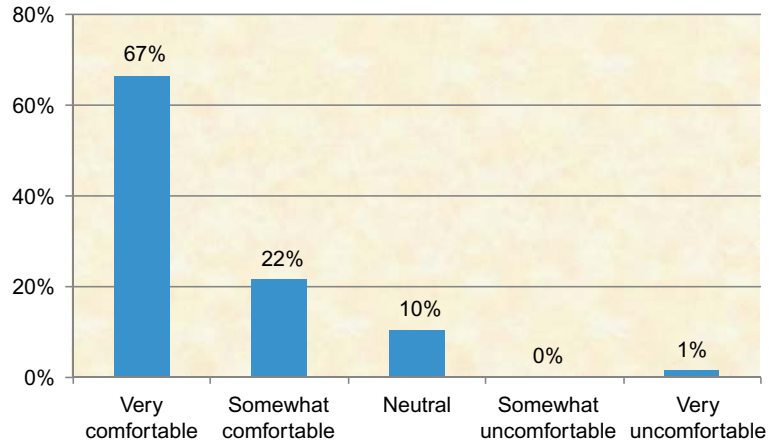


Figure 7.
Students' comfort level using technology and technology applications

There was, however, a significant variation between the students from the different participating universities in terms of the type of phones they possessed as well as their self-reported comfort levels with technology. For example, over 70 percent of the students at the UCT reported to have smartphones, while less than 40 percent of their counterparts at Makerere University had smartphones.

4.2 Experiences with LMSs, access and use

At the UCT, Sakai (branded "Vula" locally) is the major LMS used, and all the respondents from UCT used Vula. At Makerere University, Moodle (branded "MUELE" locally) is the major platform used, and all of the respondents from Makerere University used Moodle. The question with respect to experience with LMSs was asked on a five-point scale (1 – highly experienced; 2 – somewhat experienced; 3 – neutral; 4 – somewhat inexperienced; 5 – struggling). Overall, the students rated themselves as shown in Figure 8.

However, as might have been expected, the variation between the students' experiences with LMSs at the different universities was quite significant, demonstrating the fact that universities and students vary in their use of the technology. For example, while the majority of students from UCT reported high experience, the majority of their

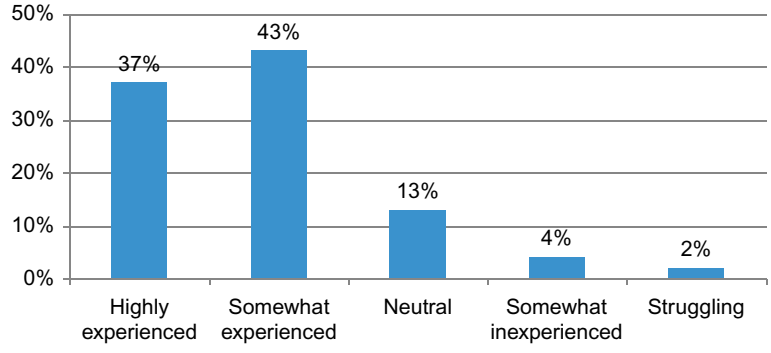


Figure 8.
Students' experience with LMSs

counterparts from Makerere University reported lower experiences. Table II shows how the students rated themselves on their experience using LMSs.

Asked how often they access the LMS and the devices they use, 51 percent of the respondents said they access the LMS several times a day, while 3 percent never access the system at all (Figure 9).

On the devices they use to access the LMS, 60 percent use PCs and laptops at least most of the time (Figure 10), while over 70 percent rarely or do not use their mobile phones at all (Figure 11).

Overall there was no variation between the students from the different participating universities regarding the devices they use to access the LMSs. For example, although

	Highly experienced (%)	Somewhat experienced (%)	Neutral (%)	Somewhat inexperienced (%)	Struggling (%)
Makerere University	9	50	25	11	5
University of Cape Town	56	38	6	0	0

Table II.
Differences in experiences with LMSs between students at different universities

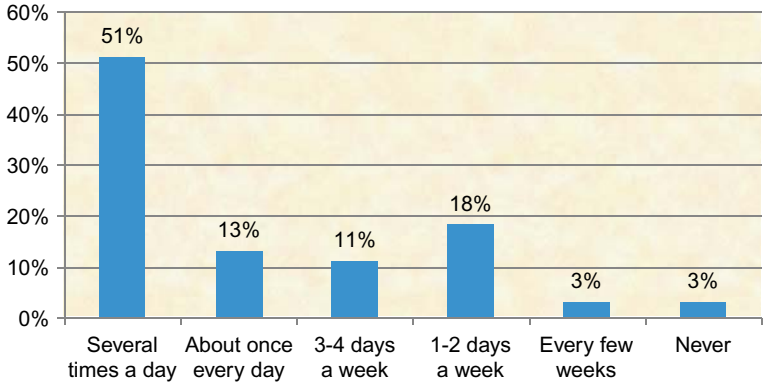


Figure 9.
Frequency of LMS Access by the Respondents

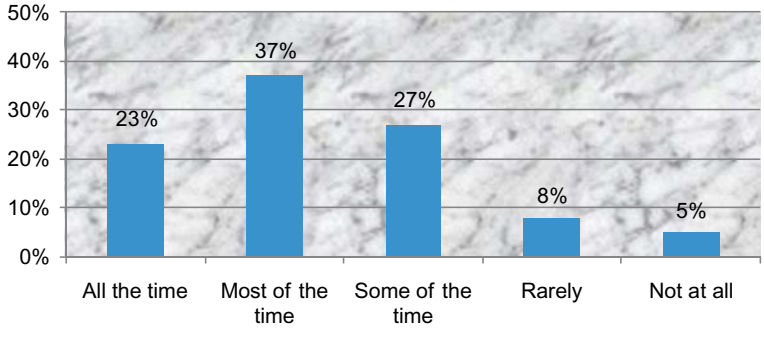


Figure 10.
How often do you access the LMS using a PC/laptop?

over 70 percent of students at the UCT have smartphones, and almost every smartphone can read and display full desktop web sites, the students still do not find it appealing to use phones for accessing LMSs. Instead, the students ranked laptops as the most preferred device for accessing the LMS (Figure 12).

The preferences for the different devices for accessing the LMSs shown in Figure 12 become more important when we explore the over 100 views expressed by the students in choosing the devices to use. The views, some of which are quoted below, highlight issues of screen size, processing power, portability, power-save, wireless connectivity, etc.:

> A laptop is the most convenient because it is portable, as fast to open a page as a Pc/desktop computer and its use is not limited to power availability. A mobile phone is as good as a laptop though it is slow when opening some page. A PC is good but limited to power availability. I don't know about the Tablet.

> The laptop takes the first ranking because it is more reliable in terms of electricity and easily portable.

> A tablet is somehow smaller than a laptop or even a desktop, whereas a mobile phone lighter and easy carry compared to desktop and laptop [. . .] so I would choose a tablet and mobile phone due to convenience reasons.

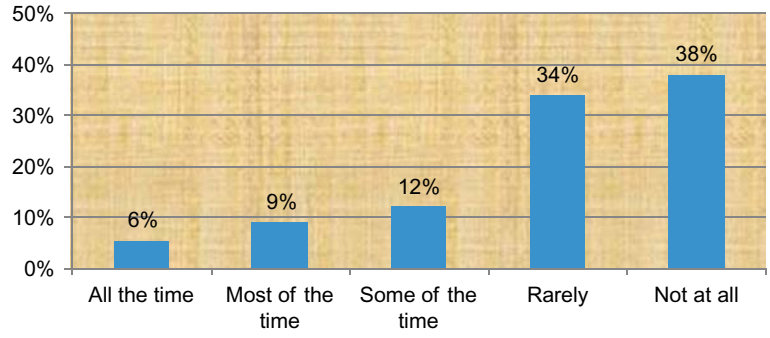


Figure 11.
How often do you access the LMS using a mobile phone?

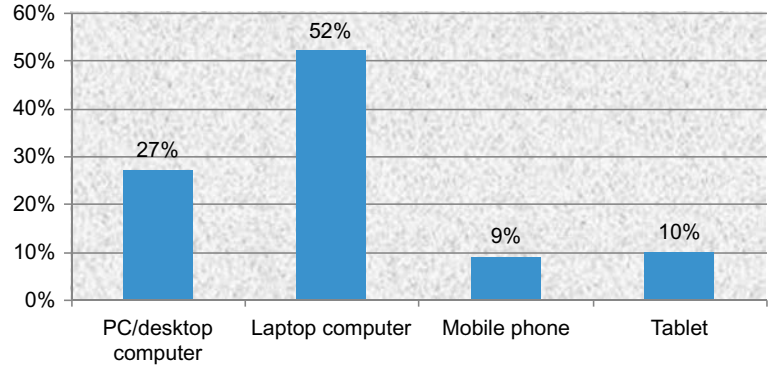


Figure 12.
Students' preferred devices for accessing LMSs

4.3 Most needed vs most desired LMS services

The needed services are those that the students are required to access most of the time, while the desired services are those that the students like most. Table III shows how the students rated the need and desire of the different LMS services. The last column of the table gives the average percentage of the need and desire of services. The services with the highest average score are the most needed and desired LMS services by the students.

In addition to the LMS services presented to the students for selection, the students were also asked to write down any other LMS services that are important them, or which they would like the LMS to provide. The following were mentioned: grade book; assignment submission; video lectures/tutorials; video forums/videoconferencing; automatic marker; eCards for exams, graduation, etc.; notification of important deadlines; picture blog; receiving results and tutorial Signups.

5. Design and implementation of the mLMS

Literature on optimization of web sites for mobile phone access (Nielson, 2012) reveals that web sites can be optimized for mobile access in two ways, either:

(1) enable access to a fewer services through the mobile phone, but with all the necessary details for each service; or

(2) enable access to all the web site services through the mobile phone, but with little detail for each service.

Service	Respondents who selected service as frequently used-needed		Respondents who strongly agree that the service is desirable		Average of "need" and "desire"
	Number	Percentage	Number	Percentage	
Assignments	121	84	102	71	77
Announcements	106	74	99	69	72
Resources	97	67	96	66	67
Course outlines	74	51	90	62	57
Chat room	77	53	64	44	49
Slides	57	39	74	51	45
Calendar	57	39	66	46	43
Tests and quizzes	54	37	64	44	41
Dropbox/file exchange	49	34	58	40	37
Discussion forums	48	33	55	38	36
Participants/groups	52	36	44	30	33
Search	37	26	57	39	33
Messages	43	34	43	29	32
Q&A	34	23	57	39	31
Email archive	36	25	43	29	27
News/RSS feeds	18	12	28	19	16
Wikis	18	12	26	18	15
Blogs	16	11	23	16	14
Polls	16	11	24	16	14
Podcasts	11	8	18	12	10

Table III.
How the students rated the need and desire of the different LMS services

Because LMSs have several service components (atypical LMS like Sakai or Moodle with over 20 services), and some of which are occasionally used/accessed by the students, the most feasible and appropriate way to optimize the LMS for mobile access would therefore be to provide a few selected services, with the necessary detail for each service.

In this study, the most needed and desired LMS services by the students in the surveyed universities were identified through the students' ranking of the services (Table III). The top ranked services were then the ones to be provided for access on the mobile phone. These included: assignments, announcements, resources, course outlines and chat rooms.

Having identified the LMS services to provide access for on the mobile phone, the next task was then how to design the mobile interfaces through which such services could be effectively and satisfactorily accessed by the students on their mobile phones. This was achieved through a participatory design process (Jones and Marsden, 2006) with the students at the UCT, where Sakai is the LMS used. Thus, the design of the mobile learning management system (mLMS) interfaces for accessing selected LMS services was explored on the Sakai LMS. At UCT however, Sakai is branded as "Vula", and so the mLMS would be dubbed mobile Vula (mVula). The students who participated in the participatory design process of mVula interfaces were randomly, but purposefully selected (first year students were not used because they were assumed not to have had enough experience using the LMS) and were met in groups of 2's and 3's. The students in focus groups were asked how they perceived the idea of mobile LMS; whether they preferred the mVula to be service- or course-based. Then they were asked to draw sketches of how they wanted the mVula interfaces for the selected services to look like. From the sketches drawn by the students, the first paper prototype of mVula interfaces was created, which was again validated with the students to generate the final paper prototype of mVula (Figure 14).

The key design issues learned from the participatory design process included: having straight forward non-congested interfaces; the application to focus on presenting services; and having fewer clicks through the application before the required information is obtained by the user.

The paper prototype was then transformed into a working prototype using various technologies. mVula was developed and implemented with support for WebKit-based browsers, using HTML, CSS and JavaScript at the client side, and PHP at the back end, linking and obtaining data from the main Vula server via SOAP and REST endpoints, and in cases where the REST points where not available for some services, we scraped the HTML from the existing Vula portal.

WebKit is the underlying browser engine that allows most native smart phone web browsers to render web pages across the major mobile platforms (iOS, Android, BlackBerry 6 + , Tablet OS, Nokia Symbian and webOS). Thus, with support for WebKit-based browsers, many students using a wide range of smart phones would be able to access the application.

The mVula application is hosted on a publically accessible server (Figure 13), and through it, users were able to access the selected Vula services on their mobile phones through a web address.The index page of the application required user login. The login credentials were verified by the Vula server before a screen interface of mVula services is displayed (Figures 14 and 15).

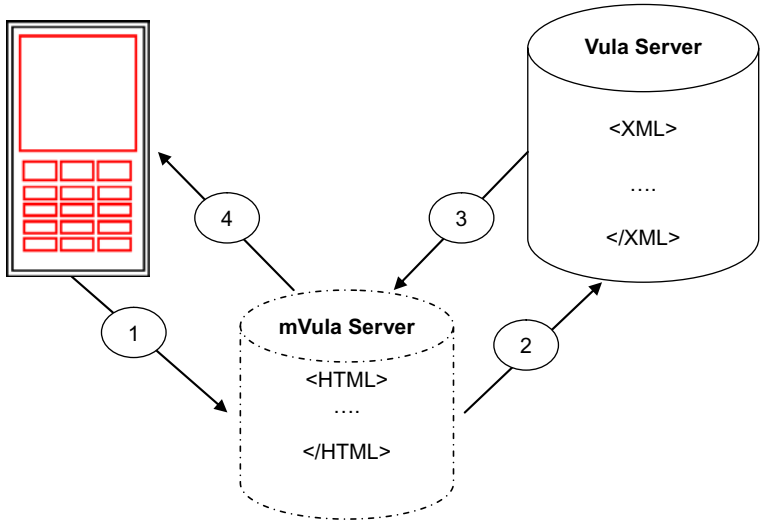


Figure 13.
System setup

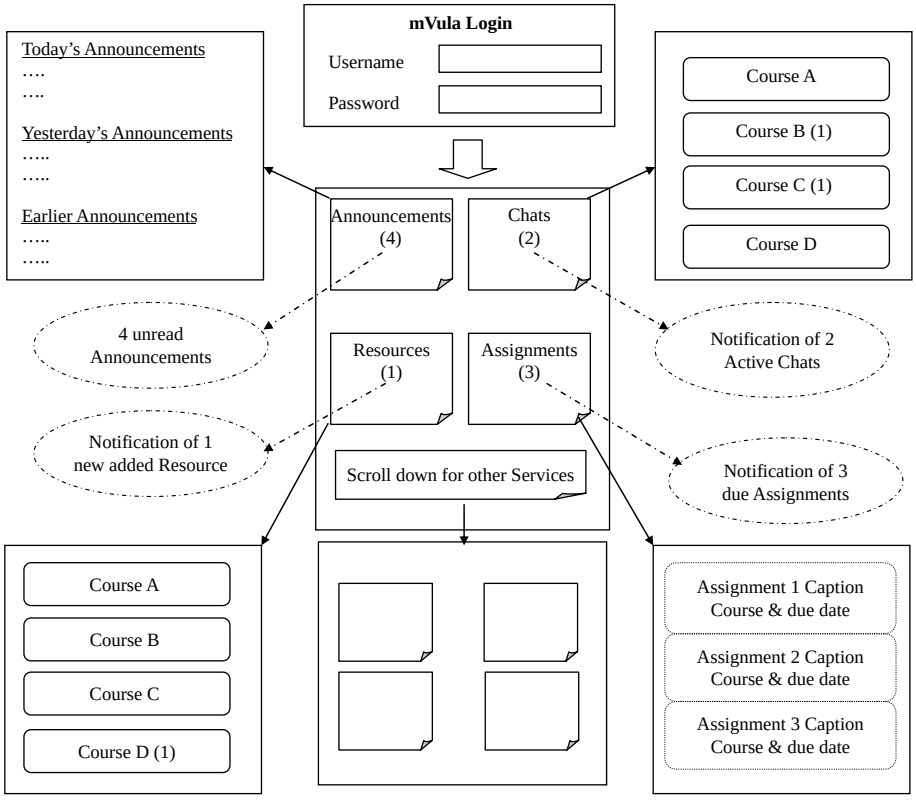


Figure 14.
Paper prototype of mVula interfaces

Figure 15.
Snapshots of the interfaces of the working prototype of mVula

5.1 Evaluation of mVula

The term evaluation has been widely defined. Below are two closely related definitions which this study took as the working definition for the evaluation:

> The systematic acquisition and assessment of information to provide useful feedback about some object. And it involves collecting and sifting through data, making judgements

about the validity of the information and of inferences we derive from it, whether or not an assessment of worth or merit results (www.socialresearchmethods.net/kb/intreval.php).

Evaluation is the systematic determination of the quality or value of something (Scriven, 1991).

In the first definition, the term "object" is used while in the second definition the term "something" is used. Both of these terms may refer to a program, policy, technology, person, need, or activity.

Davidson (2004) agrees with Scriven's definition and adds that, evaluations are generally conducted for one or two main reasons: to find areas for improvement and/or to generate an assessment of overall quality or value (usually for reporting or decision-making purposes).

mVula intervention was evaluated for both of these reasons; that is to say:

(1) for improvement, which was done through a usability evaluation carried out on the application; and

(2) for assessment of the overall value, which was done through an impact evaluation of the mVula intervention.

5.1.1 Usability evaluation. Usability evaluation of the application was carried out using standard usability evaluation procedures (Nielsen and Mack, 1994) which were complemented with case-specific measures. According to Ardito *et al.* (2006), the ISO 9241 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 of use (ISO 9241-11, 1998).

In this case, the product was a mobile application (mVula) designed to encourage the users (students) to access the LMS services through their mobile phones.

The application was evaluated for usability at three levels: expert evaluation; focus group evaluation and user experience evaluation.

(a) Expert evaluation. The expert/heuristic evaluation (Nielsen and Molich, 1990) of the prototype was done with a team of five human computer interaction (HCI) experts and practitioners. These were identified and recruited from graduate students at the Department of Computer Science, UCT, who had studied HCI and had practical experience in HCI related studies. The experts interacted with the application in a laboratory environment and were asked to examine the application interfaces and judge its compliance with recognized usability principles – the "heuristics" (Nielsen, 1992, 1994). Specifically, the mVula application was evaluated for: simplicity; error; comprehensibility; and flexibility and efficiency of use; as well as identifying any HCI related concerns and interface flaws to improve user interaction.

From the heuristic evaluation, the interface layout and concepts in mVula were described as appropriate and familiar to the users, and the information appeared in a logical order. The application was also found to be intuitive, allowing the users to recognise what they wanted to do rather than requiring them to recall from the previous experiences. However, in order to enhance user satisfaction, the evaluators also identified and highlighted some issues that needed to be addressed (Table IV), these were implemented before the application was rolled out for a user-experience evaluation.

From the design and implementation process, and the expert evaluation of the first mVula prototype, it was concluded that the ideas presented in mVula are viable within

Include an "About" tab on the login page of the application within which to give a brief description of the application	Done
Turn off text prediction at login	Done
Remove the bread crumbs, as they make the application look congested. Keep only the "Home" tab on all screens, to provide consistency in navigation. No need for back button in the application, the device/system back button will be sufficient	Done
Make links look clickable, and provide visual feedback when an item is selected	Done
Have to indicate where you are all the time in the application – as it is done in announcements. Replicate it for resources and other services. Also indicate the source of the announcement and assignment, given that these are not grouped according to courses	Done
Show the file type (mime type) of the resources and other downloadable files (metadata)	Done
When system times out, and requires a fresh login, it should automatically go the login page	Not implemented. The user would refresh manually to re-login
Where text is longer than screen, use ellipses [. . .]	Done
The different colours used for the different service-blocks could destruct the user	Done-all services-blocks were made blue, a familiar dominant Vula web site colour
Allow more user control and freedom, i.e. provide "emergency exits" or easier navigation forward and back	Done – home button put to every page, and a button, to "one step back"

Table IV.
Highlights of the feedback from HCI experts on mVula

the WebKit framework, and the application meets standard usability requirements. The application was then rolled out for user experience evaluation, first with focus groups, and then for voluntary use.

(b) Focus group evaluation. The focus group evaluation was carried out with real users who were randomly recruited from the students at the UCT. The recruits however had to fulfill two requirements:

(1) not from the Department of Computer Science (this was because the user-experience evaluation – the rollout of the application was planned to be done in the Department of Computer Science); and

(2) to have a smart phone, preferably not a blackberry (this was because non-WebKit versions of blackberry would not access the application.

11 students were recruited, and arrangements were made for these to meet with the principal investigator in groups of 2's and 3's in a controlled environment (lab). After being briefed about the application, they were required to accomplish a set of tasks using the application on their mobile phones.

The focus group evaluation was aimed at measuring learnability (ease of use) as well as to identifying any functional errors and flaws that could have skipped the attention of the expert evaluators. Learnability was assessed with two measurements:

(1) The ability to use the application without instructions/guidance on the first try.
(2) Task completion without errors or getting frustrated.

The data collection instrument (online questionnaire), which was going to be used at the voluntary user experience evaluation, was also pre-tested with the focus groups. The feedback was used to further improve the prototype and the survey tool.

(c) User experience evaluation. ISO FDIS 9241-210 defines user experience as: "A person's perceptions and responses that result from the use and/or anticipated use of a product, system or service", and can be measured during or after use of the product, system or service (Bevan, 2009).

The user experience evaluation of mVula application was done by the students of Department of Computer Science, UCT.

The application was hosted on a publically accessible server. Through mVula, the students could access the selected LMS services through their mobile phones upon login using their university login credentials.

The principal investigator visited second and third classes at the Department of Computer Science, briefed the students about the application, and requested them to participate in the user-experience evaluation of the application. 70 students volunteered to participate, and these registered with the principal investigator.

The web address through which mVula could be accessed was given to the students in class and was also later sent to the e-mail addresses of the 70 students who registered to participate.

The students were asked to voluntarily use the application in accessing the LMS services for about two to three weeks and thereafter provide feedback about the ideas presented in the application, its usability and usefulness.

Within the application, there was a link to the online questionnaire (survey tool) which the students had to use to evaluate the application. The online questionnaire link was also separately sent to the 70 students through their registered e-mail address. 30 valid responses were obtained – representing a response rate of 44 percent. The feedback was further used to improve the application, and would also be used to enrich the experience of designing and developing mobile LMSs.

5.1.2 Impact evaluation. Impact evaluation assesses the overall or net effects (intended or unintended) of an intervention as a whole.

Having identified and addressed the usability concerns (to a possible extent) of the mVula application, an assessment (longitudinal) of the overall value of the intervention (impact evaluation of the application) is being carried out. This is focused on answering the questions that required to establish whether or not creating mobile interfaces for LMSs influences the way students access information on LMSs.

6. Conclusions and future work

First, the majority of the students from the surveyed universities have the desire and experience to use LMSs. They reported high abilities and self confidence to use the different technology platforms available for accessing the LMSs. At the same time, although the majority of the students (especially from the UCT) possess smartphones, and would have been expected to use them to access the LMS, they instead reported a stronger preference for using laptops and desktop computers for accessing the LMS. They expressed various views upon which their preferences were based.

These broadly included: screen size, processing power, portability, usability, power-save, wireless connectivity and convenience of use.

Second, much as the students reported a stronger preference for using laptops and desktop computers to access the LMS services, they do not have access to these devices most of the time, yet they do with their mobile phones. Furthermore, the use of such devices, especially the desktop computers, is dependent on the institutional ICT infrastructure, such as computer labs and internet bandwidth, which is a major constraint in most universities in the developing countries.

However, as literature reveals (Jones *et al.*, 1999; Fling, 2009), and also as highlighted by the students, mobile phones present usability and compatibility problems while trying to access web sites meant for desktop or laptop computers, and this is indeed the main reason why students do not use them to access the LMSs. Thus, if mobile phones are to be used to effectively access LMSs, the LMSs have to be optimized for mobile access. According to literature (Nielson, 2012), this can be done in two ways, either:

(1) provide fewer LMS services on the mobile phone, but with all the necessary details for each service; or

(2) provide all the LMS services with little detail for each service.

Both of these options are worth exploring if LMSs are to be effectively optimized for mobile access. A third option could also be a balance of the two options;, i.e. provide fewer services with little detail and defer secondary information to secondary pages, which can be accessible through more optimal devices such as the desktop computers or laptops. The design challenge is to optimize the LMS in such a way that the mobile site (optimized LMS) satisfies at least most of the mobile users' needs for the LMS. As Nielson (2012) argues, if this goal is achieved, the extra cost of accessing the full LMS will be incurred fairly rarely, and this will also reduce the over reliance on the institutional ICT infrastructure for accessing the LMS services all the time by the students.

Third, this study also identified the services that are most desired and needed by the students in the surveyed universities, which if the LMS is to be optimized for mobile access, they have to be given priority. These include: assignments, announcements, resources, course outlines and chat rooms. These services however may vary for the different institutions/universities depending on the context in which the LMS is used and the needs for the various stakeholders especially the students.

Lastly, through a participatory design process with the users, we created a paper prototype, and then a working WebKit-based prototype for mVula to test the ideas of a mobile LMS. From the design and implementation processes of mVula, and the usability evaluation of a working mVula prototype, it was concluded that the ideas presented in mVula are technically feasible and the application exhibits good usability. Currently, we are carrying out a longitudinal user experience evaluations to assess the overall value (impact evaluation) of mobile LMS.

References

Akeroyd, J. (2005), "Information management and e-learning: some perspectives", *Aslib Proceedings: New Information Perspective*, Vol. 52 No. 2, pp. 157-167.

Ardito, C., Costabile, M.F., De Marsico, M., Lanzilotti, R., Levialdi, S., Roselli, T. and Rossano, V. (2006), "An approach to usability evaluation of e-learning applications", *Universal Access in the Information Society*, Vol. 4, pp. 270-283.

Bevan, N. (2009), "What is the difference between the purpose of usability and user experience evaluation methods", *Proceedings of the Workshop UXEM'09, Uppsala, Sweden*, available at: http://nigelbevan.com/papers/What_is_the_difference_between_usability_and_user_experience_evaluation_methods.pdf (accessed 10 March 2013).

Cavus, N. and Ibrahim, D. (2007), "Assessing the success of students using a learning management system and together with a collaborative tool in web based teaching of programming languages", *Journal of Educational Computing Research*, Vol. 36 No. 3, pp. 301-321.

Costabile, M.F., De Marsico, M., Lanzilotti, R., Plantamura, V.L. and Roselli, T. (2005), "On the usability evaluation of e-learning applications", *Proceedings of the 38th Annual Hawaii International Conference on System Sciences* (*HICSS'05*) – *Track 1*, Vol. 01, IEEE Computer Society, Washington, DC, p. 6.2.

Couper, M.P. (2000), "Web surveys: a review of issues and approaches", *Public Opinion Quarterly*, Vol. 64 No. 4, pp. 464-494.

Couper, M.P., Traugott, M. and Lamias, M. (2001), "Web survey design and administration", *Public Opinion Quarterly*, Vol. 65, pp. 230-253.

Dagger, D., O'Connor, A., Lawless, S., Walsh, E. and Wade, V.P. (2007), "Service-oriented e-learning platforms: from monolithic systems to flexible services", *IEEE Internet Computing*, Vol. 11 No. 3, pp. 28-35.

Davidson, E.J. (2004), *Evaluation Methodology Basics: The Nuts and Bolts of Sound Evaluation*, Sage, Thousand Oaks, CA.

Du Plessis, J. and Koohang, A. (2005), "Learning object: from conceptualization to utilization", *Proceedings of Knowledge Acquisition and Management Conference*, Vol. 13, pp. 38-46.

Fling, B. (2009), *Mobile Design and Development: Practical Concepts and Techniques for Creation Mobile Sites and Web Apps*, O'Reilly Media, Inc., Sebastopol, CA.

Gurau, C. (2007), "The ethics of online surveys", in Reynolds, R.A., Woods, R. and Baker, J.D. (Eds), *Electronic Surveys and Measurements*, Idea Group Publishing, Hershey, PA, pp. 112-119.

Hadjerrouit, S. (2010), "Developing web-based learning resources in school education: a user-centred approach", *Issues in Information Science and Information Technology*, Vol. 6, pp. 115-135.

ISO 9241-11 (1998), "Guidance on usability", available at: www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=16883/ (accessed 20 April 2012).

Jones, M. and Marsden, G. (2006), *Mobile Interaction Design*, Wiley, New York, NY.

Jones, M., Marsden, G., Mohd-Nasir, N., Boone, K. and Buchanan, G. (1999), "Improving web interaction on small displays", *Proceeding of the Eighth International Conference on World Wide Web, 11-14 May, Toronto, Canada*, pp. 1129-1137.

Kakasevski, G., Mihajlov, M., Arsenovski, S. and Chungurski, S. (2008), "Evaluating usability in learning management system Moodle", *Proceedings of the ITI 2008 30th International Conference on Information Technology Interfaces, Cavtat, Croatia, 23-26 June*.

Kaplowitz, M.D., Hadlock, T.D. and Levine, R. (2004), "A comparison of web and mail survey response rates", *Public Opinion Quarterly*, Vol. 68 No. 1, pp. 94-101.

Koohang, A., Floyd, K. and Stewart, C. (2011), "Design of an open source learning objects authoring tool – the LO creator", *Interdisciplinary Journal of E-Learning and Learning Objects*, Vol. 7, pp. 111-124.

Leal, J.P. and Queirós, P. (2011), "Integrating the LMS in service oriented e-learning systems", *International Journal of Knowledge Society Research*, Vol. 2 No. 2, pp. 1-12.

Nielsen, J. (1992), "Finding usability problems through heuristic evaluation", *Proceedings ACM CHI'92 Conference, Monterey, CA, 3-7 May*, pp. 373-380.

Nielsen, J. (1994), "Heuristic evaluation", in Nielsen, J. and Mack, R.L. (Eds), *Usability Inspection Methods*, Wiley, New York, NY.

Nielsen, J. and Mack, R.L. (Eds) (1994), *Usability Inspection Methods*, Wiley, New York, NY.

Nielsen, J. and Molich, R. (1990), "Heuristic evaluation of user interfaces", *Proceedings of ACM CHI'90 Conference, Seattle, WA, 1-5 April*, pp. 249-256.

Nielson, J. (2012), "Mobile site vs. full site", available at: www.useit.com/alertbox/mobile-vs-full-sites.html/ (accessed 25 April 2012).

Paulsen, M.F. (2003), "Experiences with learning management systems in 113 European institutions", *Educational Technology & Society*, Vol. 6 No. 4, pp. 134-148.

Saeedikiya, M., Mooghali, A. and Setoodeh, B. (2010), "Stages of the implementation of e-learning in traditional universities", *EDULEARN10 Proceedings*, pp. 6620-6624.

Scriven, M. (1991), *Evaluation Thesaurus*, 4th ed., Sage, Newbury Park, CA.

Sife, A.S., Lwoga, E.T. and Sanga, C. (2007), "New technologies for teaching and learning: challenges for higher learning institutions in developing countries", *International Journal of Education and Development using Information and Communication Technology* (*IJEDICT*), Vol. 3 No. 2, pp. 57-67.

Ssekakubo, G., Suleman, H. and Marsden, G. (2011), "Issues of adoption: have e-learning management systems fulfilled their potential in developing countries?", *Proceedings of the 2011 Annual Conference of the South African Institute of Computer Scientists and Information Technologists, Cape Town, South Africa*, pp. 231-239.

Thompson, L.F., Surface, E.A., Martin, D.L. and Sanders, M.G. (2003), "From paper to pixels: moving personnel surveys to the web", *Personnel Psychology*, Vol. 56 No. 1, pp. 197-227.

Wong, B., Nguyen, T.T., Chang, E. and Jayaratna, N. (2003), "Usability metrics for e-learning", *Proceedings of the Workshop on Human Computer Interface for Semantic Web and Web Applications, Catania, Sicily, Italy*, LNCS, Vol. 2889, Springer, Berlin, pp. 235-252.

Further reading

Jabr, A.M. and Al-Omari, K.H. (2010), "Design and implementation of e-learning management system using service oriented architecture", *World Academy of Science, Engineering and Technology*, Vol. 64, pp. 59-64.

Petrelli, D. and Not, E. (2005), "User-centred design of flexible hypermedia for a mobile guide: reflections on the hyper audio experience", *User Modeling and User-Adapted Interaction*, Vol. 15, Springer, New York, NY, pp. 303-338.

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