A Streamlined Mobile User-Interface for Improved Access to LMS Services

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***Abstract*— Universities in developing countries face greater challenges in implementing Learning Management Systems (LMSs) due to resource-poor settings, characterized by: low levels of ICT infrastructure; electricity outages; few computers; and limited and expensive Internet bandwidth, among other constraints. It is anticipated that if mobile phones are carefully integrated into the ecologies of LMSs, the impact of some of the above challenges in implementing LMSs would be reduced. This paper presents a user-centered design process of mobile LMS interfaces for accessing selected LMS services on mobile phones, and a user experience evaluation for a mobile LMS application implementation. From the design and implementation processes of the mLMS (mobile LMS), and the user experience evaluation of a working mLMS prototype, we conclude that: the ideas presented in the mLMS are technically feasible; the application is useful to the students and the students are encouraged to use their mobile phones to access LMS services more often, thereby reducing the over-reliance and pressure on the constrained institutional ICT resources.**

Keywords-Learning Management Systems; Developing Countries; Mobile Phones; Mobile interfaces; User-centered Design

I. INTRODUCTION

As universities strive to satisfy their students and the students' needs, they are facing competition at different levels ranging from local to global [1][2]. In a globally-competitive educational system, innovative universities that promote a culture of change and are willing to adopt new technologies for enhancing the students' learning experiences stand a better chance of staying relevant and thriving in the new knowledge age [3][4]. Information and Communication Technology (ICT) has proved to be an essential component of the educational system. It has positively impacted the educational system and has played an important role in meeting challenges ranging from educational and administrative to supportive [5].

The application of ICT to support (or enhance) teaching and learning is commonly referred to as electronic learning or e-learning. E-learning covers a spectrum of activities from supported learning to blended learning and to learning that is delivered entirely online. According to Akeroyd [6] and Kakasevski [7], among the various ICT tools that can be used to implement e-learning, Learning Management Systems (LMSs) are the most widely used tools for the support of blended learning and learning that is entirely delivered online. Paulsen [8] also argues that much of the success of e-learning can be attributed to the availability of learning management systems. He further states that the majority of European institutions have extensively implemented and benefited from e-learning via LMSs. The success of LMSs in European institutions has been attributed to Internet penetration as well as a well-developed ICT infrastructure.

In developing countries, however, the potential of LMSs has not been fully exploited, mainly due to resource-poor settings characterized by low levels of ICT infrastructure, among other constraints [9].

Current literature reveals that although universities in developing countries have continued to increasingly invest in the LMSs [10][11], the LMSs have not been fully exploited by the majority of the universities implementing them. To a larger extent, most LMS-supported e-learning initiatives, particularly in developing countries, have not fulfilled their potential. Prior work by the authors [9] and Sife [12] identified various factors that are responsible for the limited success of e-learning initiatives in general, and LMSs in particular, in developing countries. These included: limited ICT infrastructure such as LANs; few computers; limited and expensive Internet bandwidth; power outages; high ICT-illiteracy rates and low comfort levels using ICT–solutions among the students; LMS usability issues; ineffective maintenance and inefficient user support strategies; high expectations from the institutions and their clients, the students; and poor marketing strategies . The studies [9][12] conclude that if learning management systems were to be implemented more effectively in developing countries to support students' learning and to justify the high investment costs incurred by the universities in setting them up and maintaining them, further research and development efforts should be aimed at identifying strategies of reducing (or overcoming) the impact of the above challenges.

In a related study [13], which was carried out to identify possible intervention(s) that could be instigated to reduce the impact of some of the challenges identified, it was noted that the proliferation of mobile phones among university students in the developing countries presents an opportunity to think of alternative ways of making LMS services effectively available to the students via their mobile phones. If this is achieved, it would reduce the over-reliance and the pressure on the institutional ICT resources for accessing the LMS services all the time by the students. After all, Minovic [14] noted that mobile devices have the potential to be integrated into the classroom because they contain unique characteristics such as: portability, social interactivity, context sensitivity, connectivity and individuality. The study [13] revealed that the majority (over 99%) of the

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students in the surveyed universities possessed mobile phones, of which over 70% were Internet (feature) phones and 58% were smart phones. However, the students never used their mobile phones to access the LMS services. They reported that mobile phones presented usability and compatibility problems in trying to use them to access the LMS services. The constraints of using mobile phones to access full websites meant for desktop and laptop computers has also been clearly documented in the literature [15][16][17].

Thus, if mobile phones are to be effectively integrated into the LMS ecology to support students in accessing LMS services, directed/tailored mobile LMS interfaces have to be designed, and here is where the work of this paper seeks to make a contribution. The paper presents: a user-centered design process of mobile LMS interfaces for accessing selected LMS services on mobile phones; the technologies for developing the mLMS application; and the implementation and user-experience evaluation of the mLMS application.

The next section of this paper presents the literature associated with the increased adoption and use of LMSs by Universities and the accessibility of LMS services by the students. The need to enhance accessibility of LMSs for the users (the students) who are constrained by poor ICT infrastructure is also presented in literature review. Then, the design of the LMS mobile interface is presented, followed by the development of the mVula application. Next, we present the evaluation of the mVula application through standard usability evaluation procedures that included: expert evaluation; focus group evaluation and user experience evaluation, followed by a presentation and analysis of the evaluation results. Finally, we conclude with the major findings of this research on optimizing LMS interfaces for mobile access, and the future work.

II. RELATED LITERATURE

A. *LMS Adoption*

Learning management systems, sometimes referred to as Virtual Learning Environments (VLE), Course Management Systems (CMSs), Learning Content Management Systems (LCMSs), Managed Learning Environment (MLE), Learning Support Systems (LSSs) or Learning Platforms (LPs), can be defined as Web-based software application platforms that use Web technologies and Internet services to support: online course creation, maintenance and delivery; student enrolment and management; education administration and student performance reporting [18][19]. The LMSs and related technologies such as the Internet have provided new directions in teaching and learning, and have had a significant impact on the ways in which universities and teachers interact with students. For example, LMSs allow learners to use interactive features such as threaded discussions, chatrooms, discussion fora and other methods of communication among them, with the teachers, and with the university. As a result, LMSs have been widely adopted by universities. In fact, it is difficult to identify many universities that do not use a learning management system of some sort [10].

The increased adoption of learning management systems by universities is premised on the fact that the LMSs are: domain independent; have better administration capabilities; integrated authoring tools; and support the design and publication of reusable learning resources [7][10]. They are thus regarded as the most basic and reliable e-learning tools in blended learning environments, and they are often viewed as the starting point of any Web-based learning program [10]. Furthermore, the emergence of open source platforms such as Moodle and Sakai has encouraged universities, particularly those working with limited budgets, to adopt the LMSs [20], mainly for two reasons: scalability, because the open source platforms allow the universities to have as many users as they like without incurring bigger license fees, given that they are operating under tight budget constraints; and flexibility, because the universities can choose to develop/tailor the open source platforms to meet their particular needs [21].

B. *Accessibility of LMS Services*

Accessibility can be defined as the ability of the Learning Objects (LO) to be accessed by learners in any location regardless of the learner experience, device or the type of platform the learner uses [22][23]. Learning Objects are units of instructional content that can be used and reused on Web-based e-learning systems In LMSs, Learning Objects are presented in the various service components such as: announcements, assignments, resources, forums, chat rooms, course outlines and wikis [24]. According to Ardito [25], Costabile [26] and Wong [27], accessibility of the learning objects plays a significant role towards the success of any online learning programme. Yet Leal and Queiros [24] 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 [24] and Dagger [18] 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. After all, the current generation of LMSs embraced the “services” principle, exposing certain aspects of their functionality externally [11][18]. This means that as designs became more modularized, it is easier for platforms to integrate new functionality as it arises [13]. Furthermore, Dagger [26] argues that 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 [18].

The work presented in this paper, however, distinct from prior research, in that the main goal was to enhance accessibility from the point of view of LMS users (the students) who are constrained by poor ICT infrastructure, 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 [8] 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 of 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, besides the low Internet penetration, there are other constraints such as power outages and the physical infrastructure such as the local area networks and the lack of enough computers for the learner community. These constraints make it harder for the students to access the LMS services. However, the proliferation of mobile phones in the developing countries has to some extent made up for the generally poor physical ICT infrastructure. In this study, mobile phone were integrated into the LMS ecology by designing and developing streamlined mobile LMS interfaces to enhance the accessibility of LMS services through the mobile phones and increase the LMS usage by the students.

III. DESIGN OF THE MOBILE LMS

Overall, a User-Centred Design (UCD) approach was taken. Winograd [28] defines user-centred design as an approach to software design that grounds the process in information about the users of the software product. It focuses on users through the analysis, design, implementation and evaluation of the product. Its aim is to develop applications and systems that are usable and meet the requirements of the users in their context of use [19]. The approach incorporates three principles: involve users and gives them high priority; use rapid prototyping in the design phase to produce a number of prototypes that can be revised through user feedback [29]; and, thirdly, the approach is incremental throughout the whole process, because a number of revisions are necessary to improve the quality of the application through a continuous cycle of gradual refinement [19].

The design of the mobile LMS interfaces was done through a participatory design process [16] with students at the University of Cape Town. At the University of Cape Town, the Sakai LMS is used, and it is locally branded ‘Vula’. During the design process, the term mobile Vula (mVula) was used, instead of mobile LMS.

The students who participated in the design process of mVula were randomly selected and, meetings with them were organised in focus groups of 2s and 3s. A total of 13 students participated. The idea of optimising Vula for mobile access by providing access to a few selected Vula services was introduced to the students (in focus groups). To some students, it was a completely novel idea, while others were aware of the presence of a mobile version of the Vula site but had not accessed it. Some had accessed the mobile version of Vula, which they said was not very different from the full desktop Vula site and was not so appealing on the small phone screen. During the discussions (semi-structured interviews) with the students (which lasted 10-15 minutes) some interesting ideas about their expectations for mobile Vula came up, and these were noted by the investigator. The students were then engaged in a co-design session. They were provided with pencil and paper and asked to draw storyboard sketches of what they wanted the mVula interfaces for the selected services to look like. At first, this did not work out well, as most students did not know how to represent mobile phone interfaces on paper, and those who had an idea also wasted a lot of time drawing pictures of full mobile phones (screen, buttons, keypads etc) other than sketching the interfaces.

To provide a hint to novices, and to avoid wasting time in drawing mobile phone pictures, familiar mobile phone screen templates (Figure 1) were printed and given to the participants instead of the plain paper, such that they could now draw the interfaces within the templates.

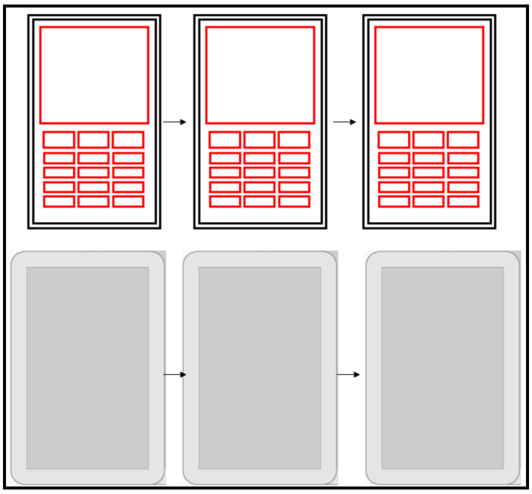

Figure 1. Templates of mobile phone screens

This improved the process greatly and meaningful storyboard sketches were drawn by the students.

From the storyboard interface sketches drawn by the students using the templates in Figure 1 above, the investigator created the first paper prototypes of mVula interfaces, with two distinct ideas: (i) course-based (Figure 2) and (ii) service-based (Figure 3).

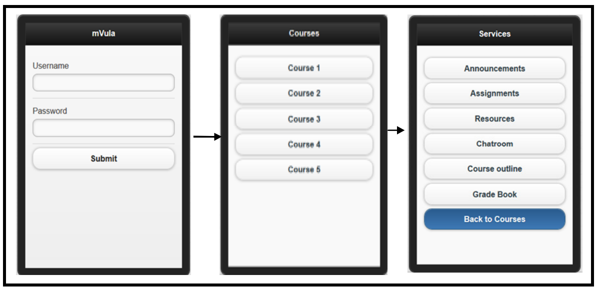

Figure 2. Paper Prototype 1a: Course-based interface

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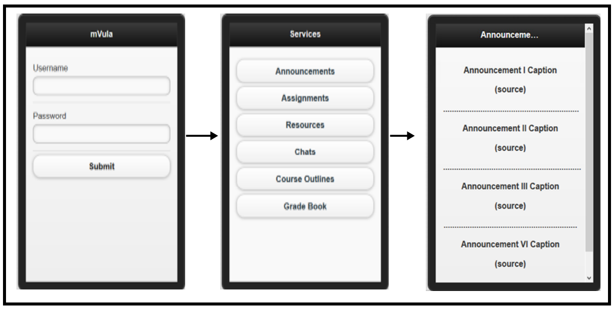

Figure 3. Paper Prototype 1b: Service-based interface

Both of the prototypes (Figures 2 and 3) were given to students to be validated and to choose the most appropriate and appealing prototype to them. Ten students participated in this validation exercise. Eight out of the ten students selected the service-based prototype (Figure 3) and, in addition, they suggested that the services be block-based instead of the tabs. Then, the final paper prototype of mVula (Figure 4) was generated.

The main features presented in mobile Vula include: the application should be service-based (as opposed to course-based); to provide a few services with only the necessary details for each service (defer access to more details through more appropriate devices like PCs); the services to be block-based (as opposed to tabs); services like announcements to be populated with information from across the various courses, and presented according to date.

The most needed/required LMS services to be provided for access on the mobile phones have to be identified and, these may differ from university to university. In the surveyed universities, the most needed/required LMS services included: announcements, assignments, resources, course outlines and chat rooms [13].

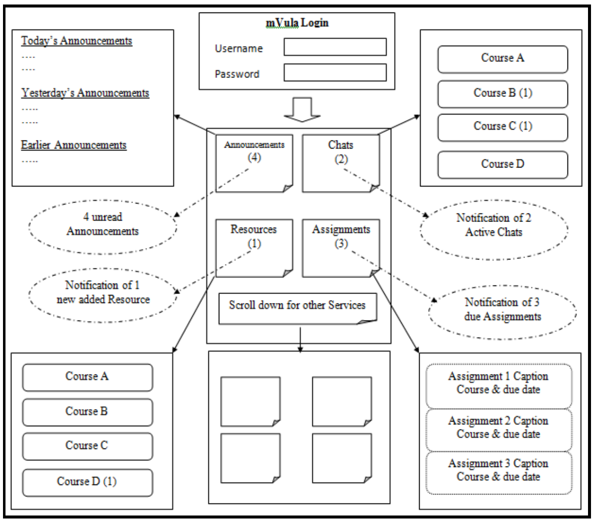

Figure 4. Final paper prototype of mVula interfaces

IV. DEVELOPMENT OF MVULA APPLICATION

After generating the final paper prototype of mVula through the participatory design process, the next step was then to develop a working prototype of mVula, bearing in mind that the users (students) possessed different mobile handsets with differing operating systems/platforms such as Android, iOS, Nokia Symbian, BlackBerry and Windows OS.

As literature on mobile application development highlights [17], there were two ways to develop the mVula application: either (i) to develop mVula for a single mobile platform (native application) and test the ideas on that one platform; or (ii) develop a cross-platform application [30] and test the ideas across all the major platforms.

While the native application option would be easier and more straight-forward in terms of development [31], such an application would be restrictive. Only students with mobile phones with a particular platform would be able to use it. To obtain feedback (about the ideas presented in mVula) from as many users as possible using a wide range of mobile phones, possibly with different platforms, would require development of mVula as a native application for each platform separately. This would require a lot of time; also, it would be difficult to implement and maintain several native applications.

mVula was thus developed as a cross-platform application so as to capture as many users as possible across the major platforms. However, this also presented a different set of challenges, such as the limited number of technologies available to develop cross-platform applications, and the fact that such an application would not be able to utilise some smart phone features that could possibly be required.

In the recent past, the smart phone industry has experienced a major development that has seen most of the current generation of smart phones built with a compatible underlying browser engine, called Webkit [15]. Webkit is an open source library that renders HTML. It eliminates the incompatibilities among mobile browsers, making it easier to develop cross-platform Web applications. This means that any WebApp developed with Webkit support would easily be rendered by the native browsers of most smart phones.

Additionally, there are Cross-platform Mobile Development tools (XMTs) (examples in Table1), that can be used to create apps for different smart phone platforms from the same code base [32][30]. This development does not only reduce the coding load, but also ensures that the services provided through such an application would reach a wider audience of potential users [33].

However, although mobile Web applications do not make any explicit assumptions about features of the delivery context, best practices assume devices with support for standard Extensible HyperText Markup Language (XHTML), JavaScript and Cascading Style Sheets (CSS) capability (W3C n.d). Thus, cross-platform mobile applications are typically Web applications. The World Wide Web Consortium has defined Web application as a term that refers to a Web page (XHTML or a variant thereof + CSS) or collection of Web pages delivered over Hypertext Transfer Protocol (HTTP) that use server-side or client-side processing (e.g., JavaScript) to provide an "application-like" experience within a Web browser. Table 1 below shows some of the cross-platform mobile application development tools, and the mobile platforms each supports, as of April 2013; the situation is dynamic, and could change (or have changed).

TABLE 1: SOME OF THE CROSS-PLATFORM MOBILE APPLICATIONS DEVELOPMENT TOOLS (XMT)

XMT	Android	Bada	BlackBerry	iOS	MeeGo	Symbian	webOS	WP7	MinMob
Application Craft	✓	✓	✓	✓	✓	✓	✓	✓	✓
Flash Builder	✓			✓		✓		✓	✓
Illumination Software Creator	✓			✓					
jQuery	✓	✓	✓	✓	✓	✓	✓	✓	✓
LiveCode	✓			✓		✓			
Marmalade	✓	✓	✓	✓	✓	✓	✓		
MonoCross	✓	✓	✓	✓	✓	✓	✓		✓
MoSync	✓		✓	✓		✓			✓
OpenPlug Studio	✓		✓	✓		✓			✓
PhoneGap	✓	✓	✓	✓		✓	✓	✓	✓
Rhodes	✓		✓	✓		✓		✓	✓
RhoStudio	✓		✓	✓		✓		✓	✓
Titanium	✓			✓					✓
XUI	✓	✓	✓	✓	✓	✓	✓	✓	✓
Zepto	✓	✓	✓	✓	✓	✓	✓		✓

Source: Ohrt, [34], plus the individual sites of the presented tools

TABLE 2: SUPPORTING PROGRAMMING LANGUAGES FOR SOME XMTS

XMT	Programming Language
Application Craft	JavaScript, HTML, CSS, Visual Editor
Flash Builder	ActionScript and MXML
Illumination Software Creator	None (drag-and-drop)
jQuery	JavaScript, HTML, CSS
LiveCode	Livecode
Marmalade	C++
MonoCross	C#
MoSync	C++
OpenPlug Studio	ActionScript and MXML
PhoneGap	HTML and JavaScript
Rhodes	JavaScript, HTML, CSS, Ruby
RhoStudio	Ruby
Titanium	JavaScript
XUI	JavaScript, HTML, CSS
Zepto	JavaScript, HTML, CSS, Visual Editor

Source: Ohrt [34] and http://www.markus-falk.com/mobile-frameworks-comparison-chart/

Although Table 1 does not show an exhaustive list of cross-platform mobile application development tools, all the tools presented support Android and iOS, while BlackBerry, Symbian and WinMob are also well supported.

In this case, the tools that support most or all of the major mobile platforms were considered for selection for the development of mVula. However, as already noted, HTML and JavaScript are a prerequisite for Webkit-based applications. Therefore, choice of the final XMT for the development of mVula also depended on the tool's supporting programming languages (Table 2).

From Tables 1 and 2, it is clear that Application Craft and jQuery were the strongest candidates for choice. Finally, as Ohrt [34] argues that the option of using a familiar tool can be a strong incentive to select a certain XMT, jQuery was chosen for the development of mVula.

V. EVALUATION OF MVULA

The first working prototype of mVula was evaluated for usability through standard usability evaluation procedures, complemented with case-specific measures. According to Ardito [25], the ISO 9241 [35] 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. The application was evaluated for usability at three levels: expert evaluation; focus group evaluation and user experience evaluation.

The expert (heuristic) evaluation [36] was aimed at evaluating the application for: simplicity; errors; efficiency and comprehensibility as well as identifying any Human Computer Interaction (HCI) related concerns and interface flaws to improve user interaction. This was achieved with five HCI practitioners who interacted with the application in a laboratory setting and provided feedback to the developer. The feedback was then used to improve the application before the focus group evaluation.

The focus groups were made up of students who were randomly recruited through a research assistant. The research assistant was asked to identify any students who had smart phones and introduced them to the investigator for further briefing about the exercise. This evaluation was aimed at measuring learnability (ease of use) of the application as well as identifying any functional errors and flaws within the application. Learnability was assessed with two measurements: (i) the ability to use the application without instructions/guidance on the first try, and (ii) task completion without errors or getting frustrated. Feedback was obtained through observations and verbal feedback, as well as a structured questionnaire that the students were requested to fill at the end of the exercise.

With feedback from the experts and focus group evaluations, the application was improved to generate a second prototype (Screenshots in Figure 5).

Figure 5: Screenshots of the interfaces of the working prototype of mVula

The second prototype of the application was then rolled out to students for a 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 [37]

The user experience evaluation of the mVula application was done with students from the Department of Computer Science, University of Cape Town. Through mVula, the students could access the selected Vula services through their mobile phones, upon login using their University login credentials. The application was hosted on a publically-accessible server, and its address was given to the students. Following a call for participation in this, seventy (70) students volunteered to participate. The students were asked to voluntarily use the application in accessing Vula services for about 2-3 weeks and thereafter provide feedback about the ideas presented in the application, its usability and usefulness. Within the application, there was a link to an online questionnaire (survey tool) that the students had to use for evaluating the application.

VI. EVALUATION RESULTS

Feedback from the user experience evaluation was obtained through an online questionnaire. The questionnaire had two sections. Section one required the users to evaluate the application in terms of ease of use, perceived usefulness and overall satisfaction with the ideas presented in the application. These were probed through Likert-type questions. Section two was the narrative section, which required the users to comment on the application as well as define/mention any other requirements that would make the application more useful to them. Out of seventy (70) evaluation requests that were sent out to the participants, thirty (30) valid responses were obtained, representing a response rate of 44%.

The analysis of the collected data has been divided into two: the Likert–type responses that have been analyzed as ordinal data, and the narrative section that has been organized thematically.

A. *Analysis of the Likert-type Responses*

Likert data can either be of Likert-type or Likert-scale. Clason and Dormody [38] described Likert-type items as the form of the original Likert (Likert 1932) response alternatives that are considered and analysed as individual questions (not summated). In the Likert-type, multiple questions may be used in a research instrument, but the responses from the items may not be combined into a composite scale [39]. That is, Likert-type questions are unique and stand-alone.

In this study, Likert-type questions with five response alternatives (e.g., strongly agree, agree, neutral, disagree and strongly disagree) were used to assess the students’ level of satisfaction with the ideas presented in the application as well as to evaluate the application in terms of ease of use

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and perceived usefulness. Several similar mobile application studies have deployed this evaluation technique [40][41]. However, because Likert-type responses express "a greater than" relationship without indicating by how much, the analysis of such data is often limited to ordinal procedures [39].

Methodological and statistical texts recommend that, for ordinal data, one should employ the median or mode as the measure of central tendency, and frequencies (or percentages) as the measure of variability [39][42][43][44]. This is because the arithmetic manipulations required for calculating the mean, standard deviation and some parametric tests are inappropriate for ordinal data, where the numbers generally represent verbal statements [42].

1) *Ease of Use and Perceived Usefulness of mVula*

To assess the ease of use and perceived usefulness of the mVula application, seven questions were asked. Table 3 below presents the responses from the students.

TABLE 3. LIKERT-TYPE RESPONSES ON THE EASE-OF-USE AND PERCEIVED USEFULNESS OF THE MVULA APPLICATION

	Questions		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
1	*Interaction with mVula is clear and understandable*		33.3% (n=10)	36.7% (n=11)	20.0% (n=6)	6.7% (n=2)	3.3% (n=1)	n=30
2	*mVula Application is:*	Easy to use	60.0%(n=18)	33.3%(n=10)	6.7% (n=2)	0.0%(n=0)	0.0%(n=0)	n=30
		Navigable	50.0%(n=15)	30.0%(n=9)	13.3%(n=4)	6.7%(n=2)	0.0%(n=0)	n=30
		Intuitive	23.3% (n=7)	46.7%(n=1)	30.0%(n=9)	0.0%(n=0)	0.0%(n=0)	n=30
		Attractive	10.0% (n=3)	26.7%(n=8)	33.3%(n=10)	26.7%(n=8)	3.3%(n=1)	n=30
3	*I find it useful to use my mobile phone to access some services of Vula*		60.0% (n=18)	33.3% (n=10)	3.3% n=1)	3.3% (n=1)	0.0% (n=0)	n=30
4	*These mVula features make it easier to access Vula via a mobile phone*	Having only a few options/services.	36.7% (n=11)	36.7% (n=11)	16.7% (n=5)	6.7% (n=2)	3.3% (n=1)	n=30
		Using block-based interfaces for the services.	30.0% (n=9)	33.3% (n=10)	36.7% (n=11)	0.0% (n=0)	0.0% (n=0)	n=30
		Merging Information from across courses.	50.0% (n=15)	26.7% (n=8)	13.3% (n=4)	0.0% (n=0)	0.0% (n=0)	n=30
5	*mVula influences me to access Vula more often*		23.3% (n=7)	50.0% (n=15)	23.3% (n=7)	3.3% (n=1)	0.0% (n=0)	n=30
6	*mVula enhances my learning effectiveness:*	in class	16.7% (n=5)	33.3% (n=10)	46.7% (n=14)	3.3% (n=1)	0.0% (n=0)	n=30
		outside class	30.0% (n=9)	40.0% (n=12)	30.0% (n=9)	0.0% (n=0)	0.0% (n=0)	n=30
7	*mVula saves me the need for a computer all the time I need to access information on Vula*		43.3% (n=13)	43.3% (n=13)	6.7% (n=2)	6.7% (n=2)	0.0% (n=0)	n=30

From Table 3, question one was intended to find out whether the ideas presented in the mVula application were clear to the students. The question was well understood by the respondents and 70% affirmed the clarity of the ideas. Question two evaluated four usability aspects of the application. The responses indicated that although over 80% of students agree that the application is navigable and easy to use, 60% indicated that the attractiveness of the application can be improved. Over 90% of the respondents indicated that the idea of accessing Vula services through streamlined mobile interfaces was very useful. The students were able to get the information they needed from Vula via mVula without the need for full desktop interfaces.

Question four was intended to evaluate the perceptions of the students about some of the ideas presented in the mVula application. While over 60% of the respondents agreed that the features of mVula make Vula services easier to access on the mobile phone, they also suggested more features.

The question about the effectiveness of the mVula application registered the highest percentage of neutral responses. This was probably because the respondents were not in position to judge the effectiveness of the intervention within a period of three weeks. This attribute of the study will be assessed further in a longitudinal impact evaluation that will be carried out in subsequent studies.

2) *Overall Satisfaction*

The overall satisfaction with the ideas presented in the mVula application was probed through a five-point Likert-scale (Table 4).

TABLE 4. OVERALL SATISFACTION OF THE IDEALS PRESENTED IN MVULA APPLICATION

Question	Highly Satisfied	Satisfied	Partially Satisfied	Not Satisfied	Not at all Satisfied	Total
What is your overall satisfaction with the ideas presented in mVula?	26.7% (n=8)	43.3% (n=13)	30.0% (n=9)	0.0% (n=0)	0.0% (n=0)	n=30

Although none of the respondents was "not satisfied", almost a third of the respondents (30%) were partially satisfied. Therefore, this means that more work had to be done on mVula to create greater satisfaction. By incorporating some of the comments provided by the respondents, it is hoped that the satisfaction level will increase.

B. *Comment Analysis*

The feedback from the narrative section of the questionnaire was analysed with the following as guiding questions:

- What additional requirements are defined by the users?
- What improvements in the prototype should be made to enhance user satisfaction of the application?
    - o What is the problem with the prototype and what is the scope and severity of the problem?
    - o What solutions can be implemented across the platforms and which ones require native applications?

1) *Additional requirements defined by the users*

a) More services, such as Tutorial signups, Grade book and Tests & Quizzes, were requested for in the application by some students. However, the original idea of the application was to provide a few services, given the limitation of the mobile phone. Eight services were provided, and these had been identified as the most needed/required services. These services can differ from university to university and can easily be changed from time to time. In this case, however, the chosen services will be maintained.

b) Enable assignment submission using the phone. Some students requested that the application should allow them to make submissions, especially assignments. This can possibly be implemented across the platforms. However, the students will still be advised that the use of the mobile phones to access LMS services cannot be used as a surrogate for computers, so to perform some tasks such as attaching and sending files would better be done using more appropriate devices, such as PCs and laptop computers.

c) Notifications for new announcements and reminders for assignment deadlines. The notification function could not be implemented across platforms. It required the use of smart phone features that are supported differently for each platform. To test the feasibility of this ideal, however, an Android notification service was developed and has been integrated into the mVula application.
The service connects to the LMS server and runs in the background of the phone and notifies the user of any new announcement posted.

2) *Required Improvements*

a) Given that the application pulled all the announcements from across all the courses and presented them according to date, the students said that it was difficult for them to determine which announcement is for which course by simply looking at the announcement caption. So, they required that the source of the announcement be indicated as part of the announcement caption. The same also applied to the assignments. This has been implemented and works across all platforms. The captions of the announcements and assignments are displayed with title and source (course), and are arranged according to date.

b) Most current courses should be displayed first (or courses should be ranked on the screen according to the users' preference.). This has been implemented. The priority in course listing is according to the date of course registration. That is, the current semester courses are listed first, and then the older/previously registered courses follow.

c) Some students felt that the colours used and the overall visual appeal of the interfaces was quite dull, and buttons seemed too big to fit on some screens. Best practices of visual presentations have been consulted and the colour scheme improved.

Overall, there were no major problems with the prototype. There were more positive comments from the students, most of whom seemed happy to use the application in the current state.

Most of the additional requirements raised by the students could be implemented on Webkit (across the major mobile platforms), except one: the notification service which required native services for each platform. The additional requirements that could be implemented on Webkit have been implemented, and a native service to pop up notifications of new postings in Vula has been created for the Android platform and integrated into mVula.

VII. CONCLUSION AND FUTURE WORK

Understanding students' expectations for a mobile LMS, and involving the students in the design process of the mobile LMS interfaces is key to designing and developing usable mobile interfaces for accessing LMS services. The students prefer: to go through less "clicks" before they can be able to access the desired LMS information; that access of LMS through the mobile phones should be service-based, as opposed to course-based; that the mobile LMS application should be made as simple as possible and non-crowded, that is, fewer LMS services (the most needed/desired services) should be made accessible through mobile phones.

Some of the students who participated in this study (and possibly the majority of students in developing country universities) exhibited behaviors that we had not seen previously reported in the literature in the use (and ability) of their smart mobile phones. This may be symptomatic of technology "leap frogging," where the new internet users among the students are obtaining access by mobile devices and are skipping the traditional means of access. This has to be taken into consideration when involving such users in the design process of streamlined (directed/customized) interfaces. For instance, in our case, some students did not know what to expect in streamlined mobile interfaces for an LMS, and how different such interfaces could be from the full LMS interfaces meant for computer access. The fact that we had to prepare and use mobile screens templates instead of plain paper during the co-design sessions with the students to generate paper prototypes may also indicate a lack of clarity in the difference in the roles between mutable software and immutable hardware.

Through the participatory design process with the students, we created a paper prototype, and then a working Webkit-based prototype for mobile Vula (mVula) to test the ideas of a mobile LMS. From the design and implementation processes of mVula, it has been demonstrated that mobile interfaces for LMSs can be made more usable and useful by selecting an appropriate subset of services. The user experience evaluation of the application also indicated that the idea of accessing Vula services through streamlined mobile interfaces was very useful to the students. Actually, the streamlined mobile interface encourages greater use of LMSs and allows students to get the information they need without the need for a full desktop interface.

However, during the user experience evaluation, the students also defined additional requirements, most of which have been implemented to further better the usability and usefulness of the application. In future, we will deploy the application for a longitudinal user experience evaluation to assess its overall value–impact evaluation.

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