

Title: Usability Requirements for Learning Management Systems in Open Distance Electronic Learning Environments: Considering Lecturers' Views on Students' Needs

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Please cite as: Sewisha Lehong, Judy van Biljon & Ian Sanders (2022) Usability Requirements for Learning Management Systems in Open Distance Electronic Learning Environments: Considering Lecturers' Views on Students' Needs, International Journal of Human-Computer Interaction, DOI: [10.1080/10447318.2022.2121205](https://doi.org/10.1080/10447318.2022.2121205)

USABILITY REQUIREMENTS FOR LEARNING MANAGEMENT SYSTEMS IN OPEN DISTANCE ELECTRONIC LEARNING ENVIRONMENTS: LECTURERS' VIEWS

ABSTRACT

The 2020 health pandemic brought renewed interest in using learning management systems (LMSs) to deliver educational services as routinely done in open distance and electronic learning (ODeL) environments. LMSs usability has been researched but the lecturers' perspective remains unexplored. The purpose of this study was to propose validated usability guidelines for an LMS in an ODeL context. A set of usability requirements was abstracted from the literature and used as the basis for a heuristic evaluation (HE) of the institution's LMS. These results of the HE was triangulated with three other usability evaluation methods including usability testing with eye tracking, a post-test system usability scale (SUS) questionnaire and interviews. The primary contribution is the validated usability requirements for ODeL LMSs based on the lecturers' perspective. A secondary contribution is the triangulation approach to evaluating the guidelines in situ which confirmed HE as a valid evaluation method for LMSs.

Keywords: Distance education and online learning, Evaluation methodologies, Human-computer interaction

Abbreviations:

HE – Heuristic Evaluation

LMS – Learning Management System

ODeL-- Open Distance and electronic Learning (also Open Distance e-Learning)

Funding: This work is based on the research supported by the South African Research Chairs Initiative of the Department of Science and Technology and National Research Foundation of South Africa (Grant No. 98564)..

1. Introduction and background

Open Distance e-Learning (ODeL) refers to the provision of education through the use of contemporary technologies to enable varied combinations of synchronous and asynchronous communication among learners and educators who are physically separated from one another for part or all of the educational experience (Arinto, 2016). ODeL is a successor of ODL that utilises e-learning technologies to bridge the geographical distance between tutors and students while achieving their learning purposes (Maphosa & Bhebhe, 2019). ODeL aims to be open, inclusive, accessible, interactive, social, diverse, student-centered and technologically advanced, underpinned and guided by pedagogical principles (Jakovljevic, Buckley, & Bushney, 2014; Maboe, 2017). ODeL encompasses a fully online educational provision system (Ngubane-Mokiwa, 2017) which involves the use of various electronic technologies including massive open online courses (MOOCs), open educational resources (OERs), social media tools, discussion forums (Ngubane-Mokiwa & Letseka, 2015) as well as video conferencing, audio, mobile phone short message services (SMSs) and multimedia messaging services (MMSs) (Jakovljevic et al., 2014). ODeL institutions employ learning management systems (LMSs) to facilitate teaching and learning activities, where a LMS is an integrated software system used to support online learning strategies and processes (Mershad & Wakim, 2018).

Towards providing a LMS that is effective, efficient, comprehensible, satisfactory and reliable in supporting students with educational services, LMSs design should take into consideration factors which affect the learning experience, such as usability, aesthetics, structure, freedom of learning, social interaction and collaboration (Horton, 2011; Almarashdeh, Elias, Sahari, & Zain, 2013; Ertürk & Önaçan, 2016). In an ODeL environment there is the assumption that students have access to the required technology and the skills to use the technologies (Ngubane-Mokiwa and Letseka, 2015). However, infrastructural constraints, information overload and accessibility/usability issues affect online knowledge resources in ways that can prevent students from meeting their educational needs (Maboe, Nkosi, & Makoe, 2013). A LMS that lacks the required level of usability could decrease a student's learning experience and satisfaction (Conley, Earnshaw, & McWatters, 2019) and eventually their chances of success in graduating (Çelik, 2012). This compels the need for evidence based ODeL LMS usability evaluation guidelines.

ODeL usability evaluation guidelines have been studied in depth with most studies considering only the students' input e.g. Ssemugabi and De Villiers (2010), Mtebe and Kissaka (2015). However, lecturers' (supervisors') are often the people receiving the students' complaints and dealing with the consequences of students not being able to use the LMS as intended. LMSs in ODeL have not been investigated or described in depth (Alharbi & Drew, 2014). Therefore, the omission of lecturers' expertise regarding students' information content needs and challenges in using the LMS signify a gap in the LMS usability literature. Furthermore, the rapid advancement in information and communication technologies mean that LMSs are expected to be technologically advanced and offer a broad and inclusive integration of social interaction, multimedia, and teaching and learning technologies (Oliveira, Cunha, & Nakayama, 2016). The digitization drive has been exacerbated by the Covid-19 related health pandemic which forced a global shutdown of several activities, including educational activities, and that resulted in crisis response migration of universities to online learning management systems serving as the educational platform (Adedoyin & Soykan, 2020).

Taking cognisance of the ongoing technological development and users' increasing needs and expectations is the rationale for proposing a set of LMS usability guidelines that have been validated in an online learning context

The recent studies on LMS usability include a number of literature reviews, for example Kraleva, Sabani, & Krlev (2019) and Nakamura, Oliviera, & Conte (2017). There are also investigations into the relative merits of evaluation methods, for example comparing CSUQ, SUS, and UMUX in measuring perceived usability (Lewis, 2018) and the comparison between eye tracking and traditional usability testing data (Conley, Earnshaw & McWatters, 2019) as well as the use of specific evaluation methods like eye tracking in evaluating aspects of LMSs (Wang, Antonenko, Celepkolu, Jimenez, Fieldman & Fieldman, 2019). Based on a comparative analysis of the usability and software functionality of 36 electronic learning management systems Kraleva, Sabani, & Krlev (2019) found few detailed studies of the LMS platforms. We found only one study considering lecturers' views, notably Alhadreti (2020) who assessed Academics' Perceptions of Blackboard Usability using SUS and CSUQ; they found that the usability of Blackboard at the institution investigated in Mecca was inadequate and needed to be enhanced but they did not provide any guidelines towards informing that. Therefore, we argue that this study is necessary to provide evidence-based guidelines that have also been informed by the supervisors' views on the students' usability requirements of an ODeL LMS.

We consider lecturers' input as pertinent since they have cumulative experience of the students' LMS usage, issues and the consequences of the usability issues. De Kock, Van Biljon, & Botha (2016) investigated UX from the lecturer's perspective but here the focus is on lecturers' view of students' LMS usage and related issues experienced by students. The study was guided by the research question: What are supervisors' perspectives on the usability guidelines for an ODeL LMS? Consequently, the objective was to extract usability guidelines for an ODeL LMS from literature (as described in section 2) and then evaluate those from an ODeL supervisors' perspective.

Evaluating LMS guidelines is not trivial since it involves the guideline as an artefact with content and format and the effectiveness of the guideline in identifying usability issues. Therefore, we used different usability evaluation methods as described in section 3. The results are discussed in section 4 where a refined set of usability guidelines for an ODeL LMS is presented. The paper concludes with suggestions for further research in section 5.

2. Literature review on LMS usability

This section briefly discusses the challenges of using LMSs as the foundational technologies in e-Learning in section 2.1 and presents an overview of usability evaluation criteria extracted from literature in section 2.2.

2.1. Challenges in using LMSs

LMSs' acceptance and sustained use poses several challenges. Table 1 depicts these challenges grouped under the headings of general, technical and usability.

Category	Challenge	Reference
General	<p>LMSs are often restricted to providing learning material rather than meeting students' needs for collaboration and social interaction.</p> <p>LMS' statistical data does not easily help instructors to draw specific conclusions regarding the course or student progress.</p>	<p>(García-Peñalvo, Conde, Alier Forment, & Casany, 2011; Pan, Coleman, Manago, & Goodof, 2019; Fischer, Lundin, & Lindberg, 2020; Dagli, 2021; Ali, 2021)</p> <p>(Valsamidis, Kazanidis, Kontogiannis, & Karakos, 2012; Somyürek, Brusilovsky, Çebi, Akhüseyinoğlu, & Güyer, 2021)</p>
Technical	<p>Infrastructure, cost or computer literacy when it comes to technology integration</p>	<p>(Harris & Greer, 2016; Ruth, 2018; Mehta & Aguilera, 2020; Kant, Prasad, & Anjali, 2021)</p>
Usability	<p>Usability issues that detract from students' ability to learn and use the LMS; and</p> <p>Designers emphasize the educational content and system functionalities at the expense of the system's interface and functional usability</p>	<p>(Freire, Arezes, & Campos, 2012; Mtebe, 2015; Adhiambo, Okeyo, & Cheruiyot, 2017)</p> <p>(Al-khalifa, 2010; Freire et al., 2012; Pangestu & Karsen, 2016; Hammad, Alnabhan, Doush, Alsalem, Al-Alem & Al-Awadi, 2020; Alhadreti, 2020; Conley, Earnshaw & McWatters, 2019)</p>

Table 1 provides evidence of a number of challenges in using LMSs including content problems, accessibility and inability to deliver useful information timeously and usability issues. Providing an educational service through technology can be even more challenging in resource-constrained areas where ICT infrastructure is lacking; internet access remains costly and internet services are problematic and/or erratic (Olaniran, Duma, & Nzima, 2017). In addition, many students may lack communication skills as well as confidence (Bernstein & Osman, 2012). Given that ODeL students do not interact with lecturers or their fellow classmates on a regular basis these challenges, especially the usability issues may cause users to lose interest in using LMSs (Mtebe, 2015).

Given the challenges LMSs in the ODeL environment face on the one hand, and the rising expectations of what functionality LMSs should provide and the way in which it should be provided on the other, ensuring the usability of LMSs is challenging yet imperative. The usability of ODeL LMSs has been investigated in depth and a number of studies have produced usability guidelines for ODeL. As evident from Table 1, the literature on ODL and ODeL usability is mature and the findings have mostly been expressed in usability guidelines for LMSs. The next section considers the concept of usability and how that can be used to improve the acceptance and sustained use of LMSs in an educational context.

2.2. Usability and usability evaluation criteria of LMSs

Usability is the extent to which a system, product, or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use and the usability measures are defined as follows (ISO, 2018): *Effectiveness* as the accuracy and completeness with which users achieve specified goals; *efficiency* as the resources used in relation to the results achieved and *satisfaction* as the extent to which the user's physical, cognitive and emotional responses that result from the use of a system, product or service meet the user's needs and expectations. Towards managing usability goals, usability is often expressed in terms of usability goals or attributes which enable users to carry out tasks with success and ensure that users meet their needs or accomplish their envisaged tasks in a satisfactory manner.

Usability goals are typically presented in the form of specific questions or guidelines, which can be reduced to usability evaluation criteria (Preece, Rogers, & Sharp, 2002). Such criteria enable researchers to assess systems, with the aim of identifying usability problems and improving the usability of those systems. A concept related to usability is that of user experience (UX). UX focuses on how the users experience an interactive system. According to Roto, Law, Vermeeren, & Hoonhout, (2011:7), this view "emphasises *the outcome and memories of an experience* rather than its dynamic nature". Examples of UX goals include systems that are fun, enjoyable, entertaining, satisfying, helpful, motivating, aesthetically pleasing, supportive of creativity, rewarding and emotionally fulfilling.

According to Preece et al. (2002), a person's "perceptions and responses" can be aligned with the concept of satisfaction when it comes to usability. From this perspective, measures of UX can encompass effectiveness, efficiency and user satisfaction (the three-component model of usability), particularly when the experience is task-related. Usability and UX both influence the learning processes on LMSs by making the platform more usable, interesting, attractive, pleasing and satisfactory for the user (Nakamura et al., 2017).

Usability evaluation involves identifying and fixing usability problems so that the system delivers on usability attributes (e.g., easy to use, learnability, memorability, etc.), whereas UX maximises the hedonic (e.g., stimulation, identification and evocation, and associated emotional responses) and pragmatic goals (acceptance of system use and its consequences). Usability and UX goals are vital because if the LMS system design and development are aligned to them, there is a high possibility of achieving user satisfaction. Due to the interdependencies, UX is mentioned here to clarify the relationships and differences between usability and UX, but the focus henceforth is on usability. There are several ways to evaluate usability as discussed in section 3.1. The core usability knowledge used in the design, implementation and evaluation of LMSs is often expressed in terms of usability criteria which can be formulated in terms of guidelines.

Nyang'or, De Villiers and Ssemugabi (2013:1098) maintain that the "usability of [an] e-learning system involves both technical and pedagogical usability" so the criteria should focus on usability of the system, user interfaces or educational context. The proposed usability guidelines for this study appear in Table 2, with references provided in the far-right column to indicate the original sources.

Table 2: Usability criteria for ODeL LMSs based on (Anonymised, 2019).

Heuristics	Criteria	Guidelines	References
HE1	The simplicity of navigation, readability, organisation and structure of the content of the website	Users know where they are and have the option to select where to go next. Navigational options are limited, so as not to overwhelm the user. Users need not scroll left and right when reading on this website. The content of the website is well organised and related information is placed together. Each page has the required navigation buttons or hyperlinks (links) such as previous (back), next and home.	Du Toit and Bothma (2009), Ssemugabi and De Villiers (2007), Ssemugabi and De Villiers (2010), Medina-Flores and Morales-Gamboa (2015)
HE2	The relevance of site content to the learner and the learning process	Content is relevant and appropriate to learners using the Anonymised platform. The materials and topics are up to date. It is clear which materials are copyrighted and which are not.	Ssemugabi and De Villiers (2010)
HE3	Clear learning goals, objectives and outcomes	There are clear goals, objectives and outcomes for learning encounters.	Ssemugabi and De Villiers (2007), Ssemugabi and De Villiers (2010), Nyang'or et al. (2013), Medina-Flores and Morales-Gamboa (2015)
HE4	Visibility of system status in terms of content	The website keeps the user informed through appropriate and timely feedback. The system responds to user-initiated actions without surprise actions.	Nielsen (1994), Sabri et al. (2013), Mtebe and Kissaka (2015)
HE5	Match between the system and the real world (i.e., between designer model and user model) in terms of content	Language usage in terms of phrases, symbols and concepts is similar to that of users in their day-to-day environment. Metaphor usage corresponds to real-world objects and concepts.	Nielsen (1994), Sabri et al. (2013), Mtebe and Kissaka (2015)
HE6	Flexibility and efficiency of use in terms of content	The site caters for different levels of users, from novice to expert. Shortcuts or accelerators (unseen by novice users) are provided to speed up interaction and task completion by frequent users. The system is flexible, to enable users to adjust settings to suit themselves (i.e., to customise the system).	Mtebe and Kissaka (2015), Nielsen (1994), Sabri et al. (2013)
HE7	Learner control and freedom in terms of content	There are facilities for Undo and Redo.	Mtebe and Kissaka (2015), Nielsen (1994), Sabri et al. (2013)
HE8	Consistency and adherence to standards	The same concepts, words, symbols, situations or actions refer to the same thing. Common platform standards are used.	Mtebe and Kissaka (2015), Nielsen (1994), Sabri et al. (2013)
HE9	Recognition rather than recall	Objects to be manipulated, options for selection and actions to be taken, are visible. The user does not need to recall information from one part of a dialogue to another. Instructions on how to use the system are visible or easily retrievable, whenever appropriate.	Mtebe and Kissaka (2015), Nielsen (1994), Sabri et al. (2013)

HE10	Effectiveness of collaborative learning	Facilities and activities encourage learner–learner and learner–teacher interactions, including both asynchronous and synchronous communication (e.g., e-mail, discussion forums, Wikis and chats). There are tools for communicating within a group (e.g., forums, e-mails, Wikis and chats). The site provides precise announcements of new or unread messages.	Ssemugabi and De Villiers (2007), Ssemugabi and De Villiers (2010), Nyang'or et al. (2013)
HE11	Adaptive learning content	Learners have some freedom to direct their learning, either individually or collaboratively, and have a sense of ownership. Learners are given some control of the content they learn, how it is learned, and the sequence of units. Individual learners can customise the site to suit their personal learning strategies. Educators can customise learning artefacts to the individual learner (e.g., tests and performance evaluations can be customised to the learner's ability). Learners feel a sense of ownership of learning by customising the system to suit their needs. The LMS allows learners the choice of actively participating in discussions or simply observing in the background. Learners take the initiative regarding the methods, time, place, content and sequence of learning. Learners have a wide range of media through which to express their understanding.	Ssemugabi and De Villiers (2007), Ssemugabi and De Villiers (2010), Nyang'or et al. (2013)

3. Research methodology

This section describes the research methodology by starting with an overview of the relevant usability evaluation methods in section 3.1 and the research design of this study in section 3.2.

3.1. Usability evaluation methods

Usability evaluation methods (UEMs) refer to the techniques evaluators use to identify usability problems that need to be addressed through the design and redesign of a system (Nyang'or, De Villiers, & Ssemugabi, 2013). UEMs can be divided into three categories, namely user testing (UT), inspection and inquiry (Alghamdi, Al-badi, Alroobaea, & Mayhew, 2013).

- In employing a UT method, users are given specific tasks involving the use of the system, to test to what extent the system supports them in completing their tasks (Alghamdi et al., 2013).
- Usability inspection (also known as expert-based evaluation) examines usability-related problems from the system's user interface (Alghamdi et al., 2013). Such inspection methods include cognitive and pluralistic walkthroughs, heuristic evaluation (HE), feature inspection and perspective-based evaluation (Usability Evaluation Website, 2012).
- By using inquiry methods, evaluators attempt to understand users' interests (likes or dislikes) and needs, by asking them questions and observing them while they perform tasks (Usability Evaluation Website, 2012). Such methods include field observation,

logging actual use, proactive field study focus groups and interviews (Usability Evaluation Website, 2012).

In this study, controlled UT with eye tracking, post-test questionnaires, HE and interviews were employed to evaluate usability. Controlled UT belongs to the category of usability testing; HE belongs to the inspection category; and questionnaires and interviews belong to the category of inquiry.

3.2. Research design

The purpose of this study was to propose validated usability guidelines focused on the requirements for an LMS in the context of ODeL Honours research projects. The study is novel in including the lecturers' perspective but notably on the usability as experienced by students.

The study was guided by the research question: What are supervisors' perspectives on the usability guidelines for an ODeL LMS? Towards answering that question the following objectives were set:

- a) determining the existing usability guidelines for an ODeL LMS (as done in section 2.2);
- b) showing how heuristic evaluation compares with other usability methods when evaluating LMSs; and
- c) revising the usability guidelines for an ODeL LMS considering the supervisors' points of view.

3.3. Research method

Both qualitative and quantitative data was captured. The qualitative data through interviews and heuristic evaluations which aimed to capture human insights and understanding of specific concepts while the quantitative data came from a questionnaire and the usability testing which were used to identify specific usability issues or confirm the usability in other cases.

In this study, the participants consisted of supervisors of Honours research students at a large ODeL institution in Africa. The Anonymized institution consists of more than eight faculties across 20 schools and registers more than 400 000 students in a year. This study focused on the School of Computing, which offers a research module for Honours students. All students at the Anonymized institution use the LMS to access study material and services (e.g., registration, library system, financial system). For the purpose of this study, the focus was on Honours students' supervisors, who were deemed to have knowledge of using the Anonymized LMS platform, apart from being experts in the educational content and usability of an LMS. Notably, their views have been underrepresented in the literature.

Within Anonymized LMS, the postgraduate student portal serves Doctoral, Master's and Honours students, by offering study support. The Honours qualification is a two-year course offered to students who have completed a Bachelor's degree, an advanced diploma, or who receive recognition of prior learning (RPL). The Honours programme consists of eight modules, including two research modules (research proposal and research project).

The target group was too small for random sampling so a convenience sampling approach was followed. Convenience sampling is a non-probability (non-random) sampling that basically allows the researcher to select participants that are accessible and available to participate in the study (Taherdoost, 2016; Sarstedt, Bengart, Shaltoni, & Lehmann, 2018).

Initially, 15 SoC participants were targeted for data collection in this study. They were invited via email. Three participants withdrew so 12 supervisors participated in the study, three in the pilot study and nine in the final study.

The target population and resulting small sample (12 lecturers) could be considered a limitation of the study. However, according Hwang and Salvendy (2010) a general rule for optimal sample size in usability evaluations including user testing and HE is '10±2' instead of '4±1' as previously thought. This study with 9 evaluators is within that acceptable range. Furthermore, we used four data collection methods to allow triangulations between the findings. Triangulation, an approach advocated by Sarstedt et al. (2018), involves more than one data collection method and corresponding analysis to compare and contrast the findings from the different data streams.

The nine participants involved in this study had different background knowledge and experience in terms of the educational content and usability of the LMS. As is evident from Table 3, there were six male and three female supervisors. The four males ranged in age from 31–40, two males and two females were aged between 41 and 50, and one female was above 50 years of age. Four of the participating supervisors had obtained PhDs, while five had obtained an MSc and were registered to undertake their PhD studies during that year (2018). Two supervisors with PhDs and six years of supervising experience each had graduated more than 25 students (Honours, MSc and PhD students combined). The other two supervisors with PhDs and five years' experience had graduated 20 students each, while five supervisors with an MSc and three years' experience each had graduated more than 15 students. The supervisors with less than two years' experience had graduated between one and ten students, respectively.

Table 3: Supervisors' demographic profiles

Age	Male	Female	Qualifications	
			MSc	PhD
Below 30	0	0	0	0
31–40	4	0	3	1
41–50	2	2	1	3
Above 50	0	1	1	0
Total	6	3	5	4

All evaluations were conducted in the HCI laboratory, and participants were asked to perform the evaluations in sequence (see below).

Data were collected by means of UT, questionnaires, HE and interviews. The gathered data were captured using MS Excel 2016. The following sub-sections provide descriptions of the techniques employed. The sequence of the tasks was as follows: UT was conducted first, then questionnaires, then HE, then post-test interviews.

- ***UT method***

The Anonymised LMS was tested for ease of use, as part of UT, through an eye-tracking system. This allowed the researchers to identify any usability problems. Further, the usability of a system has an impact on user perceptions, therefore it was necessary to evaluate the effectiveness, efficiency and user satisfaction of the Anonymised LMS.

- **SUS questionnaire method**

The SUS questionnaire was used to test user satisfaction, after the participants had completed the UT tasks. The questionnaire featured an accepted set of questions that closely tracked the success metrics of a system (Djamasbi, 2014). All participants rated each question using a five-point Likert scale, ranging from “strongly disagree” to “strongly agree” (Brooke, 2013). An analysis of the SUS scores provided the researcher with an opportunity to identify usability problems from the perspectives of the participating supervisors.

- **HE method**

The supervisors were given a set of HE criteria to apply on the system, in order to enable them to evaluate the Anonymised LMS independently. There was no specific time limit within which to complete the evaluation, but most participants were done within 30 minutes. The heuristics consisted of 34 HE items and 11 criteria. After completing the evaluation, the participants were invited to participate in the post-test interviews.

- **Post-interviews method**

Post-test interviews were held to obtain the participants’ feedback, feelings and opinions about the system. The participants were asked pre-planned questions and their responses were captured on paper. Five questions were aimed at gathering feedback on (1) the usability of the Anonymised LMS; (2) the content found on Anonymised; (3) system capability in terms of communication between students and their peers; (4) system capability in terms of communication between students and supervisors; and (5) comments regarding the LMS.

3.4. Research process

The research process followed (as depicted in Figure 1) can be described as follows:

- 1) Conduct literature review

A literature review was conducted on usability and the existing usability guidelines for LMSs, to identify and propose a set of HE criteria to use in evaluating the LMS. ODeL, as a concept, was also reviewed to explain its foundational technologies and applications and determine where the term originated. The results of the literature review delivered a set of usability requirements for LMSs in the form of a heuristic evaluation criteria conceptual framework that was used to evaluate the usability of LMSs within the ODeL context (see section 2).

- 2) Evaluate LMS usability with supervisors

Phase 2 of the implementation involved an iterative process – pilot study, critical reflection by the authors and then full evaluation. The supervisors of postgraduate students were regarded as expert evaluators, since they have extensive knowledge of using this platform – which made them the ideal participants in this study. Ethics clearance was given by the host institution.

The pilot study was conducted to demonstrate the use of the usability guidelines for evaluating the LMS under study here (initial design process). The same data collection methods were employed, namely UT, survey, HE and interviews. Based on the results of the pilot study, the following adjustments were made to the guidelines.

- The order of tasks for the usability tests was amended;
- The order of the guidelines was updated;
- The numbering of the usability guidelines was changed from numeric to HE and the numbers of some of the usability guidelines were amended;
- Some of the guidelines were removed; and
- Some of the guidelines were reformulated.

3) Evaluate the results

The results obtained from each data-gathering technique were captured and analysed independently – see section 4.

4) Triangulate the results

The results of the findings from all four techniques were integrated

5) Compare and contrast the findings

A comparison of the findings was conducted for proper decision-making

6) Refine usability guidelines

This is final step of the workflow – a refinement and editing process to present a final set of usability guidelines (HE_V2 criteria).

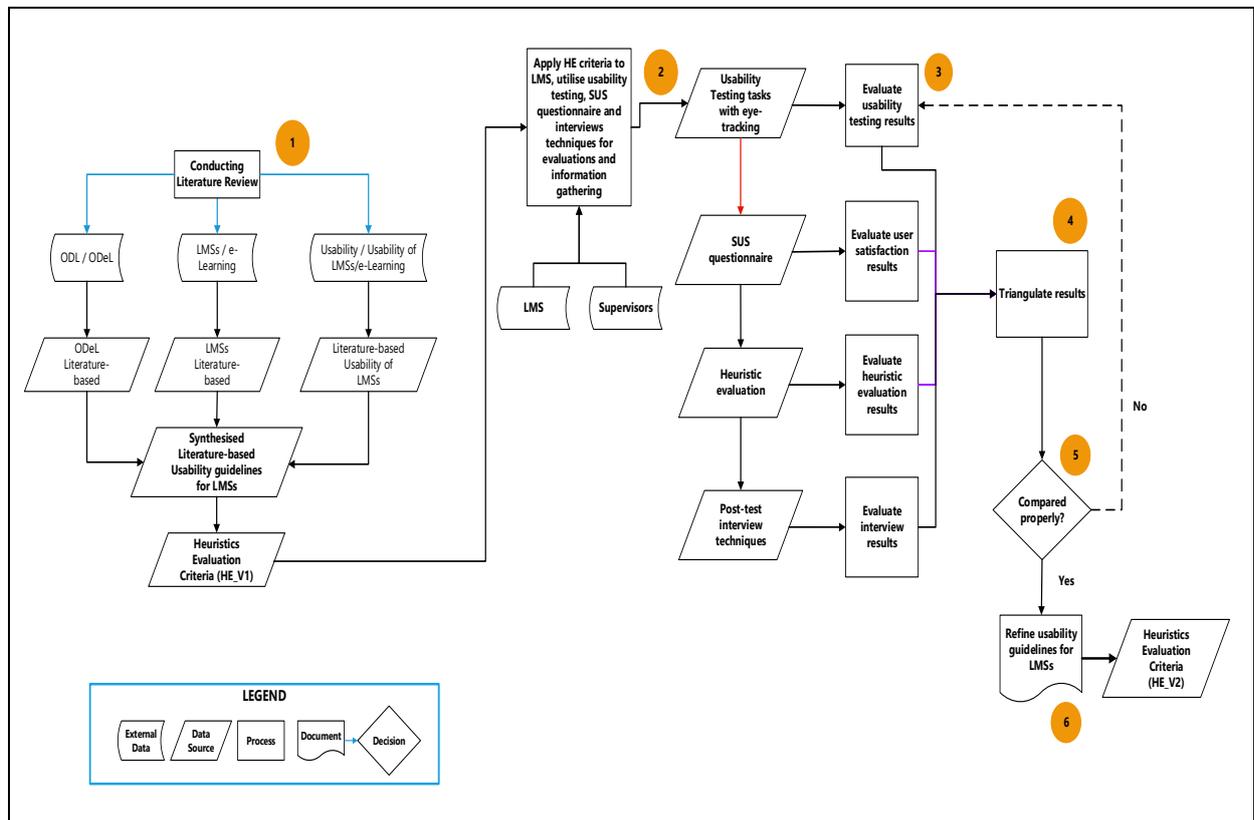


Figure 1: Research process flowchart

4. Results and findings

This section focuses on an analysis of the collected data, which was undertaken with the aim of identifying usability problems in the Anonymized LMS, validating the proposed usability guidelines and making recommendations, where possible. The UT techniques were analysed

based on the time taken to complete a task and on measures of task completion (i.e., with or without assistance). The SUS questionnaire was used to test user satisfaction. While HE was used in the experts' evaluation of the usability guidelines for the LMS, interviews provided the participants' insights – specifically as regards the usability of the LMS – using thematic analysis. The results from the data-capturing techniques were subsequently triangulated and the findings recorded.

4.1. UT Results

The LMS was evaluated for effectiveness, efficiency and user satisfaction. Eye tracking was done with the user testing and the data analysed to provide additional insights. This allowed the researchers to identify any usability problems. The UT tasks (see Table 4) featured activities which were divided into four tasks and labelled T1–T4: In task T1 the purpose was to find out if users could use the Wiki portal, the instructions were to add a comment; in task T2 the purpose was to check whether they could effectively use the discussion forum; in task T3 the purpose was to determine whether they could personalise settings to suit their needs; and in T4 the purpose was to check whether they could easily find and select a project.

These tasks were chosen to test whether supervisors have the ability to use the LMS efficiently and effectively, retrieve features which were deemed to be hidden, access, utilise, modify and personalise the system's features to suit their needs. The tasks deliberately reflect three attributes of usability of systems namely efficiency, effectiveness and user satisfaction. The supervisors observe the system differently from students and therefore their insights may highlight important views of the requirements of the usability of the LMS.

Table 4: UT tasks

Tasks	Aims	Descriptions
T1	<i>Testing the ability to use Wiki portal</i>	Add a new comment on the Wiki portal as follows: <i>'Hello, world'</i>
T2	<i>Testing the system's ability to provide a discussion forum or collaborative learning tools</i>	Add a new topic on the discussion forum, using the subject heading indicated below: <i>'What are e-learning technologies?'</i>
T3	<i>Testing the systems' ability of customisation or personalisation or preference settings</i>	Customise the following features to suit your preferences: 1. <i>Change language to: 'English – United Kingdom'</i> 2. <i>Change notifications to: 'Do not send me notifications'</i>
T4	<i>Testing the ease of finding the project for students to perform tasks</i>	Look for projects and read aloud (verbalise) the title of the following project: <i>'Agile Software Development Adoption in South Africa'</i>

The following performance metrics were identified as relevant:

- **Effectiveness (task success)** – completing the task within a time frame, albeit with assistance if necessary.
- **Efficiency (time on task)** – time taken to complete a task.
- **Satisfaction (user satisfaction measured with SUS post-test questionnaires)** – scores that rate user satisfaction with the system.

4.1.1. Effectiveness

Figure 2 depicts the success rates as percentages. It can be observed that T1 and T2 did not present major usability challenges but T3 and T4 presented some usability challenges to the participants. These results are useful in identifying the tasks to focus on in further analyses. The success was measured by considering the time required in completing the task and whether participants required assistance.

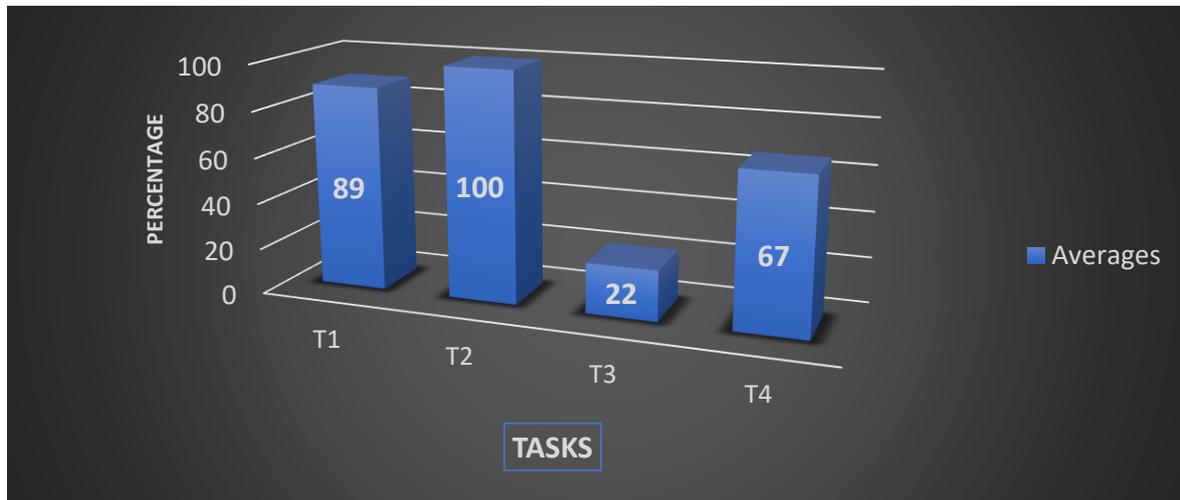


Figure 2: Success rate as average percentage per task

Figure 3 depicts the task completion for each participant. All participants completed T1 and T2 without seeking assistance, P1 completed T3 and T4 with assistance; P4 completed T1, T3 and T4 with assistance. In comparison, P5, P6, P7, P8 and P9 completed T1, T2 and T4 without assistance, although it took P7 and P8 longer to complete T3. Notably, most participants did not complete either T3 or T4 without asking for assistance, and it took them longer than expected to complete these tasks. This implies usability problems with T3 (setting preferences to suit user needs) and T4 (finding a project from the site).

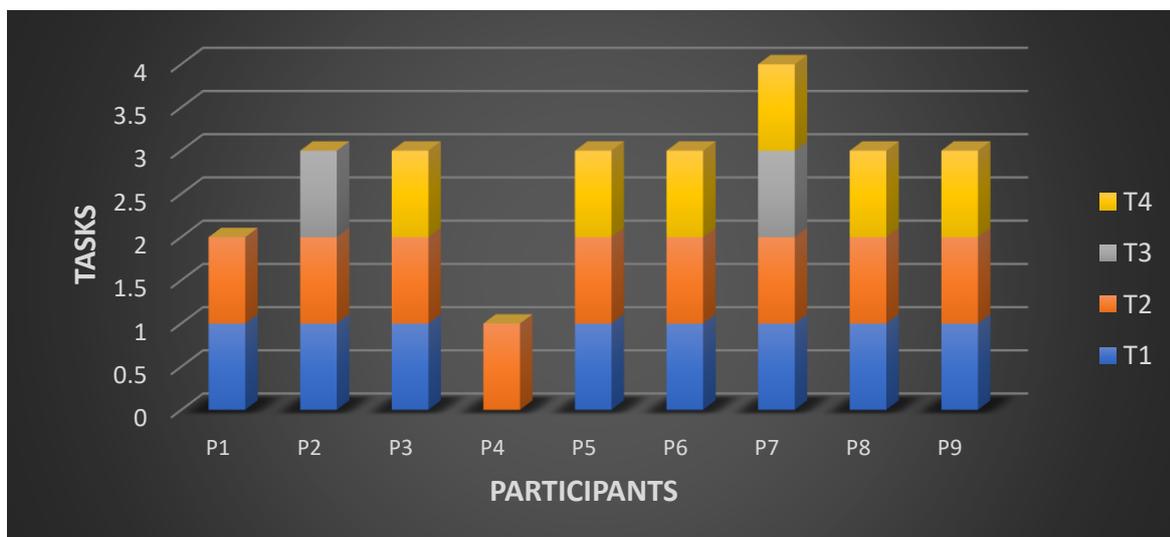


Figure 3: Number of completed tasks per participants

4.1.2. Efficiency

The efficiency of the system is represented by the total time taken to complete a task. The time spent on a task is measured according to the time which elapses between the start of a task and the end thereof (Tullis & Albert, 2013). The time on task for all nine participants across the four tasks was recorded in minutes and seconds and rounded up to the minute. Based on the pilot test the expected time for completing all tasks, was six minutes. Of the nine participants, only P2, P5, P6 and P9 completed the tasks within the expected time of six minutes. Amongst them, P5 and P9 were the fastest at completing the tasks (in four minutes). P3 and P7 took seven minutes each. P8 took the longest to complete all tasks at 13 minutes, followed by P4 at 11 minutes and P1 at 10 minutes. Both P4 and P8 struggled to find the answers to T3 and T4.

The difference in completion times indicate that the LMS has usability issues and cannot be considered efficient for all students.

4.1.3. Usability issues identified by eye tracking

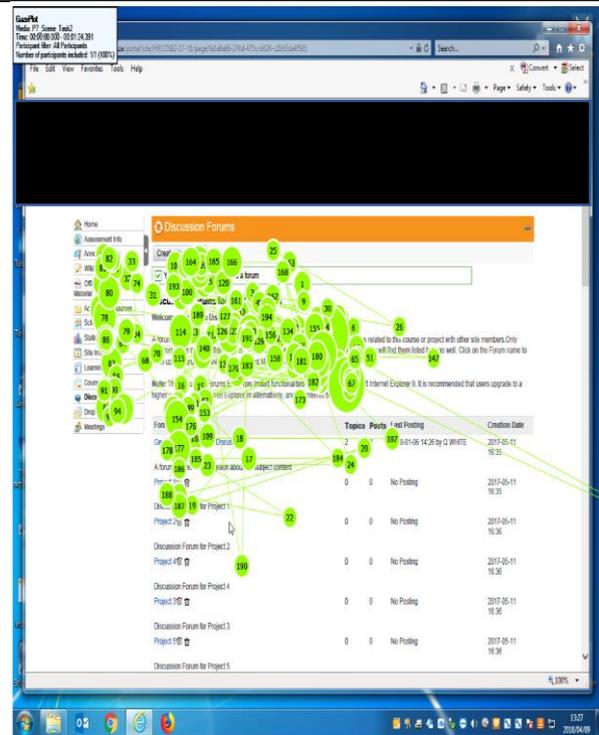
Eye tracking is the process of capturing participants' gaze points and eye movement while they are doing specific, predefined tasks to provide information about the sequence, timing and nature of the participants' cognitive processing during those tasks (Tullis & Albert, 2013). Augmenting the traditional usability testing methods, like user testing with eye movement analysis provides additional insights regarding the interface elements associated with the usability tasks (Wang et al., 2019). The basic metrics are fixations and saccades, a fixation is the accretion of all the gaze points captured from viewing an interface and a saccade is the quick movement between fixations (Tullis & Albert, 2013). Fixations are used to generate several visualisations like gaze plots or heat maps of the interaction. Gaze plots show a succession of fixations, which demonstrate a participant's eye movements during UT. A larger fixation indicates a participant's concentration on a specific functionality while performing the task. While heat maps are useful in showing an intense fixation, using various colours: red spots denote the most intense fixation (hotspot), yellow more moderate fixations, and green the least intense fixations (Djamasbi, 2014).

We created both gaze plots and heat maps for all the participants but since those provided similar insights, we discuss only the gaze plots here focusing on tasks 2 and 3 where the issues were. Task 2 provides a baseline of the participants' gaze plot when they did not experience usability challenges, and Task 3 is considered to find out what the usability issues are. Figure 4 depicts the results of two participants, namely P4 and P8 on Task 2 and Task 3. Those participants were chosen based on the longer time they took to complete the UT tasks. P4 spent a great deal of time on T1, T3 and T4, looking for information on the LMS, while P8 spent long periods on T1 and T3, in the end taking longer than any of the other participants. We now consider each task.

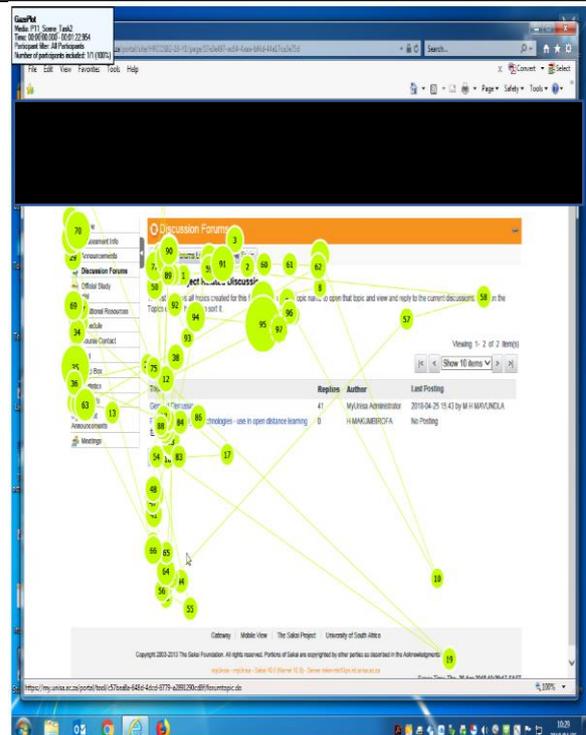
Task 2: T2 involved adding a new topic on the discussion forum (see Table 4 for more detail). Even though both P4 and P8 completed the task without assistance, the sequence of fixations shows that P4 fixated on the sidebar, moving his eyes to the body of the page while presumably trying to locate the *topic*. There are bigger circled fixations on the menu bar and sidebar of the LMS, indicating that the participant was looking at the correct point of interest.

P4 and P8: GAZE PLOTS

P4: TASK 2 (T2)



P8: TASK 2 (T2)



P4: TASK 3 (T3)



P8: TASK 3 (T3)



Figure 4: P4 and P8's task comparison on Gaze plots

Task 3: T3 involved the customization of LMS features to suit user’s needs (see Table 4 for more detail). The many saccades and fixations indicate that P4 struggled with this task. There are eight fixations within the LMS and they are not in sequence. This means the participant moved his eyes across the page, looking for the element, going back and forth, and revisiting the LMS’s features without finding the answer. The time taken to notice the first button leading to the answer was 150 seconds, which indicates that the participant struggled to find the correct path to locate the preference feature. For P8, the big fixations appear only on the menu bar, where the participant almost spotted the preference element. As P8 came closer to finding the preference element, the more the order of fixations became constant.

In summary, T2 was processed successfully with only a few challenges related to the layout of the features from the LMS. For example, the “Wiki tool” was placed under the projects feature which results in users having difficulty accessing it. P4 took longer than average time to complete T3, struggling to find the *preference* feature, as is shown where the participants’ fixations regularly went back and forth. The *preference feature* is obscured by placing it within other features. However, P8 did not experience much difficulty in determining the *preference* settings on T3 so this is an issue to be confirmed by triangulation with the usability results.

4.1.4. User satisfaction

The SUS questionnaire was used to test to what extent a participant was satisfied with the usability of the LMS. Therefore, each participant was provided with a questionnaire after completing the tasks on the eye tracking system. The results are depicted in Figure 5.

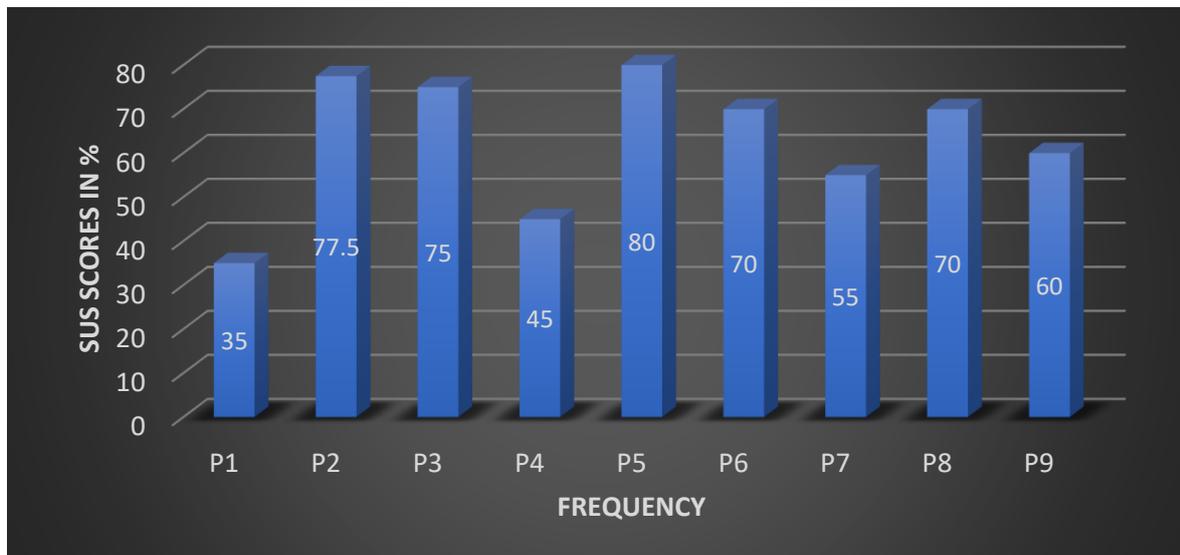


Figure 5: SUS scores – participants’ responses (n=9)

The average SUS score with respect to the usability of the LMS was 63%. In interpreting this average, less than 50% is deemed unacceptable, between 50% and 70% is deemed marginal, and above 70% is deemed acceptable. This means the results of the UT, in terms of user satisfaction with the LMS, were found in the range between marginal and acceptable. A score located in the marginal category implies that the LMS platform requires some intervention in order to be acceptable, thus certain steps need to be taken to rectify the observed usability issues. However, this measure does not identify the specific usability issues and therefore it needs to be combined with other evaluation methods.

4.2. HE Results

The supervisors utilised the proposed usability guidelines on the LMS to assess and validate their usefulness and appropriateness. The HE covers both the user interface and educational guidelines. The average ratings resulting from the descriptive analysis of the HE criteria are discussed below. As regards the HE, the combined values for “agree” and “strongly agree” are as shown in Table 5.

Table 5: Results of the heuristic evaluation

	Criterion	Result (%)	Findings
1.	Simplicity of navigation, organisation, and structure of the content of the portal.	73.3	The evaluators were satisfied with the navigation and structure of the Anonymised LMS.
2.	Relevance of site content to the learner and the learning process.	74.1	The evaluators were satisfied with the relevance of the content.
3.	Clear learning goals, objectives and outcomes.	55.6	The goals and objectives were not well identified, and learning units were difficult to locate
4.	Visibility of system status in terms of content:	72.2	The evaluators were satisfied with the visibility of the information.
5.	Match between the system and the real world (i.e., between designer model and user model).	77.8	The supervisors were satisfied that the criterion reflected a match between the designers' and the users' needs.
6.	Flexibility and efficiency of use in terms of content:	63.0	Users had difficulty finding the <i>preference</i> functionality.
7.	Learner control and freedom in terms of content.	44.4	Some features were problematic, for example the Redo functionality.
8.	Consistency and adherence to standards:	72.2.	Inconsistent use of terminology, for example the word 'project'.
9	Recognition rather than recall:	59.3.	Evaluators found it necessary to memorise some functionalities of the system.
10	Effectiveness of collaborative learning:	75.0	The Discussion Forum functionality was rarely used, which affected effective, collaborative learning amongst students.
11.	Adaptive learning content:	54.0	Little evidence of adaptivity.

The total average of “agree”, for HE criteria from all categories, was 65.5%. This places the HE scores of the LMS in the category of marginal (between 50% and 70%). The result corresponds with the SUS range, which means the HE and SUS methods point to the same overall findings as the results reported in Section 4.1. Notably, the scores on the features involving learner control and freedom (44.4%) and adaptive learning content (54.2%) are lower which aligns with the identification of usability issues in the “setting preferences” feature.

4.3. Post-test interview results

Post-test interviews were conducted with the participants immediately after they had completed the HE. The interviewer asked the participants to reflect on their experience of the usability of the Anonymised LMS. Their responses to the interviews were captured and thematic analysis as advocated by Braun & Clarke (2006) and also applied by Maguire and Delahunt (2017) was used to analyse the interview data. The process included the following actions: the data was gathered (step 1), categorised (step 2), themes and codes were

searched for (step 3), evaluation and elimination process of the themes was applied (step 4), definition of themes was finalized (step 5) and the write-up was performed (step 6). The results of this analysis provided four themes: 1) usability; 2) relevance of the content; 3) collaborative learning; and 4) customisation. The results of the interviews, based on the themes, are discussed below.

4.3.1. Theme 1: Usability

There was a mixed reaction to the question of the *effectiveness* of the LMS. The participants who found the system effective, responded as follows:

P5 clarified: "I think the system is usable. Students just have to read and understand what they need." In addition, P6 indicated: "The site is easy to use for people who use it frequently. However, the site might be challenging for new users." Thus, in the view of P6, new users must receive training before starting to use the system.

Those participants who questioned the effectiveness of the system responded as follows:

P1 said: "At times, the site feels a bit cluttered. It is dull – no stimulating elements to interact with. [Some features do not display info clearly and correctly]." This happens when users attempt to open features on the site, then surprisingly the system displays unexpected results (e.g., small fonts, or disorganised tables or graphics).

The *efficiency* of the system evaluates resource usage including whether users can complete tasks in a reasonable time. Participants who complained about the system's *inefficiency*, included:

P9 who said: "Some of the options are not easy to be found." And thus it required more time to complete the task.

P4 added: "Project feature is located under Wiki, which means [it] is hidden." P6: "Good to expect a "preference feature". But it is not easy to be found." P3 concurred with this view. Technically, the *efficiency* of the system met users' requirements, since the system responded rapidly to user actions.

Interview participants who seemed *satisfied* with the usability of the LMS responded as follows: P5, P8 and P9 confirmed that the system is easy to use.

Those who seemed *dissatisfied*, responded as follows:

P1 said: "At times, the site feels a bit cluttered. It is dull – no stimulating elements."

P7 commented: "I have been working on the site before, however, I need to 'look' for specific links every time I visit the site."

P7 opined: "The content is suitable, however different projects do not use the same layout and templates". P1 added: "The silence is too loud. When an LMS does not have a social aspect, students will not come back often."

The participants complained about their inability to find the *preference* and *project* features easily. They reported needing to move their eyes around the system or webpages, which frustrated them.

4.3.2. Theme 2: Relevance of the content

The participants who agreed that the content was relevant, responded as follows.

P4 stated: "All the information that is necessary, is there." P6 added: "Content is clear and straightforward."

As P5 mentioned: "There is missing information about the assignment. It is not clear for students to know exactly where the info is to be found."

P8 opined: "The content of the site is aimed at conveying info to the students, to allow them to choose a project and access learning materials, in addition, to communicate with each other via Discussion Forum ..."

On the other hand, participants identified a number of issues regarding the content.

P10 explained: "The content is suitable. However, different projects do not use the same layout and templates, making it difficult for students to choose a project."

P12 added: "I think content is fine, but finding a piece of specific information is hard."

In summary, there were mixed reactions to the relevance of the content of the site.

4.3.3. Theme 3: Communication and collaborative learning

For communication and collaborative learning, users can use email and discussion forums to interact with one another and with their supervisors. Group formation allows for improved interaction and collaborative learning. Below are the responses the participants gave during the interviews, as regards the communication tools on the LMS:

P2: "Relevant tools are available on the system, although they are not being used sufficiently. Students might be using other tools such as Skype."

P6: "... but the site does not accommodate students in terms of [their] preferred technologies, such as Facebook, Skype, WhatsApp and Twitter."

P8: "Emails and discussion forums allow students to communicate with each other. But the use of additional tools can facilitate knowledge sharing among students."

P9: "There is a discussion forum, but this option is not safe for in-depth communication between students. I would prefer WhatsApp, since Anonymised already ha[s] student[s'] cell phone numbers. The system could be developed to add the newest options to improve group work."

These responses indicate concerns that the LMS – with its collaborative learning components such as the Discussion Forum – is underutilised. Limited engagement with this functionality could imply that users are uncomfortable with the system's usability. The use of other functionalities (e.g., WhatsApp and Skype) could be considered for the purposes of collaborative learning. The use of email and Facebook was put forward as alternatives to the Discussion Forum. This raises the question of why the institution does not integrate trending social networking technologies with the LMS.

4.3.4. Theme 4: Customisation

The LMS allows users to customise user preferences. However, the participants were concerned that the *preference* feature is not easily accessible, therefore it is not obvious where users can set or change their preferences. The participants also identified that not every user is familiar with the Wikis or their purpose. This finding is supported by the results of the eye tracking exercise, where not all users could complete tasks on time, and some needed assistance. Some participants commented that (1) although the *preference* setting feature is provided it is hidden, and (2) users are able to customise the site to suit their personal learning strategies, but the *preference* feature is difficult to find. In summary, the results of the thematic analysis of the interviews with the participating supervisors confirmed that the LMS was usable, but not optimally so.

4.4. Triangulation of the UT, questionnaire, HE and interview results

An earlier publication from this research (Anonymized, 2019) focused on the recommendations for improving the institution's LMS, those recommendations are not revisited here. This paper provides a more in-depth coverage of the results towards triangulation as the basis for validating the HE guidelines. Notably, the post-test interviews and the eye-tracking aspect of usability testing has not been covered before. Each evaluation method added specific value. Heuristic evaluation, post-test questionnaires and interviews are useful in identifying the nature and scope of the usability issues whereas usability testing – the eye-tracking data analyses – allowed the researchers to locate the usability issues within the system design and identify the design issues. Figure 6 presents the results of the data for all four techniques used in this study. The results have been triangulated with the aim of revealing convergent evidence on the salience of the findings.

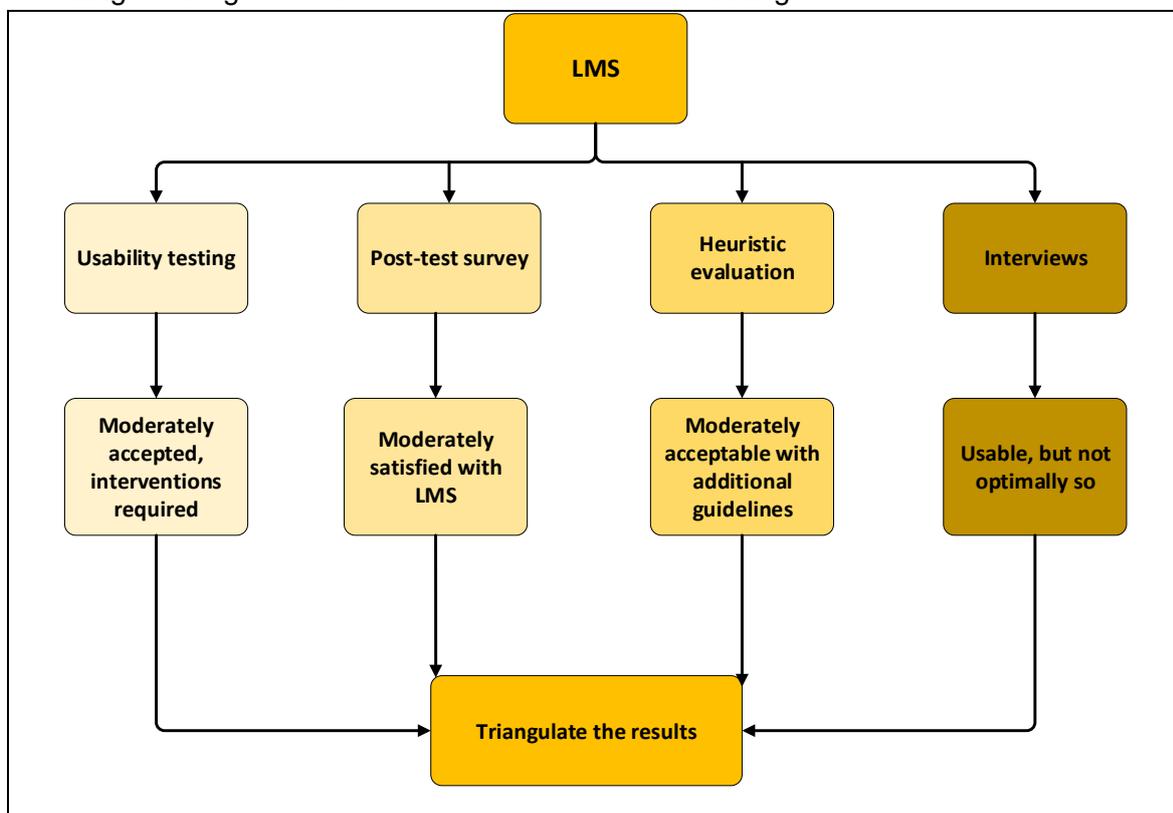


Figure 6: Data triangulation results

UT sought to capture both effectiveness (task success; i.e., whether tasks were completed with or without assistance) and efficiency (time spent on task; i.e., minimum, maximum and average time spent). The results of the UT indicated that most users (7 of 9) needed assistance in completing Task 3. Notably, these are lecturers, so students might have found this even more difficult and hence the usability challenges could have been prohibitive for isolated ODeL students. Efficiency as measured by the completion time is below par, that is evident from the large difference between the minimum time (4 minutes) and the maximum time (13 minutes) as well as the fact that most participants took longer than the expected time to complete. As is evident in Figure 6, the results suggest that some interventions are required for the LMS to be acceptable to users.

The post-test survey focused on user satisfaction. The results (in the marginal category, 63%) indicated that users were moderately satisfied with the usability of the system, thus certain steps are required to resolve the observed issues, in order to make the system fully acceptable.

The HE comprised 11 criteria and 34 guidelines. The results in respect of the HE guidelines show that 65% “agree” (Section 4.2). This is in the range between 50% and 70%, which means the system is marginally acceptable. The results of the HE imply that the guidelines are acceptable, and could be used to evaluate the LMS under study here.

The interview comments were useful for arriving at an understanding of the actual users’ concerns. From the analysis of the interview data, four themes emerged which confirmed the findings from the UT and added more detail. For example, UT identified usability issues with task 3 based on the performance time and assistance required while the interview revealed the reason, i.e. the preference setting was not placed on the main page and hence difficult to find. As the results indicated, the supervisors’ insights into the system revealed that it is usable, but not optimally so.

In summary, the results of the triangulation align with respect to the overall evaluation of the usability of the LMS as measured by the UT, post-test survey and interviews as moderate. The results also imply that the proposed heuristics are useful for evaluating the usability of the LMS, because the findings from the HE delivered the same overall results as the other three methods, i.e. the usability evaluation, post-test SUS questionnaire survey and interviews. This is important since HE is less resource intensive than any of the other methods so if the results are similar then HE could be recommended to save time and money while delivering a valid usability result.

4.5. Refined usability guidelines

Table 6 outlines the refined HE criteria for the LMS (M and the corresponding number represent usability guidelines). The heuristics were refined based on the results of the findings. A number of heuristics (highlighted in yellow) were added to the list of the usability guidelines initially proposed. This makes the proposed usability guidelines more valid, since the results of the findings serve to make them useful and appropriate. As shown in Table 6, the final measures for the usability guidelines of LMSs encompass 11 criteria and 40 guidelines. Each criteria is followed by the number of the heuristic and the related guideline(s).

Table 6: Refined HE criteria for LMSs in ODeL contexts

The simplicity of navigation, organisation and structure of the content of the student portal	
M1	Users should know where they are and have the option to select where to go next.
M2	The navigational options are limited, so as not to overwhelm the user.
M3	Users need not scroll left and right when reading on this website.
M4	The content of this website is well organised and related information is placed together.
M5	Each page has the required navigation buttons or hyperlinks (links), such as previous (back), next and home.
M6	Links are consistent and indicate which ones have been visited.
M7	The system provides quality performance in terms of uploading and downloading materials.
The relevance of site content to the learner and the learning process	
M8	Content is relevant and appropriate for using the LMS site.
M9	The materials and topics are up to date.
M10	It is clear which materials are copyrighted and which are not.
M11	The project site has a consistent format or templates.
Clear learning goals, objectives and outcomes	
M12	There are clear goals, objectives and outcomes for learning encounters.
M13	The content of the site motivates students and encourages active, cognitive and critical thinking.
Visibility of system status in terms of content	
M14	The website keeps the user informed through appropriate and timely feedback.
M15	The system responds to user-initiated actions, without surprise actions.
Match between the system and the real world (i.e., between designer model and user model)	
M16	Language usage in terms of phrases, symbols and concepts is similar to that of users in their day-to-day environment.
M17	Metaphor usage corresponds to real-world objects and concepts.
Flexibility and efficiency of use in terms of content	
M18	The site caters for different levels of users, from novice to expert.
M19	Shortcuts or accelerators (unseen by novice users) are provided to speed up interaction and task completion by frequent users.
M20	The system is flexible to enable users to adjust settings to suit themselves, i.e., to customise the system.
M21	The site is consistent in terms of feel and look.
Learner control and freedom in terms of content	
M22	There are facilities for Undo and Redo.
M23	Users control the system and can correct mistakes at any time.
Consistency and adherence to standards	
M24	The same concepts, words, symbols, situations or actions refer to the same thing.
M25	Common platform standards are used.
Recognition, rather than recall	
M26	Objects to be manipulated, options for selection and actions to be taken, are visible.
M27	The user does not need to remember information from one part of a dialogue to another.
M28	Instructions on how to use the system are visible or easily retrievable, whenever appropriate.
Effectiveness of collaborative learning	
M29	Facilities and activities encourage learner–learner interactions, including both asynchronous and synchronous communication, such as e-mail, discussion forums, Wikis and chats.

M30	Facilities and activities encourage learner–teacher or teacher–learner interactions, including both asynchronous and synchronous communication, such as e-mail, discussion forums, Wikis and chats.
M31	There are tools for communicating within a group, for example, forums, email, Wikis and chats.
M32	The site provides clear announcements of a new or unread message.
Adaptive learning content	
M33	Learners have some freedom to direct their learning, either individually or collaboratively, and have a sense of ownership.
M34	Learners are given some control over the content they learn, how it is learned, and the sequence of units.
M35	Individual learners can customise the site to suit their personal learning strategies.
M36	Educators can customise learning artefacts to the individual learner, for example, tests and performance evaluations can be customised to the learner’s ability.
M37	Learners feel a sense of ownership of learning, by customising the system to fit their needs.
M38	The LMS system allows learners the choice to actively participate in discussions or simply observe in the background.
M39	Learners can take the initiative regarding the methods, time, place, content, feedback and sequence of learning.
M40	Learners can use a wide range of media to express their understanding.

Six new usability guidelines were added to the initial proposed guidelines (see Table 4 – highlighted in yellow). These new guidelines were abstracted from supervisors’ inputs during the interviews and the analysis of usability issues.

- M6: Links are consistent and indicate which links have been visited.
- M7: The system provides acceptable response time in terms of uploading and downloading materials.
- M11: The project site has a consistent format or templates.
- M13: The content of the site motivates students and encourages active, cognitive and critical thinking
- M23: Users control the system and can correct mistakes at any time

4.6. Recommended guidelines

Recommendations were abstracted from the supervisors’ comments during interviews and heuristic evaluations. These recommendations confirm some of the existing usability guidelines and can potentially improve the design of LMSs (see Table 4). They are categorised into usability and broader guidelines and also show the corresponding usability guidelines that appear in Table 4.

Usability guidelines:

- a) Clearly display the options and commands (such as shortcuts) available, to make sense to the user; **M19**.
- b) Clearly display the course structure; **M1, M4**.
- c) Increase space for uploading learning materials; **M9**.
- d) Design the site to be accessible to users with special needs; **M18**.
- e) Provide for the possibility of using Undo and Redo functionalities; **M22**.
- f) The same concepts, words and symbols should refer to the same thing (e.g., ‘project’ and ‘subject’); **M24**.
- g) Provide the option to personalise the user interface and allow users to customise features to suit their needs; **M20, M35**.

- h) Maximise personalised access to learning contents and allow the possibility of personalising the learning path **M36, M37.**

Broader guidelines:

- i) Design communication tools in such a way that they allow collaborative learning (e.g., WhatsApp, Skype); **M29, M30, M31.**
- j) Consider the use of emerging technologies to maximise student interaction, support and collaboration; **M31.**
- k) Supply different media channels for communication; **M40.**

It is imperative that these recommendations be taken into consideration, when designing or updating LMSs. Pangestu and Karsen (2016) evaluated the usability of an e-learning web based system at a Higher Education Institution by applying the USE questionnaire to determine users' perceptions about the quality of the e-learning system. The USE Questionnaire involves usefulness, satisfaction, ease of learning and ease of use. Their findings confirm the relevance of the high level HE criteria proposed in this study, while this study contributes by presenting the HE criteria in a more detailed format.

Conclusions

The use of heuristic evaluation in determining usability requirements and evaluating LMSs is a mature field of study but the evaluation of LMS usability guidelines presents contextual challenges. Most previous evaluations of HE criteria involved students as participants and used only one evaluation method. This research builds on those HE criteria published; the novel contribution is to incorporate the supervisor's view and triangulate the findings with the findings from three other usability evaluation methods. Comparing the results of the HE with the results of the other methods allows for in situ, albeit indirect, evaluation. Notably, this covers all three of the usability evaluation categories of testing; inspection and inquiry. HE is more cost and time effective than the other three methods used and more practical in developing countries which do not have usability testing facilities. Demonstrating that the findings from the four methods are comparable suggests the value of HE as an appropriate, resource effective, high-level method for LMS evaluation. However, more research is needed to confirm this and also to look into context sensitive HE criteria. This study contributes on the theoretical level in terms of the usability requirements (expressed as HE criteria) for ODeL LMSs. The value of these HE guidelines is limited by the fact that it is contingent on the number and expertise of the evaluators. Therefore, future research is necessary to evaluate the HE criteria proposed with ODeL students at other ODeL universities and on mobile phone platforms.

Acknowledgement

To be added if the paper is accepted.

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