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Usability Testing of a Mobile-based Learning Management System for Teacher Continuous Professional Development in Tanzania

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ABSTRACT

The last two decades have seen the growing adoption of mobile devices to enhance the quality of teachers' continuous professional development (TCPD) in low-income countries. Using mobile devices, typically not designed for educational use, presents new usability challenges, preventing teachers from effectively accessing learning materials in learning management systems (LMS). Therefore, it is important to test usability to improve the delivery of TCPD via mobile devices. This study evaluated the usability of TCPD-focused mobile-based LMS accessed via a mobile web browser and mobile app. The evaluation used a hybrid think-aloud method involving 63 teachers from 12 schools in Tanzania. Half of the schools were evaluated using a concurrent think-aloud method, and the other half using a retrospective think-aloud method. The study found that teachers encountered many usability problems in using the mobile app compared to those who accessed the LMS via mobile web browsers. The study also found usability flaws in the registration and login process, poor language translation, technical errors, and issues with quiz questions. These findings show the importance of user testing, even for well-developed LMS, such as Moodle. Additionally, this work provides useful guidance for those who want to implement mobile learning via an LMS in low-income countries.

Keywords: *Usability testing; Mobile-based learning; Learning Management System; Teacher development.*

INTRODUCTION

The last two decades have seen increasing adoption and use of various digital technologies to enhance the quality of teachers' continuous professional development (TCPD) in low-income countries (Hennessy *et al.*, 2022). Studies show that digital technologies can provide cost-effective approaches to TCPD (McAleavy *et al.*, 2018), and reach teachers in various geographical areas, including remote regions (Haßler & Moss, 2020). They also show that digital technologies can increase access to teacher learning in remote/rural areas (Hennessy *et al.*, 2022) and improve quality and student learning outcomes (Dachi, 2016).

Given these benefits, the Government of Tanzania, in collaboration with the Education Program for Results and the World Bank's BOOST component, has implemented the technology-supported school-based TCPD for Tanzania's primary education sector. They customized the Moodle Learning Management System (LMS) to meet the specific needs of TCPD activities for teachers in primary schools in Tanzania (https://tcpd.tie.go.tz/). The system provides online access to various learning resources, such as self-learning modules and Community of Learning resources. In addition, the LMS collects data on training needs from teachers. The collected data becomes instantly available to Local Government Authorities (LGAs), reducing the cost of printing, distribution, and data analysis.

As many schools in low-income countries have limited technological infrastructure and expensive computers, education providers have leveraged teachers' mobile devices - and usage know how - as low cost substitutes for computers to implement TCPD activities (Burns, 2015). These devices are portable, cheaper per unit compared to desktop computers, and provide more significant opportunities to be shared among colleagues (Hennessy *et al.*, 2022). Therefore, in this project, the TCPD LMS was made available via the mobile web, which allowed teachers to access the system via mobile browsers. The system was also implemented as a mobile app which allowed teachers to access the content offline on their devices.

Using mobile devices to foster learning activities has presented new usability challenges (Kumar & Mohite, 2018). Compared to desktop computers, mobile devices have small screen sizes, low screen resolution or form factor, low storage capacity, and network bandwidth, limited processor performance, compatibility issues, lack of data input capability, short battery life, and high demand for visual attention (Punchoojit & Hongwarittorrn, 2017). They also have various mobile user interface types with usability issues, such as scroll-and-select interfaces, tilting/sensor-based interfaces, speech-based user interfaces, interfaces that use a stylus, and touch interfaces (Ivanc, Vasiu & Onita, 2012). For instance, small screens and low memory sizes mean only a small fraction of a document can be seen or stored on some devices. Small buttons and touch screens reduce input capability and increase human errors when navigating learning resources (Kumar & Mohite, 2018).

Therefore, usability testing is necessary to ensure that mobile applications are effective and easy to use (Kumar & Mohite, 2018). If the TCPD mobile LMS is not usable, teachers will spend more time learning how to use it than mastering the learning resources (Lanzilotti *et al.*, 2006). They will feel lost, confused, or frustrated when using such a system, thus becoming a barrier to effective learning (Ardito *et al.*, 2006). In worst-case scenarios, they will abandon the system if it is hard to use.

This study addresses this need by investigating the usability of LMS implemented in mobile devices. Other studies have already shown that many LMS tend to suffer from usability flaws (Kakasevski *et al.*, 2008; Adebesin, de Villiers & Ssemugabi, 2009; Ivanc, Vasiu & Onita, 2012; Ssekakubo, Suleman & Marsden, 2013; Mabila, Gelderblom & Ssemugabi, 2014; Mtebe, 2015; Hasan, 2018). However, most of these studies have evaluated the LMS implemented on the desktop paradigm.

This study focused on evaluating the LMS on the mobile paradigm. Specifically, it evaluated the usability of TCPD mobile-based LMS in web browsers and mobile apps using a hybrid think-aloud method involving 63 teachers from 12 schools in three regions: Mwanza, Arusha, and Kigoma. Half of the schools (6 of 12 schools) were involved in a concurrent think-aloud method, and the other half were involved in a retrospective think-aloud method. The results provide useful guidance for those who want to implement mobile learning via LMS in low-income countries on usability issues that should be addressed before implementation.

THE TCPD LEARNING MANAGEMENT SYSTEM PROTOTYPE

TCPD Learning Management System

The TCPD prototype was customized from the Moodle platform (https://moodle.org/), a popular open-source e-Learning platform that is low-cost and robust (Ivanc, Vasiu & Onita, 2012). The project followed a user-centric approach to build the LMS that meets TCPD activities and teachers' needs. The implementation team downloaded the system, implemented initial functionalities, and then conducted three user studies with teachers in 12 primary schools in Tanzania.

The first user study aimed to collect unique requirements of the LMS from actual users in their context. The team presented a prototype with basic functionalities to 81 teachers from 8 schools across three regions. Afterward, they collected feedback through questionnaires and focus group discussions. The findings showed that most primary schools do not have computers, but many teachers either own mobile devices or have access to mobile devices. In addition, the study found that most teachers owned smartphones with low memory and processing power capabilities. The team used these findings to identify new requirements further and customize the TCPD LMS.

The second user study aimed to validate functionalities identified in the first user study. 117 Teachers in 15 schools were given access to the system and used it for two days. Afterward, the team collected data through observation, focus group discussions, and questionnaires.

Based on these two studies, the system was configured with two language options – English and Swahili – to allow teachers to choose the most comfortable option. The system was also made accessible via two main channels: a web-based application (http://tcpd.tie.go.tz) accessible via mobile browsers and an Android-based mobile application called TCPD Mobile LMS available in the Google Play Store. Teachers were required to create a new account, as shown in Figure 1, and later verify via email to log into the system.

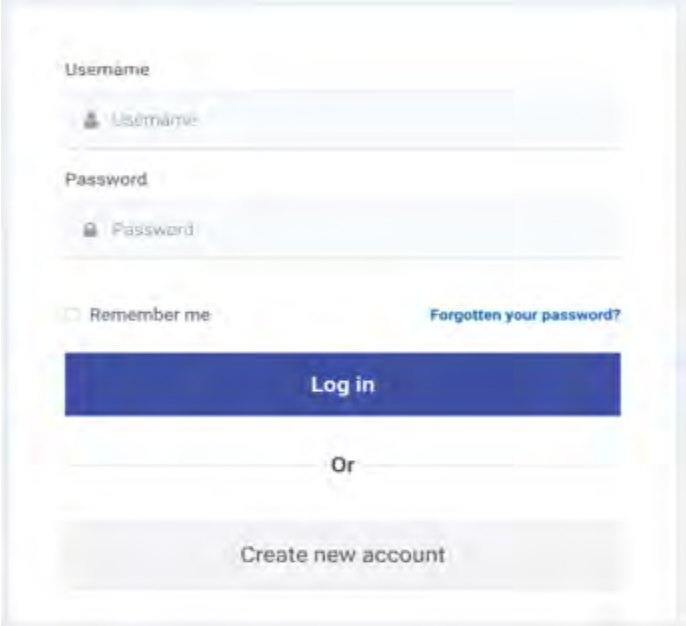

Figure 1: The TCPD System Login Page

Sample module

A sample module – Upimaji na Mrejesho – was implemented to test the pedagogical effectiveness of the TCPD mobile LMS. However, testing system usability alone is insufficient for mobile learning applications as the system might be usable but does not provide any educational value (Ardito *et al.*, 2006). In this study, the Upimaji na Mrejesho module was redesigned in a web-based format (avoiding large images, video, and documents) to ensure that learning resources are compatible with mobile devices. The module consists of 12 units with 5-question quizzes each. As part of testing multimedia content, each module had an introduction video and units with at least three images each.

LITERATURE REVIEW

Usability testing

Usability is "the extent to which specified users can use a product to achieve specific goals with effectiveness, efficiency, and satisfaction in a specified context of use" (Technical Committee ISO/TC 159. Subcommittee SC and Ergonomics of human-system interaction, 2018). It is the essential aspect of a system that directly affects how users use the system (Ardito *et al.*, 2006). Usability considers many factors, such as the ease of understanding the website structure, interface, and content observed by the user and the speed with which the users can find the items they are looking for (Flavián, Guinalíu & Gurrea, 2006).

A usable system enables users to navigate through it quickly. It helps infrequent users navigate again after a while without having to learn everything repeatedly (Nielsen, 1995). In addition, users avoid many errors when navigating through a usable system. On the other hand, in an unusable system, learners spend more time learning how to use it than learning the content (Rosa Lanzilotti *et al.*, 2006). Such systems waste users' time and network resources and prevent them from participating in learning activities more effectively and efficiently (Nielsen, 1995). Given the number and diversity of users and mobile devices, conforming to usability is important.

The usability of a system can be evaluated through usability inspection methods and usability testing. The usability inspection involves evaluators examining and judging usability-related aspects of the system based on their expertise (Ardito *et al.*, 2006). These methods include heuristic evaluation, cognitive walkthroughs, feature inspection, and standards inspection. The inspection methods are easier to administer and less costly than usability testing (Nielsen, 1995). However, a drawback of these methods is their dependence on the evaluators' skills and experience, which may produce different outcomes (Ardito *et al.*, 2006). In addition, they are not based on evidence from actual users who are expected to use the system (Lazar, Feng & Hochheiser, 2017).

Usability testing involves collecting quantitative and qualitative data from users through well-prepared scenarios (Ivanc, Vasiu & Onita, 2012). In this approach, field observation, questionnaires, and think-aloud protocol are the most widely used methods. These methods are seen as irreplaceable as they give direct input on how real users use the system, in contrast with usability inspection methods, where experts use different methods to evaluate a user interface without involving users (Koziokas, Tselikas & Tselikis, 2017). Lazar, Feng & Hochheiser (2017) indicated that usability testing can take place in a fixed laboratory, a workplace, a user's home, over the phone, or the web. The location may be determined by availability where participants are, or the type of data to collect.

As the LMS was implemented to be used with teachers in rural primary schools in Tanzania, usability testing methods were adopted. As Lazar, Feng and Hochheiser (2017) pointed out, it is better to conduct user-based testing earlier rather than later so that the results can influence the system's design with lower costs for making changes. In this case, this study is part of several iterations involved in developing the TCPD mobile LMS, ensuring that it meets the needs of teachers in rural areas of Tanzania. Many teachers in rural areas have not been exposed to ICT solutions and therefore have low confidence in using LMS for TCPD activities. In addition, adopting and using mobile devices to access TCPD activities will be their first experience. Therefore, adopting usability methods that involve direct users of the LMS to uncover possible usability flaws is important. Specifically, this study adopted the hybrid think-aloud protocol to evaluate the usability of mobile-based LMS for TCPD activities.

In this approach, users are asked to use the system while continuously thinking aloud - simply verbalizing their thoughts as they move through the user interface (Nielsen & Madsen, 2012). According to Ericsson & Simon (1998), there are two basic thinking-aloud methods. The concurrent thinking-aloud method, in which participants think aloud while carrying out the tasks, and the retrospective thinking-aloud method, in which participants verbalize their thoughts after they have completed the experimental tasks. The concurrent method provides "real-time" information during the participant's interaction with a system, making it easier to identify the areas of a system that cause problems for the user (Alhadreti & Mayhew, 2018). However, participants might have an uncomfortable or unnatural experience, as people do not usually offer running commentaries while performing tasks. In addition, verbalizing information while performing tasks might distract participants' attention and concentration, and the effort to fully verbalize the steps might change how users attend to the task components (Chandrashekar *et al.*, 2006).

As a result, in some cases, the retrospective think-aloud method, in which participants work in silence and verbalize their thoughts afterward while watching a performance recording (Elling, Lentz & de Jong, 2011) was preferred. Participants are, therefore, fully enabled to execute a task in their own manner and at their own pace and are less likely to perform better or worse than usual. However, the retrospective think-aloud has been criticized for its reliance on memory and the subsequent possibility of post-task rationalizations (Elling, Lentz & de Jong, 2011). In addition, participants may be unable to remember everything they thought about during their task performance, leading to fewer incomplete or reconstructed verbalizations of their thoughts.

Due to these weaknesses of both concurrent and retrospective think-aloud methods, Ericsson & Simon (1998) advocated for use of concurrent and retrospective methods in tandem (referred to as the hybrid method).

RELATED STUDIES

Studies have evaluated the usability of various LMS. For instance, Martin *et al.,* (2008) adopted a heuristic method to compare the usability of three platforms: Moodle, Sakai and dotLRN. The study found that none of the platforms reached 80% compliance with heuristics. Similarly, Mtebe & Kissaka (2015) developed usability heuristics that consolidated interface usability, didactic effectiveness, and motivation to learn, and used the heuristics to evaluate the usability of Moodle LMS implemented at the University of Dar es Salaam and ShuleDirect system. The study found that the two systems had several usability problems that hindered many users from using them more effectively.

Many users prefer accessing the LMS via mobile devices, so these devices present new usability challenges. Therefore, some studies have been comparing the usability of mobile LMS with that accessible via desktop computers. For instance, Hasan (2018) compared the usability of Moodle LMS accessed through the desktop and mobile interfaces using 155 students. The study revealed 17 usability problems on both Moodle interfaces, with two usability problems being uniquely on the mobile interface of Moodle. Similarly, Minović *et al.,* (2008) compared the usability of Moodle on both desktop and mobile interfaces using the think-aloud and questionnaire methods. The results showed that the students faced difficulties performing Moodle tasks using desktop platforms and mobile devices. However, the study found that mobile devices had higher usability flaws than desktop platforms. Ssekakubo, Suleman & Marsden (2013) also employed questionnaires to investigate the usability of Sakai and Moodle, accessible via desktops, laptops, tablets, and mobile phones. The study found that mobile phones had usability and compatibility problems when accessing websites designed for desktop or laptop computers.

Few studies have evaluated the LMS implemented in mobile devices without comparing it with the desktop version. For instance, Ivanc, Vasiu & Onita (2012) developed a framework to evaluate the

usability of LMS mobile web, considering pedagogical usability, the device, content, and mobile web interface. However, the study proposed a framework without testing the framework with empirical data.

These studies show that usability flaws that hinder users from using the LMS effectively still exist whether the system is implemented on desktop or mobile devices. Given the physical limitations of mobile devices and the context of use, an earlier study found usability flaws were higher in the LMS implemented in mobile devices than in the desktop version (Minović *et al.*, 2008).

Many studies that have evaluated LMS implemented in mobile devices or desktop computers have adopted heuristic methods using experts as evaluators (Kumar & Mohite, 2018). It is highly recommended that usability testing involves actual users of the system in the user's workplace or in the context where the system will be used (Lazar, Feng & Hochheiser, 2017). According to an earlier stuidy by Bevan & MacLeod (1994), the context of use is important in determining the system's usability, as changing any relevant aspect of the context may change the system's usability. In this study, a hybrid think-aloud method to examine the usability of mobile-based TCPD LMS involving teachers from primary schools in Tanzania was conducted.

METHODOLOGY

Research Design

The study adopted a hybrid think-aloud method where half of the schools (6 of 12 schools) were involved in a concurrent think-aloud method, and the other half was involved in a retrospective think-aloud method. Concurrent think-aloud means participants verbalize their thoughts as they navigate through the system to understand their interactive behavior. In contrast, retrospective think-aloud means participants were navigating the system in silence and verbalized their thoughts on the second day. In both approaches, a specific task was given to guide them through the system. At least three teachers were selected in each school to participate in a concurrent or retrospective think-aloud method. The selection was voluntary, and participants signed an informed consent form.

Participants

A total of 63 teachers from 12 schools in three regions: Mwanza (4 Schools), Arusha (4 schools), and Kigoma (4 schools), participated in the study. Lazar, Feng & Hochheiser (2017) suggested that usability testing should be conducted where participants are and the type of data to be collected. (Ivanc, Vasiu & Onita, 2012) earlier noted that usability tests must be performed as close to the normal context as possible.

The proposed TCPD mobile LMS will be used by teachers, most located in rural areas. With this consideration, the selected schools were in rural areas with similar socio-economic contexts. The usability testing took place in the school environment in each of the selected schools. A total of 31 teachers participated in the concurrent think-aloud method, and 32 teachers in the retrospective think-aloud method. The distribution of respondents per region is shown in Table 1.

***Table 1**: The distribution of the estimated number of respondents*

Region	Concurrent think-aloud method	Retrospective think-aloud method
Mwanza	13	12
Kigoma	10	9
Arusha	8	11

The hybrid think-aloud method was followed by focus group discussions to elicit participants' additional feedback on their experience with the mobile-based TCPD LMS and to provide any suggestions for improvement.

Ethical Considerations

Before starting each testing session, especially on the first day, the team explained in detail the purpose of the study and how the findings would be important to them and the wider community. Participants were given consent forms to sign, assuring them that their participation in the study was voluntary and that they could withdraw at any time during the session.

Tasks and Procedure

Participants were given instructions about the think-aloud method before starting the assignment. For the concurrent think-aloud method, participants were asked to verbalize what they were doing or thinking as they navigated through the mobile-based TCPD LMS and attempted the quizzes. The coordinators demonstrated to the participants one task to make sure that participants understood the assignment. In return, participants were given one task to practice before recording began. Each participant performed usability tasks at a desk using their smartphones, and the same setup was used for all concurrent think-aloud testing. The coordinator moderated the tasks while another person was recording. If the participant stopped verbalizing, the moderator reminded the participant to say out loud what they were doing and thinking. Each participant was studied individually, and all sessions were video recorded.

For the retrospective think-aloud method, teachers were given written instructions on the activities to be done. As in the other method, the coordinators demonstrated an example task to ensure that participants understood the assignment. Teachers were given one day to use the LMS, go through the module, and attempt the quizzes before the data collection was conducted.

Specifically, two scenarios were tested per region. The scenarios and specific tasks are explained below.

Scenario 1

This scenario tested the usability of mobile-based LMS in the web-browser version on teachers' smartphones. Teachers were given a web browser link and asked to register on the system and access the sample module. Specifically,

- Teachers at two schools in each region were given a link to access the LMS web version on their mobile devices.
- Once they have registered, they are required to access the Upimaji na Mrejesho sample module.
- While accessing the module, teachers were asked to attempt each quiz of 5 questions at the end of each unit.
- The concurrent think-aloud method was conducted on at least three teachers at each school on the same day; those who participated in the retrospective think-aloud method were given one day to use the LMS and go through the module before conducting a usability evaluation the next day.

An example of a concurrent think-aloud session in one of the regions is shown in Figure 2.

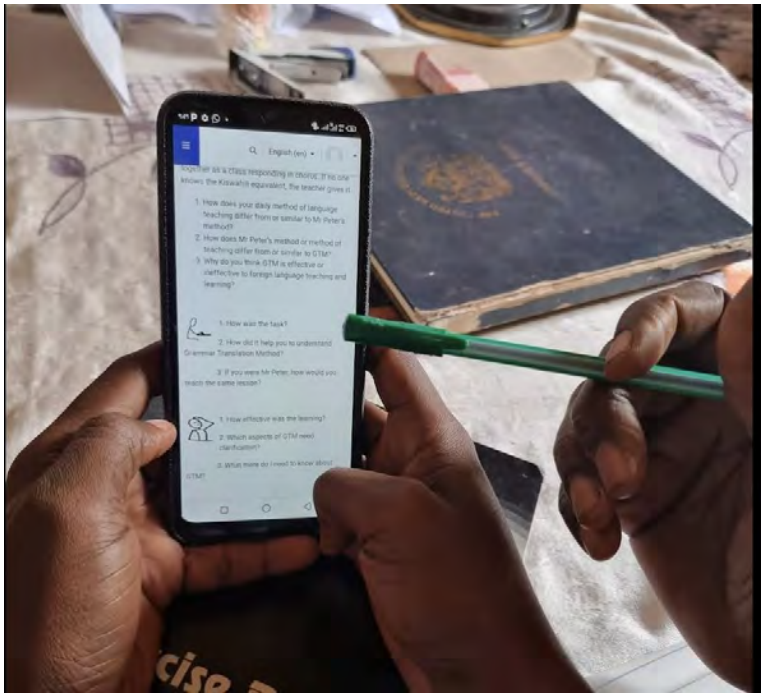

Figure 2: Concurrent think-aloud session in one of the schools in Kigoma

Scenario 2

This scenario tested the usability of mobile-based LMS as a mobile app on a smartphone. In this scenario, teachers were asked to download the mobile app, register on the system, and access the sample module. Specifically,

- Teachers at two schools in each region were given a link in Google Play to download the LMS mobile app on their personal mobile devices.
- Once they have registered, they are required to log in and access the Upimaji sample module.
- While accessing the module, teachers were asked to attempt a quiz of 5 questions at the end of each unit.
- The concurrent think-aloud method was conducted on at least three teachers at each school on the same day. Those who participated in the retrospective think-aloud method

were given one day to use the LMS via mobile app and go through the module before conducting a usability evaluation the next day.

In general, 30 teachers participated in scenario 1, and 33 teachers participated in scenario 2 in three regions, as shown in Table 2.

***Table 2**: The distribution of teachers who participated per scenario in three regions.*

Evaluation method	**Scenario 1 (Web-browser version)**	**Scenario 2 (Mobile App)**
Concurrent think-aloud method	16	15
Retrospective think-aloud method	14	18

Focus Group Discussion

After completion of the scenario, one focus group discussion was conducted to elicit participants' additional feedback on their experience with the systems and to provide suggestions for improvement. Teachers who managed to log in to the system and attempted at least half of the quizzes were selected for the focus group discussions.

Usability Problem Extraction

For a concurrent think-aloud method, each participant's testing video was reviewed to detect everyone's usability problems. Individual problems were merged across participants to form a final usability problem if they had similar problem descriptions and contexts. For the retrospective think-aloud method, teachers were to explain their experience after they had completed the tasks. In some cases, teachers had to log in to the system to explain the usability challenges they encountered. Because teachers constantly referred to the system as they discussed the experience of using the LMS, it took nearly two hours to perform the retrospective think-aloud evaluation and record the findings.

FINDINGS

Downloading the LMS mobile app

Most teachers could download the TCPD mobile app without many difficulties. In all six schools, teachers could download the app within 1-3 minutes, depending on the smartphone's capacity and the Internet connectivity speed. A total of 8 teachers could not download the TCPD mobile app for several reasons. For instance, some teachers had smartphones with low memory to install the TCPD mobile app. Figure 3 shows a smartphone screen via which the teacher could not continue installing the TCPD mobile app due to a memory shortage.

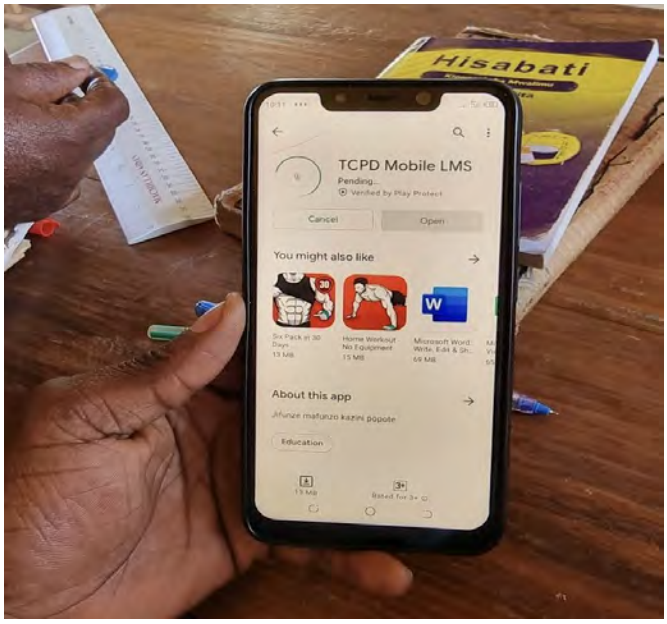

Figure 3: Downloading the TCPD mobile app

Registration process

It was found that registering into the system was challenging for most teachers in both scenarios. The following were some difficulties identified during the registration process.

The password is too complicated

Registering into the TCPD LMS requires users to provide a password that has at least eight characters, one digit, one lower case letter, one upper case letter, and one non-alphanumeric character. Many teachers found this challenging to do. Few teachers could register successfully at one attempt, while many repeated at least three times.

The username requirements are restrictive/confusing

The default setting of Moodle LMS, which was adopted for the TCPD mobile LMS, requires users to choose unique one-word usernames containing only lower case letters. Many teachers found this requirement confusing. Most of them continued to log in with a username, with the first letter being uppercase.

Email confirmation

The LMS uses an email-based self-registration authentication method whereby users can create their accounts via the 'Create new account' button on the login page. Users then receive an email at the address specified in their account profile to confirm their account. This process was complicated for most teachers for several reasons:

- Many teachers do not access email regularly and tend to forget their email credentials. Therefore, most completed the registration form but struggled to log in to their email accounts to confirm registration.

- The process of email confirmation forces teachers to close the LMS window and open the email account to click a link before returning to the LMS. Teachers struggled to navigate back and forth between the LMS registration window and the email account.
- Some teachers do not have emails. They registered on social media using their colleagues' or spouses' email addresses.

Language

Primary education in Tanzania is delivered in Swahili. Nonetheless, a few subjects are still delivered in English. Therefore, the system needs to be implemented in both English and Swahili, with the default language being Swahili. During usability testing, it was found that the system had usability flaws related to language. For instance, there was inconsistency in the interface's language as part of the content of the pages is displayed in Swahili while the other part is displayed in English. In addition, some Swahili terminology was confusing, which was down to poor translation from the language packs.

Technology Errors

A few errors were found when users tried to register into the system via a mobile app. The most common error occurred when users clicked the submit button in a mobile app. The error "*cannot read property 'message' of undefined*" was displayed to 4 users across three regions who used a mobile app to register into the system, as shown in Figure 4. However, this error did not occur for those users who used the web browser to register into the system.

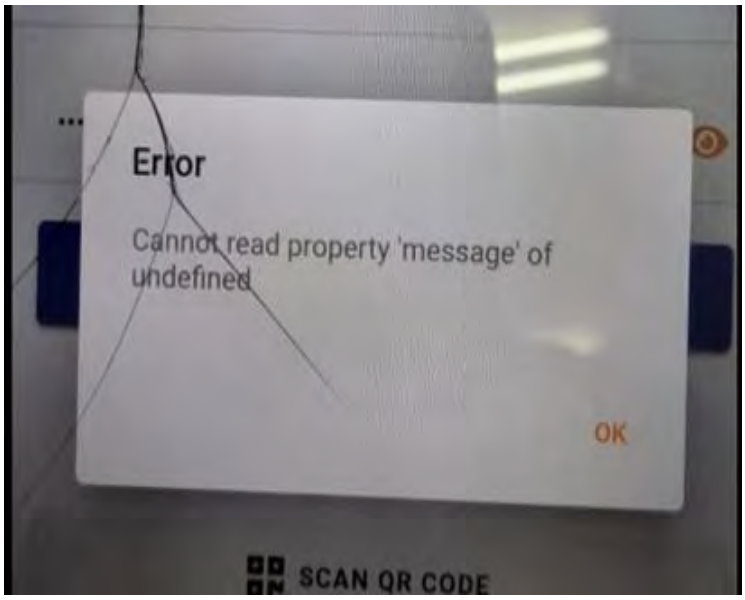

Figure 4: The error message reported during the user study.

Comparing TCPD mobile web version and TCPD mobile app

The TCPD mobile LMS was developed to be accessed on both mobile web and as a mobile app downloadable via Google Play. Therefore, comparing the usability of the system in both scenarios was important. It should be noted that 30 teachers accessed the TCPD mobile LMS via the web, while 33 teachers accessed the system via the mobile app. Although the same teachers did not

use both approaches, some interesting findings were obtained, as indicated, and explained hereunder.

- Teachers faced the same challenges related to design and usability during the registration process as their counterparts who used the mobile app to access the LMS.
- Teachers with smartphones with limited memory struggled to use the mobile app. Some could not download the mobile app because their smartphones lacked memory. Those who could not download the TCPD mobile LMS were asked to switch to a web browser to continue with the testing.
- A good number of teachers downloaded the app, but their smartphones responded slowly when navigating through the system. This finding demonstrates that It is likely that teachers would prefer accessing the TCPD mobile LMS via a web browser, especially those with smartphones with low capacity, which are the majority.

Overall Design TCPD LMS Prototype

Teachers were asked to provide their perceptions about the design of the TCPD mobile LMS after having managed to log in and access some system features. The main aim was to identify issues revolving around navigation, the use of terminologies, typography, color schemes, and the overall look and feel of the system.

In general, many teachers perceived the system was easy to use, the navigation was simple to follow, and the interface design was user-friendly. When asked further to suggest some possible improvements on the design of the interface, the following were suggested:

- The button to login into the system using the TCPD mobile app should be made visible, as it was a symbol without the word login. Many teachers indicated that they could not see the button and therefore ended up clicking various buttons to find the right button for login. Nonetheless, those who used the web browser interface indicated that the login button was labeled with the word "login" visible and could find it without facing many difficulties.

Teachers' perception of using LMS to complement TCPD activities

The purpose of a learning management system is to support learning (Costabile *et al.*, 2005). According to Adebesin, de Villiers & Ssemugabi (2009), mobile learning applications should also be evaluated for pedagogical effectiveness in addition to conventional usability criteria. In this study, pedagogical effectiveness was evaluated by eliciting teachers' perceptions on the usefulness of the TCPD mobile LMS in complementing TCPD activities. Teachers provided their perceptions on the design of the LMS after logging in, navigating from unit 1 to unit 12, and responding to quizzes and a survey. In general, many teachers perceived the system was easy to use, the navigation was simple to follow, and the interface design was user-friendly.

In addition, many teachers claimed that the introduction video was the most interesting component of the module and therefore recommended the inclusion of at least one video for each unit. Despite these findings, both thinking aloud and FGDs highlighted several usability problems related to the didactic effectiveness of the "Upimaji na mrejesho" sample modules, such as

- The quiz had only True/False (T/F) and multiple-choice questions. Teachers suggested that the quiz include other questions that tend to be provided in paper-based exams, such as open-ended and essay questions.
- Teachers claimed that some Units had a lot of content, making it difficult and boring to read such content on mobile phones. They suggested that such content could be reduced or

replaced by recording a small video. They indicated that reading long text on the smartphone was a bit boring.

Finally, teachers were asked to explain if they could access the TCPD activities and resources made available via the TCPD mobile LMS in the future. Nearly all teachers who participated in the FGDs indicated that they are willing to participate in TCPD activities via the LMS if they do not incur the cost related to the Internet.

DISCUSSION

This study evaluated the usability of TCPD mobile-based LMS in web browsers and as a mobile app using a hybrid think-aloud method (concurrent think-aloud method and retrospective think-aloud method) involving 63 teachers from 12 schools in Tanzania. Even though some teachers perceived the system to be user-friendly and easy to navigate, the study managed to identify some recurring themes related to usability flaws. One of the usability flaws identified during this usability testing concerned the user registration and login process. Teachers found the password requirements complicated, that is, passwords having at least eight characters, at least one digit, at least one lower case letter, at least one upper case letter, and at least one non-alphanumeric character. They also found the username requirements confusing. As a result, teachers struggled to complete the registration and login process alone without assistance. The finding corroborates with a study conducted by Minović *et al.*, (2008) whereby users spent more time trying to log in to the LMS using mobile devices than desktop computers.

Many teachers could also not complete registration as they could not confirm their accounts via email. Compared to other users, many teachers in primary schools do not access Internet-based services that require email verification more regularly. The study found that many teachers created email accounts when smartphones were new and needed an email account to access Google services. Having not used these services regularly, obviously, many of them tend to forget their email credentials.

These usage struggles suggest teachers, especially in rural areas in countries like Tanzania, are still not proficient with the typical conventions while accessing digital systems via their mobile devices. Many teachers are not advanced ICT users and lack experience in following otherwise standard registration procedures used on mobile devices. Therefore, there is a need to explore new usage models that are simpler and easier to manage for all teachers. These models may include allowing teachers to register using other unique tokens that they can easily remember, such as check numbers or mobile numbers, allowing them to use simple numeric PINs instead of passwords and others.

The study identified usability issues due to the limitations of mobile devices. Findings show that some teachers still have low-end smartphones with limited memory resources. As a result, these teachers struggled and failed to download, install, and use the mobile application on their devices. Even those who downloaded the mobile app could not navigate the system smoothly due to their devices responding slowly. This limitation prevents them from taking advantage of user-friendly features available in the mobile application to interact with the system. To overcome it, teachers had to interact with the LMS via mobile web browsers on their devices. This fact suggests that despite the increased use and adoption of smartphones, some of these devices can only support limited mobile applications. Therefore, as a practical implication, entities that plan to deploy mobile-based LMSs need to ensure all features available in the mobile application are also usable via the web browser on mobile devices.

The study also identified usability issues due to technical problems in the LMS itself. These issues caused random errors and inconsistencies in how the system appears on different mobile devices.

For instance, some teachers reported struggling to locate the login button due to how the system appears on their devices. Others noted how the system struggled with displaying translations in the Swahili language. This finding is consistent with the study conducted by Hasan (2018), which also found inconsistencies in the way the interface displayed Arabic content compared to the English content. These findings suggest more extensive testing is needed before teachers can effectively use mobile learning platforms such as the TCPD LMS. Users, especially in rural areas, have a wide variety of devices that may not be fully compatible with standard LMSs. Therefore, system operators need to empirically test and validate any assumptions about users' devices before they can be confident that the system works for everyone.

This study shows that with the increased availability of handheld devices among teachers in low-income countries, entities can implement LMSs using mobile devices and smartphones. However, technical limitations of the devices still limit their successful use for mobile learning situations such as TCPD. These devices have small screen sizes and limited input capabilities and operate in environments with low and unreliable Internet connections. These limitations impact the usability of the applications and lower user satisfaction. Entities that want to deploy such mobile-based learning applications must address these usability issues to promote their usage. Studies have shown that developing usable mobile applications for targeted users is critical to the success of mobile applications (Kumar & Mohite, 2018). The appropriate use of mobile devices and smartphones can facilitate the effective delivery of TCPD in remote areas and support teacher self- and peer-reflection (Hennessy *et al.*, 2022). It can also improve the skills of established and newly trained teachers in places where the quality and quantity of teachers are insufficient (McAleavy *et al.*, 2018). In addition, these technologies can significantly reduce the costs of resource-intensive training and the time and travel needed for teachers to attend TCPD activities (Burns, 2015).

CONCLUSION

This study evaluated the usability of a mobile-based learning management system (LMS) used to support the continuous professional development of teachers in Tanzania. The main goal is to investigate and identify any usability issues that prevent teachers from using and interacting with the learning resources in the system effectively from their mobile devices and smartphones. The study addresses the need to determine how current technical limitations in these mobile devices can impact the usability of an LMS and other similar systems deployed in a mobile environment.

The study adopted a hybrid think-aloud method, involving 63 teachers from 12 schools in Tanzania. It used the concurrent think-aloud method with teachers in half of the schools and the retrospective think-aloud method with teachers in the other half. In both cases, teachers performed specific tasks to navigate the system using their mobile devices and verbalized their thoughts. Results show that despite the LMS being accessible on mobile devices, usability issues related to devices, users, and the system remain. In terms of devices, the study found that teachers have low-end smartphones that prevent them from taking advantage of applications with rich features. From the users' perspective, the study identified usability problems with the user registration and login process on mobile devices. Teachers struggled to complete this standard process that uses email and user-created passwords as credentials. Lastly, the study also identified usability issues due to technical problems in the system itself that causes inconsistent experience in different devices.

The findings show that while it is possible to use a mobile-based LMS for TCPD activities in a country like Tanzania, usability issues persist that any implementors need to address to make the exercise effective. These usability issues stem from the fact that many teachers in rural areas are still uncomfortable with standard digital conventions of using smartphones and rely on devices with limited resources. These limitations suggest that other implementors need to revisit the standard assumptions of a typical mobile user when deploying mobile-based LMSs in these contexts. Similar

efforts to implement mobile based LMS should explore different ways to simplify user interactions and conduct more extensive testing.

FUTURE WORK

We plan to extend our research in two main directions for future work. First, the findings from this study are based on usability testing involving actual system users from 3 regions in Tanzania. It is recommended that future research should complement these findings by evaluating the TCPD LMS using expert evaluators. Complementing the results from this study with those of expert evaluators will provide more insight into usability violations of the system.

Second, since the Internet cost is a hindering factor for teachers accessing online material provided by LMS, we plan to investigate providing offline options for the LMS. Several solutions are already being investigated, such as using Moodle box or other low-cost micro-servers to host the LMS in school environments so teachers can access it offline.

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