International Journal of Information Technology and Web Engineering
Volume 18 • Issue 1

Evaluating the User Interface and Usability Approaches for E-Learning Systems

Jehad Saad Alqurni, Department of Educational Technologies, College of Education, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia*

https://orcid.org/0000-0002-4834-9039

ABSTRACT

E-learning offers an experience that is not constrained by time or geography. Owing to the advancements in technology and accessible computing, users have several ways to interact with e-learning programs. Therefore, usability approaches are crucial for the success of an e-learning application or a website. This study investigates various user-interface usability evaluation methods (UEM) and distribution of e-learning web-based applications, such as Moodle, Blackboard, Learning Management System (LMS), Zoom, Google Classroom, Facebook, and other online programs that exist for online education. To evaluate the usability features of online educational apps and websites, including their effectiveness and usability for students, a survey was conducted to collect responses on online education.

KEYWORDS

Blackboard and Moodle, E-Learning Systems, Learning Management System, Software Usability Evaluation, User Interface

INTRODUCTION

Technology has transformed education, with e-learning systems offering flexible and convenient study. However, user interface and usability strategies greatly impact these systems' success (Alshehri et al., 2019; Hussain & Mkpojiogu, 2016). An easy-to-use interface and good usability can improve learning and engagement. In this study work, the authors examine e-learning system user interface and usability approaches to find the most effective and modern methods. The COVID-19 epidemic has made remote learning the norm, making e-learning systems more widespread (Hussain et al., 2015; Nakamura et al., 2017).

Thus, best practices for creating e-learning interfaces and usability strategies to enhance learning outcomes are essential. Effective e-learning system user interface design requires a visually appealing and easy-to-use interface (Alghabban & Hendley, 2022; Nakamura et al., 2017). Modern methods like responsive design, which adapts to different screen sizes and devices, improve user experience. Multimedia components like films, interactive graphics, and animations can also improve learner engagement. E-learning system effectiveness is also assessed using usability testing. Automatic

DOI: 10.4018/IJITWE.333638 *Corresponding Author

usability testing uses automated techniques to imitate user interactions and provide objective feedback to evaluate the interface's usability (Alghabban & Hendley, 2022; Onacan & Erturk, 2016). This method can reduce evaluation time and identify and fix usability concerns. Interface design for e-learning systems should also include accessibility and inclusion. Features like text-to-speech, font size adjustments, and color contrast can make these systems more accessible to learners of diverse abilities and styles.

Usability is vital to software development and determines system success and user happiness. Software usability research and trends must be understood as technology evolves. This research study (Almazroi, 2021) collects recent software usability studies and displays the most prevalent methodology and datasets. This goal was achieved by searching six major research databases for 9,874 research publications. After careful screening, 62 primary studies were chosen using evidence. This research is based on these primary investigations, which illuminate software usability. Experimental and theoretical validations were used in the selected papers, with experiments being the most common. Usability studies are particularly common in web, software development, and mobile apps, reflecting their expanding importance in the software business. This research paper uses a systematic mapping study to provide a comprehensive overview of software usability studies, highlighting current methodologies and offering researchers and practitioners valuable insights and directions for future research (Kumar et al., 2022).

Technology has transformed education with e-learning platforms for students and teachers. The usability and efficacy of these technologies remain important. This research article (Yang et al., 2023) intends to create a revolutionary e-learning system that fits student and instructor requirements and is interesting. This proposed approach aims to improve users' technology tool understanding and feature use. Doing so should increase learning results and user happiness. A detailed survey of students and employees from many professions was undertaken to attain these goals. The survey was conducted from October 2nd to October 25th, 2022, with 100 students providing their e-learning system usability thoughts. In this study, the authors discuss survey datasets and data analysis and interpretation methods. This will inform the design and development of the unique e-learning system, improving usability and user experience. Overall, this study aims to improve e-learning systems by addressing obstacles and presenting creative solutions for usability and effectiveness. Moreover, e-learning website usability improves user experience and online education effectiveness. Weak communication between the user's mental model and the designer's perception makes it difficult to improve these systems' usability. This study (Ain, 2016) provides a user-minded e-learning usability evaluation paradigm to address this issue. Bridge the gap between user knowledge and designer perception to improve e-learning website usability. Researchers used virtual testing to evaluate e-learning platforms' usability and accessibility. This research used VULMS and Coursera, two popular e-learning systems. These platforms' usability and accessibility were measured by the virtual testing tool. Testing found and recorded XML and XHTML problems. Virtual testing identified problems in VULMS and Coursera's HTML and XML scripts. Identifying and fixing these issues improves the usability and accessibility of e-learning websites. This study article discusses how user mental models and virtual testing improve e-learning website usability.

Another study (Estrada Molina et al., 2022) examines how educational technology can be used to teach secondary and higher education mathematics. Digital educational tools and virtual learning environments and game-based learning are studied. The research technique used PRISMA and a comprehensive search strategy using Scopus, IEEE Xplorer, Springer, and the ACM Digital Library. Most usability assessments employ the ISO/IEC 9241-11 standard, according to 47 major research articles. The research shows that usability criteria and technical processes are not integrated. Math education uses ISO 9241-11:2018 and ISO-IEC 9126-1:2004 standards, whereas game-based learning uses ISO 9241-11:2018 to assure efficiency, efficacy, and usability. To ensure usability integration, digital educational resources and VLE scenarios use ISO-IEC 9126-1:2004 and ISO-IEC 9241-11:2018 standards and processes. Moreover, in this study (Kostadinov & Stojmenovska, 2022) the

authors analyze e-learning systems and their main features. The paper discusses common patterns and methods used to maintain and add to existing systems as well as new technologies and strategies to improve and stabilize them. The writers used Mendo and Bebras for research. The article offers many real-world use cases that demonstrate how to maintain, extend, and develop e-learning systems while maintaining privacy and usability (Abdulkhudhur et al., 2019; Ferreira et al., 2020; Ghatasheh, 2015; Islam et al., 2019; Sulaiman et al., 2018). This study seeks to inform e-learning platform developers and managers. By reviewing the pertinent studies, this research paper (Koi-Akrofi et al., 2020) examines distance, blended, and online learning (DBOL) problems. Over 65 publications from Google Scholar, ResearchGate, Academia.edu, Google Search Engine, and Elsevier were reviewed by the authors. Searches centered on distance education, online learning, blended learning, and internet-based learning. The study compares DBOL models and lists 11 obstacles that fall into six categories: infrastructure, IT skills, self-discipline, content, policy, and social (Ahmad et al., 2020; Curcio et al., 2019; Junus et al., 2015; Keselj et al., 2022). The authors stress the importance of a good policy, proper infrastructure, and stakeholder training for DBOL adoption.

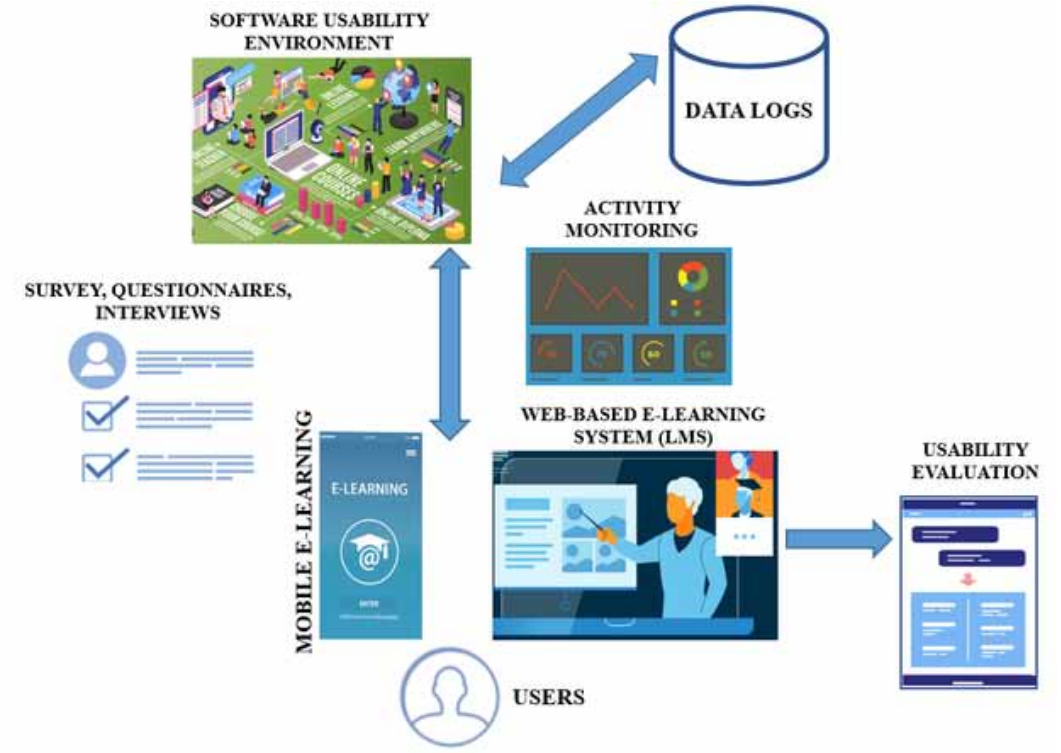
Likewise, a thorough mapping examination of mobile app software usability studies is presented in this research report (Weichbroth, 2020). The study collected 790 documents from 2001 to 2018 using Scopus. One of the important conclusions of the data analysis is that the HCI community has largely adopted and established the ISO 9241-11 usability definition as the standard. This suggests usability researchers share a common understanding. The study also examined 75 usability attributes. These factors are crucial for mobile app usability evaluation. The study also outlines usability evaluation's main research approaches. Controlled observation and surveys were the most prevalent approaches, while eye-tracking, thinking aloud, and interviews were used less but were useful for gathering additional data (Favale et al., 2020; Habeeb et al., 2020; Ramadan & Habeeb, 2023). This research illuminates the present state of software usability studies, particularly on mobile apps, and its methods and attributes. Moreover, the goal of the research study (Miya & Govender, 2022) is to examine the connection between the entire learning environment in higher education and the user experience (UX) and user interface (UI) design of e-learning platforms. A thorough evaluation of the body of research on the usability of e-learning platforms in tertiary institutions was undertaken for the study. Based on predetermined criteria, a total of 25 papers were chosen from databases including ERIC and Google Scholar. According to the research, it is crucial for successful learning in e-learning systems to pay attention to interface design and user experience.

Figure 1 shows how to assess e-learning system UI usability. Multiple components evaluate the system's UI's efficacy and efficiency. The online usability environment hosts many evaluation tasks. This environment can be web-based or mobile, depending on e-learning system accessibility. The evaluation focuses on the e-learning system. This technology lets users interact with instructional content and complete tasks. E-learning system UIs are evaluated to ensure they are intuitive and easy to navigate and enable effective learning. User feedback is collected through questionnaires, surveys, and interviews. These tools help assessors understand users' UI usability opinions. Questions can address ease of use, satisfaction, and UI support for learning goals. In addition to user feedback, the e-learning system may track student actions. UI interactions are tracked by these systems, providing extra data for review. This data can be used to improve the UI or test design modifications. Figure 1 shows an iterative evaluation approach to improve e-learning system UI usability. User feedback, data analysis, and design changes can improve the system to match learners' needs and improve their learning experiences.

The contributions of this study are as follows:

1. The study evaluates e-learning system user interface approaches. Studying and assessing these methodologies reveals the efficacy, efficiency, and usability of e-learning user interfaces.
2. The paper discusses recent e-learning user interface design methods. It offers cutting-edge ways for creating user-friendly and intuitive interfaces, improving learning.

Figure 1. Framework for user-interface usability evaluation in e-learning systems



3. The research paper also discusses e-learning software usability. It emphasizes the need of creating intuitive, attractive, and learning-friendly interfaces.
4. E-learning interface design principles are also covered in the article. Developers can utilize its recommendations to create interfaces that improve user engagement and learning.
5. E-learning system automatic usability testing is another key addition of the research article. It covers automated methods for assessing e-learning interface usability, saving time and resources.
6. Case studies and practical examples demonstrate the efficacy of the studied user interface and usability methodologies. It supports the recommended methods by showing real-world implementations and their effects on e-learning system usability.
7. Finally, the research work advances e-learning user interface and usability expertise. This resource helps academics, researchers, and practitioners enhance e-learning systems by consolidating current research and delivering new insights.

In the subsequent sections of this study, the authors shall explore diverse facets of e-learning systems. The second offers an extensive examination of the literature, encompassing a thorough overview of prior research and scholarly investigations within the discipline. This section provides a fundamental basis for comprehending the present condition of e-learning and its ramifications. In the subsequent section, the focus shifts towards the design of the e-learning interface, with a particular emphasis on exploring the usability challenges that are commonly encountered in these types of systems. This section provides a critical analysis of the significance of user-friendly interfaces in e-learning systems and investigates potential obstacles that users may face. The fourth section of this paper is dedicated to discussing the research methodology utilized in this study, providing insight into the approach adopted for data collection and analysis. This section provides an overview of the

methodologies and instruments employed to ascertain the precision and credibility of the results. The research findings are presented in subsequent sections, followed by a full discussion. The purpose of these sections is to analyze the obtained data, identify significant trends and patterns, and provide insights into the implications and potential uses of the findings. In conclusion, this paper presents a summary of the primary findings and offers a discussion on potential avenues for future research and growth within the realm of e-learning. This section provides a guide for researchers and practitioners who are interested in making further progress in the discipline.

LITERATURE REVIEW

The use of e-learning systems has grown in popularity in recent years as they offer people a flexible and practical way to learn new things (Alshehri et al., 2019; Hussain et al., 2015; Hussain & Mkpojiogu, 2016). However, the usability of these systems' user interfaces is crucial to their success. With an emphasis on contemporary usability techniques, this literature analysis intends to assess user interface and usability approaches for e-learning systems. The usability of e-learning systems has been extensively evaluated using conventional usability techniques like heuristic evaluation and cognitive walkthrough. Heuristic evaluation is a technique used by experts to compare a system to a set of predetermined usability principles (Alghabban & Hendley, 2022; Hussain et al., 2015; Nakamura et al., 2017). On the other side, a cognitive tour examines users' sequential interactions with the system. These techniques have offered insightful information regarding the usability problems with e-learning systems. User-centered design (UCD) is a methodology that incorporates users at every stage of the design process to guarantee the system's usability. It underlines how crucial it is to comprehend user demands and preferences in order to design a user-friendly interface. In order to evaluate e-learning systems, UCD techniques like user interviews, surveys, and usability testing have been used with effectiveness. UCD ensures that the system satisfies users' expectations and improves their learning experience by including users in the design process (Alghabban & Hendley, 2022; Nakamura et al., 2017; Onacan & Erturk, 2016).

The analysis of the research productivity, demographics, trends, and difficulties in software usability studies is the main goal of the review by Almazroi (2021). By reviewing research articles on software usability that were published between 2011 and 2020, the writers of this article carried out a methodical mapping analysis. They carefully chose 62 papers from a starting pool of 9,874 papers depending on their inclusion or exclusion criteria. The research trends, methodology, and application fields in software usability studies were then determined by analyzing the chosen publications. The most widely utilized validation methodologies in software usability studies, according to the authors, were theoretical and experimental validations. This shows that when assessing the usability of software programs, researchers frequently use controlled trials or theoretical frameworks. The survey discovered that the most popular application fields for usability assessments were the web, software development, and mobile applications. This demonstrates the rising significance of usability in various fields. Web, software development, and mobile apps are identified as the most popular domains for usability studies, and the study by the authors emphasizes the popularity of experiments and theoretical validations as frequent validation methodologies. However, it is crucial to consider the study's constraints, such as its short period and any potential bias in the paper selection. In order to better understand and improve software usability, future research should concentrate on incorporating field investigations and usability testing of scientific software programs.

Another study by Yang et al. (2023) focuses on the design and usability testing of a new e-learning system. The authors note the difficulties professors and students have using current e-learning platforms and seek to address these problems with their innovative solution. To acquire information and assess the usability of their system, the authors in this case used a mixed-methods strategy. Surveys, questionnaires, and interviews were used as data collection techniques. The poll, which was performed between October 2 and October 25, 2022, was aimed at students and workers

with a range of professional backgrounds. The poll received responses from 100 students in total, and data was gathered using Google Forms as the platform. The survey link was disseminated on social media sites like Instagram and WhatsApp groups. The results of the data collecting techniques, such as surveys and interviews, probably gave important insights into the problems that users faced and their recommendations for enhancing usability. In order to evaluate the effectiveness and wider usage of the suggested system, more study and evaluation are required.

In addition, the study by Ain (2016) concentrates on the creation of a model for evaluating the usability of online learning that is based on the mental model of the user. The goal of their strategy was to close the communication gap between consumers and designers, as this gap frequently prevents the usability of a product from being improved. In order to assess the usability of e-learning websites, the authors chose the Virtual University Learning Management System (VULMS) and the Coursera global learning management system as case studies. The websites' accessibility was noted as a crucial element in enhancing usability. While the study involves reviewing the chosen e-learning websites using a task analysis method. The websites were assessed by the researchers using a number of usability criteria, and points were given to indicate how well they performed. While Coursera scored only six points for the same activity, VULMS received eight points, suggesting a substantially greater degree of usefulness. The results highlight the value of accessibility and suggest using assistive technology to improve usability, especially for users who are physically challenged. The efficiency of the suggested technique needs to be confirmed, and any potential drawbacks must be addressed, through additional investigation and testing.

In addition, Estrada Molina et al. (2022) try to determine the international standards and norms of usability utilized in educational technology for teaching mathematics at secondary and higher education levels. Their research focuses on two scenarios: game-based learning and digital educational resources and virtual learning environments (VLEs). The authors used databases like Scopus and IEEE Xplorer as well as the Springer Publishing House and the ACM Digital Library, adhering to the PRISMA standard and conducting a thorough search. The goal of the search technique was to locate original research on usability in relation to mathematics education. For analysis, a total of 47 main studies were chosen. The results show that the usability-focused ISO/IEC 9241-11 standard was primarily applied in the chosen research. The researchers discovered a gap in the combination of engineering processes with usability assessment criteria. The ISO/IEC 9126-1:2004 and ISO 9241-11:2018 standards were predominantly used in the main studies on the teaching of mathematics. The ISO 9241-11:2018 standards were applied in the game-based learning scenario, along with protocols that made sure efficiency, effectiveness, and usability were integrated. The ISO/IEC 9126-1:2004 and ISO/IEC 9241-11:2018 standards were used in the case of digital educational resources and VLEs, along with procedures that ensured the integration of efficiency and ease of use; effectiveness and ease of use; ease of use and accessibility; and efficiency, ease of use, accessibility, and effectiveness. The results also highlight the necessity of integrating technical approaches with usability assessment criteria.

Similar to this, the study by Kostadinov and Stojmenovska (2022), offers an overview of e-learning systems along with their common characteristics, recurring patterns, and methods for preserving and enhancing them. Their article also covers techniques and advancements in e-learning system performance and stability. To demonstrate how e-learning systems may be updated, expanded, and enhanced over time without sacrificing privacy and usability, the authors give a number of application cases. The authors of this work review and summarize the results of earlier research to offer a thorough overview of typical methods for creating extensible e-learning systems (Abdulkhudhur et al., 2019; Ghatasheh, 2015). The findings of this study, however, were based on a survey of 100 students who were split into two groups: experimental and control. According to the results, 70% of the students strongly support using web applications for online learning. Similar to this, (Koi-Akrofi et al., 2020) study paper (Ghatasheh, 2015) focuses on the difficulties that come with distance, blended, and online learning (DBOL) modes. To identify and characterize the differences between these styles

and the difficulties they offer, the authors undertook a study of the literature and examined more than 65 publications. In contrast, the methodology employed in this work includes gathering papers from a variety of sources, including Elsevier, Academia.edu, ResearchGate, Google Scholar, and Academia.edu. To determine the DBOL difficulties, around 35 categories or sets of study results were examined. The study's findings identified 11 DBOL problems, which were further divided into six themes. These themes include a lack of infrastructure, a lack of IT expertise, issues with self-discipline, content challenges, policy concerns, and social problems (Curcio et al., 2019; Junus et al., 2015). Each obstacle is briefly discussed in the report along with how it may affect DBOL.

Weichbroth (2020) intends to explore the usability of mobile applications through a methodical review of the literature. The ISO 9241-11 definition was used by the authors as the starting point for evaluating the usability of mobile applications. A total of 790 documents were indexed by the Scopus database, and from these, 75 unique usability-related features were found. Efficiency (70%), contentment (66%), and effectiveness (58%) were found to be the most often reported criteria and were all drawn from the ISO 9241-11 standard. Learnability, cognitive load (19%), memorability (23%), errors (17%), simplicity (13%), and ease of use (9%), in contrast, were the less often mentioned qualities. The study's key finding was that a sizable number of the documents, approximately 91% of them, lacked a precise definition of usability. This emphasizes how important it is for academics and industry professionals to provide a uniform definition of usability in order to ensure consistency and comparability among studies in the area of mobile application usability. A total of 790 documents that were indexed in the Scopus database made up the dataset used in this study. An extensive search and analysis of pertinent literature were part of the approach used, which was a systematic literature review. Based on the ISO 9241-11 standard, the authors selected and organized the usability characteristics of mobile applications. The study does, however, have certain shortcomings. First off, relying exclusively on the Scopus database might have prevented the authors from including pertinent literature from other sources. The study also ignored other crucial elements like accessibility and security in favor of concentrating only on usability-related characteristics (Favale et al., 2020; Habeeb et al., 2020; Ramadan & Habeeb, 2023). Finally, the conclusions may have been biased because most of the texts examined lacked a clear definition of usability. Overall, this study report underscores the necessity for a uniform definition of usability in the industry and offers insightful information about the characteristics of mobile application usability. It offers the foundation for follow-up studies to look into and enhance the usability of mobile applications. The study by Miya & Govender (2022) examines how the user interface (UI) and user experience (UX) of e-learning platforms affect the learning process in higher education. In order to pinpoint common problems and achievements, the authors carried out a systematic evaluation of studies on the usability of e-learning platforms at higher institutions. The study examined the impact of UX/UI on e-learning in higher education using a snapshot of research from the previous five years. The ERIC and Google Scholar databases of journals, along with a set of predetermined selection criteria, were used by the authors to investigate 25 papers. This work employs a systematic review of prior research on the usability of e-learning systems as its technique. A thorough analysis of the effects of UX/UI design on e-learning in higher education was provided by the authors after they evaluated and consolidated the results of earlier studies. The findings of this study suggest that careful consideration of the user experience and interface design of e-learning systems is essential for efficient learning. According to the research, an effective UX/UI can increase students' motivation, engagement, and happiness with e-learning platforms. The study illustrates effective UX/UI design approaches for e-learning platforms and emphasizes the significance of taking user wants and preferences into account during the design phase.

For the purpose of designing efficient and user-friendly learning experiences, it is essential to assess the user interface and usability techniques for e-learning systems. Modern usability techniques, such as user-centered design, mobile usability, gamification, and adaptive interfaces, offer fresh ways to improve the usability of e-learning systems while also offering useful insights from traditional usability methodologies. Researchers and designers can make more engaging and user-friendly e-learning systems by including these strategies into the design and evaluation process.

The software usability approaches used in e-learning are listed in Table 1, along with the selected databases, keywords, results, and quantity of selected articles.

MATERIALS AND METHODS

Software Usability for E-Learning System

This study considers usability, UI, and user experience to examine how effectively software functions are integrated into e-learning management systems. It uses both qualitative and quantitative knowledge. The capabilities of interactive e-learning can be applied to integrative learning systems. The UI, usability, and user experience evaluation of e-learning management systems can be divided into three categories: analysis as an administrator, educator, or student.

Figure 2 shows the architecture of the usability-based e-learning system. It displays the instructor, student, and administrator client layers, followed by the e-learning platform layer, indicating the LMS, virtual classroom, online learning platform, and VLE. It also contained a database layer that displayed the availability of courses, study materials, and online tests.

Eight parameters were used to determine usability characteristics found in this study. Table 2 lists the factors used in this study.

The methodology used in this study encourages students to use the application to acquire new information. The usability framework of the e-learning system is presented in Figure 3.

All the features in the figure above are considered when the usability considerations are utilized as a reference in the e-learning system usability evaluation.

Interface Design for E-Learning System

The UI is a factor that influences a system's usability. Interface design principles are as important as learning ideas and concepts in e-learning systems. Various factors affect learning, which includes working stimuli, memory use, multimedia resources, and availability. This study developed suggestions using the motivation and availability criteria as guidelines. Although the other two factors are more closely related to educational materials and are not compatible with this research, they have strong relationships with the system. Using learning stimuli should raise students' enthusiasm to study without the fear of punishment, forming the basis for learning motivation. The quality of higher education has progressively increased. The curriculum, style, and positioning of learning materials, learning features, interface, and content delivery are a few system components that can be improved to boost students' motivation. Informal communication, color diversity in learning materials, giving learners influence over the learning environment, and using sound and music are all possible stimulus applications. The system's capability to deliver the material whenever required is known as availability. Adding search capabilities, content tagging, and cloud computing may increase availability.

Automatic Usability Testing Methods

Many usability-testing techniques require the user's activities to be recorded while experimenting with the interface. This can be accomplished by having the user practice the system while the evaluator takes notes, either live or by repeatedly watching a session film. Both tasks take time. An alternative is to use automated capture methods to automatically record user activities. Information that is relevant yet challenging to automatically categorize, such as work completion, can be distinguished from information that is simple to record but challenging to evaluate. Automated capture techniques differ in the level of detail they collect.

Performance measurements and remote testing are two methodologies that provide automated data collection within a UE usability testing class. To operate it, a UI must be instrumented and integrated into a UI management system. Table 3 lists the automated UI support for usability testing methods.

Table 1. List of references related to software usability methods in e-learning

Ref	Selected Databases	Keywords	Results	No. of Articles on this topic
(Almazroi, 2021)	A total of six data sources were used. Science Direct, SpringerLink, Taylor, the ACM Digital Library, IEEE Xplore, Google Scholar, and Francis are among the data sources.	Software engineering, systematic mapping studies, machine learning applications, and usability evaluation.	Around 38 percent of primary studies were conducted on Software Usability.	62
(Yang et al., 2023)	Survey conducted through the social media like WhatsApp and Instagram. Data were gathered while interviewing, questionnaires, and research based on the requirement data.	E-Learning, Online Learning, Usability.	Target audience were employees, students, with around 100 students responding through social media platforms.	13
(Ain, 2016)	Web-based Learning Usability Evaluation Model. VULMS and Coursera were tested using Virtual testing tool.	Usability, User Experience, Learning Adaptive, Usability Evaluation.	Coursera had around eight XML issues. While VULMS had 18 errors. For Coursera, one page had Usability error. While for VULMS, five pages had usability issues.	23
(Kostadinov & Stojmenovska, 2022)	MENDO, Bebras were used as the database.	E-Learning, Web-based System, Stem Education	Results were divided with strongly agree and strongly disagree among the students. Around 70 students strongly agree with the experimental group and 30 students strongly agree with the control group.	8
(Estrada Molina et al., 2022)	Approximately 48 primary studies related to mathematics Software usability were used. Data sources include ACM Digital Library, Scopus, IEEE Xplore, WoS, and Springer.	Software Usability, PRISMA Protocol, Virtual Learning Environment.	Around 66% in Scopus, 18% in IEEE, 2% in Springer, 18% in ACM Digital Library.	52
(Koi-Akrofi et al., 2020)	The web application consists of 15 randomly generated questions. The dataset contains around 2640 samples.	Artificial intelligence, User modelling, and Human–computer interaction. CNN, Ensemble Model, UX, Machine Learning, Automatic Evaluation.	Training datasets have 2,100 images, whereas test datasets have 259 images.	38
(Weichbroth, 2020)	Scopus, ACM Digital Library.	Mobile Applications, Software Usability.	A total of 80 usability attributes were identified.	69
(Miya & Govender, 2022)	For Online Learning Process, Learning Management System (LMS) tool is used. UX/UI was used in Online Learning Platforms. ERIC database with Google Scholar was used.	Usability, User Interface, LMS, E-Learning, Higher Education.	There was a total of 25 publications for ERIC and Google Scholar web search.	48

Figure 2. Architecture of e-learning system with usability factors

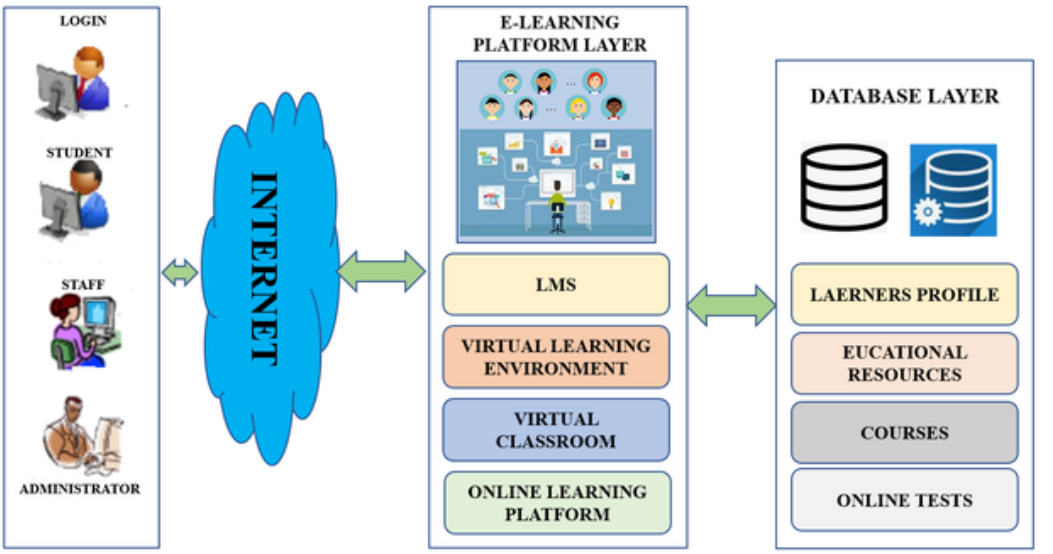


Table 2. Factors related to software usability in e-learning systems

Factors	Explanation
Content	The terminologies and languages utilized, the instructional and auxiliary materials, and any other data in the system make up this element.
Learning and Support	This component is linked to the capabilities that directly affect how academic conversations, learning resources, and learning evaluations are delivered and carried out inside the system.
Visual Design	The layout, color, typeface, user interface graphics, and ease of comprehension make up this aspect.
Navigation	This component includes variables such as website browsing behavior and feature use.
Accessibility	This feature describes the accessibility of website pages and functionality.

Usability Evaluation of E-Learning Applications

The usability of e-learning programs and their educational performance should be considered. Usability is linked to the following factors:

- Content and application parts are arranged visually.
- Interaction modes with application operations and content components.
- Navigating between application and content components.
- The content aspect of educational planning.
- The instructional strategies that are used.
- The suggested materials' suitability for educational purposes.
- The proposed content's level of detail.
- The planned content's level of update.
- The proposed contents are correct and accurate.

Figure 3. E-Learning usability framework

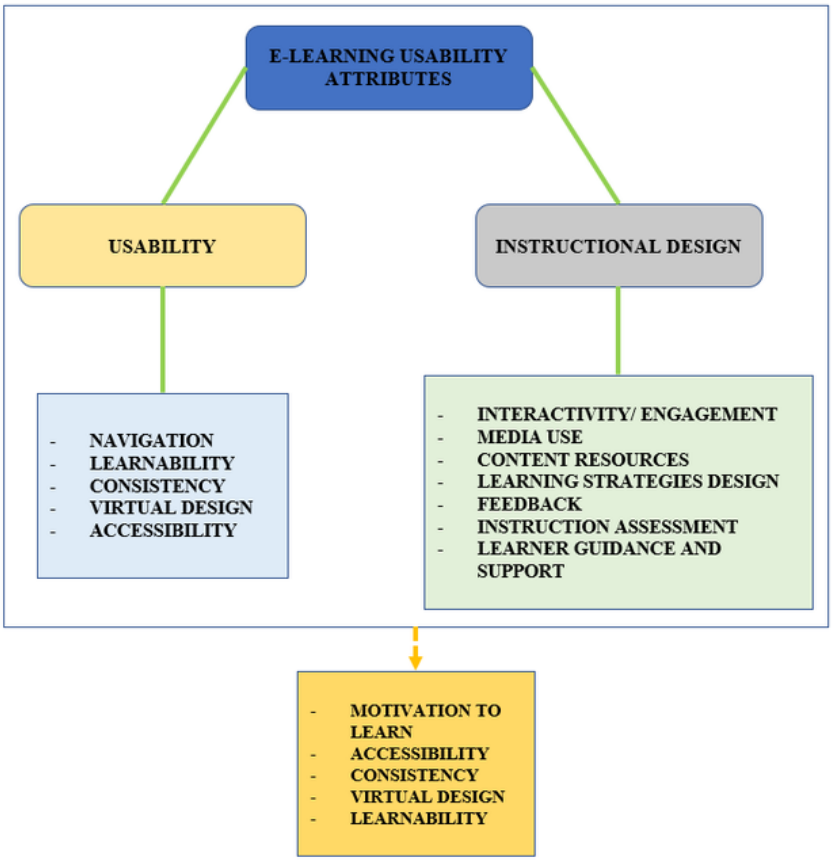


Table 3. Automating user interface support for usability testing methods

Method Type	Usability Testing
Method for evaluating usability	User Interface
System-level events should be recorded.	Web Interface
Event Logging for the User Interface Management System	Web Interface
Keep track of E-Learning Web Server Requests.	Web Interface
Keep track of client-side actions.	Web Interface
Using a Different place.	Web Interface
Examine an e-learning application.	Web Interface

An e-learning program should allow users to browse, arrange, and use instructional materials based on their cognitive styles. Coaching and cooperative learning should also benefit from simple communication between lecturers and peers. An e-learning platform is a complicated environment with various integrated tools and services for managing the learning content, teaching, learning, and communication.

Figure 4 shows the technique used to evaluate the usability of the e-learning applications. The preliminary phase contains the usability characteristics of an abstract task tool, followed by systematic inspection, user testing, and assessment feedback methods.

The results of software usability testing performed by various evaluators might differ even when they employ the same approach; therefore, the process must be automated or the number of usability evaluators involved must be expanded.

The techniques shown in Figure 5 offer a fundamental framework for understanding and producing practical interactive software to adopt constructivist approaches to e-learning.

- **Tutorials:** Tutorials are frequently used to carry out the first two phases of education, similar to the general instructional paradigm that entails planning, directing learners, practicing, and evaluating learning.
- **Drills:** Drills are exercises that help students improve fluency and memory. Drills and gaming techniques are frequently used to encourage the participation of online learners.

All aforementioned instructional models can be covered using simulations, which are regarded as the most crucial approach for e-learning.

- **Tools and an open-minded learning environment:** These are computer programs that students can use independently, typically in conjunction with other media, to achieve various educational

Figure 4. Approach to usability evaluation of e-learning applications

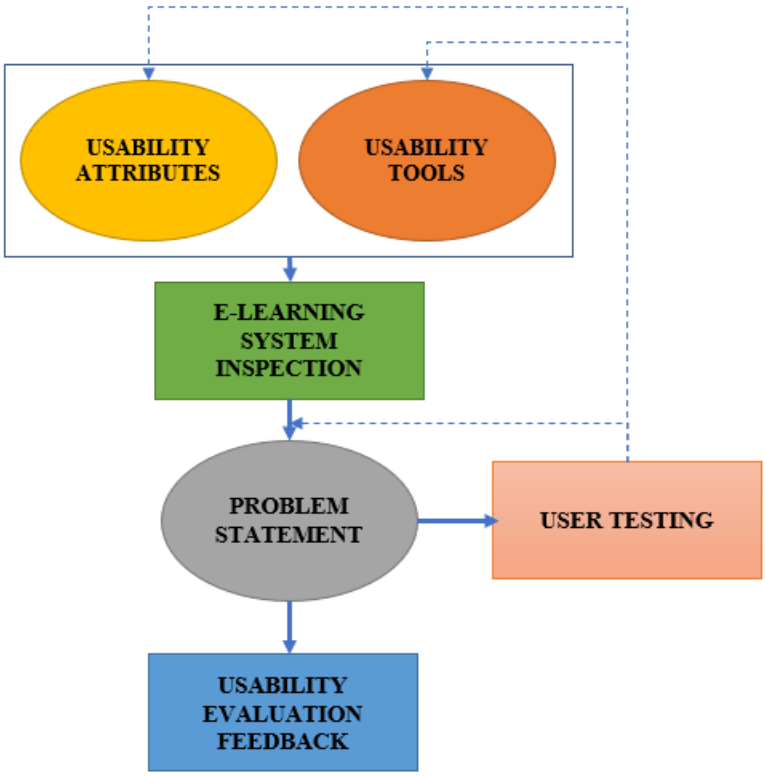
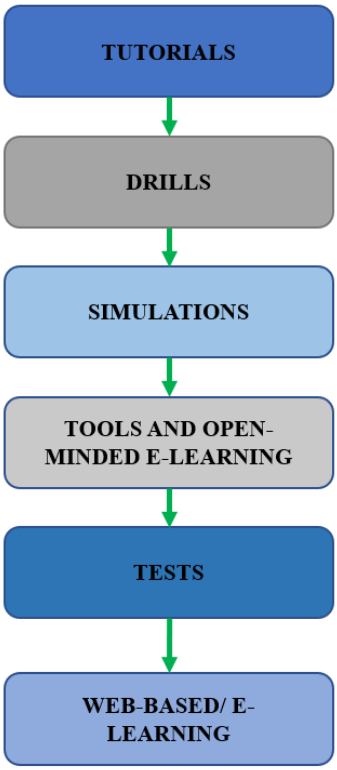


Figure 5. Software usability testing stages



objectives. Although they can also be used in objectivist learning, they are more flexible and open-ended and support constructivist learning. Any phase of instruction can utilize this information.

- **Tests:** Although they can be utilized during interactive practice in practice exams and quizzes, they are employed in the final training phase to evaluate students.
- **Web-based learning/e-learning environments:** The internet is a delivery medium that may be used in conjunction with other techniques in any of the four stages of education. These are known as web-based learning or e-learning environments.

Designing, assessing, and implementing interactive computer systems for people and researching the critical phenomena surrounding them are all part of the interdisciplinary approach of HCI. For any product to be built to satisfy user demands, including web-based e-learning programs, its usability requirements must be determined. During the development and use of a product, the UE ensures that these needs are understood. It provides an overview of the usability, usability design, and usability concepts. A discussion on usability testing and various usability evaluation methods is then presented.

- **Human–computer interaction:** The HCI refers to a multidisciplinary approach to designing, assessing, and implementing interactive computer systems for human use and associated human elements.
- **Interaction styles:** Computer and user communication is referred to as interaction. The success of this discussion depends on the interface style. The most frequently used interface styles are as follows:

- **Command-line interface:** The computer is guided via a command-line interface using functional keys, single characters, abbreviations, or whole-word commands.
- **Menu:** The user's selections are shown on a screen and then chosen using an arrow, numeric keys, alphabetic keys, or a mouse.
- **Question/answer and query dialogue:** In this type of interaction, the user responds to a series of closed questions guided stepwise through the interaction.
- **Spreadsheets with form filling:** An interface that resembles a paper form with fillable spaces is shown to the user.

Windows icons, pointers, menus, and WIMP are based on Windows UIs, such as Microsoft Windows. WIMP is the foundation for most of today's interactive computing environments, particularly those used on PCs and workstations. However, the majority of operations are carried out with a single mouse click on many multimedia apps and web browsers. The WIMP interface design is similar to a point-and-click interface design. Point-and-click is more closely associated with hypertext than WIMP and has a more straightforward philosophy. The type of HCI depends on the chosen interface style and environment in which it is utilized.

Usability Design for E-Learning Websites

The usability design must be based on extensive observations of present users and improved by a rigorous study of task frequencies and sequences. The design must be tested for usability and acceptance on an e-learning platform through early, detailed, and meticulous prototypes. The following quantifiable human variables that may be used to gauge usability must be part of the goals of validating the UI design:

- Rate of errors by users
- Subjective satisfaction
- Speed of performance
- Time to learn

User Analysis

Understanding the intended users' age, gender, physical capabilities, educational attainment, cultural background, training level, driving forces, objectives, and personalities is necessary for user analysis. These variables can help the designer determine whether the user is a novice, knowledgeable, or an expert. Following user analysis, task analysis must be completed.

Environment

Usability design strongly emphasizes the users, the tasks they must do, and the environment in which they will operate. Systems that fulfil user demands should be the outcome of good usability design.

Task Analysis

It aims to prompt user activity descriptions, anticipate challenges, and assess systems against usability or functional objectives. Task analysis focuses on how people complete tasks, which should be created in a manner that makes sense to the user and makes them want to do them.

Classification of Usability Evaluation Methods

The categorization of usability evaluation methodologies may be done in various ways. An overview of the classifications offered by some of the top writers and researchers in the field of HCI opens this section as shown in Table 4. The type of usability evaluation techniques aligns with the elements of the literature review that will be discussed:

Table 4. Classification of usability evaluation methods

Classification	(Alghabban & Hendley, 2022)	(Ramadan & Habeeb, 2023)	(Ferreira et al., 2020)
Observational Methods	- Evaluation during Active Use - Usability Testing and Interaction	- Monitoring and Observing Users' Interactions - Usability Testing	- Observational Techniques - Monitoring Techniques
Query Techniques	- Collecting User Opinion - Surveys	- Obtaining User Feedback	- Surveys - Query Techniques
Expert Evaluation Methods	- Predicting the Usability of a Product - Expert Reviews	- Heuristic Evaluation - Review Based Evaluation	- Expert Reviews - Predicting the Usability of E-Learning Websites
Empirical Evaluations	- Experiment Evaluations - Empirical Methods	- Experiments with Controlled Psychological Outcomes	- Benchmark Testing - Experimental
Model-Based Evaluation	- Model-based Evaluation	- Acceptance Testing - Analytical Methods	- Model-Based Evaluation

- Observational Methods
- Query Technique
- Expert Evaluation Methods
- Empirical Evaluation
- Model-Based Evaluation

Note that not all of the approaches listed under each derived classification provided by various writers are inclusive; specific techniques may fit into more than one category. For instance, acceptability testing, as highlighted in Kostadinov and Stojmenovska (2022) and Abdulkhudhur et al. (2019) is not easily categorized under any of the headings. Although it is based on anticipated, exact, and quantifiable criteria (Kostadinov & Stojmenovska, 2022), (Abdulkhudhur et al., 2019), similar to model-based evaluations, it is also comparable to empirical evaluations, despite being conducted in a working environment where the variable control is different from that in experiments. Second, not all assessment techniques are mutually exclusive.

Empirical Evaluation

Assessment relies on the application of scientific experimental procedures to evaluate theories regarding a system's usability, whether empirical or experimental. This usability-testing method is derived from scientific and technical disciplines in which experiments have been consistently employed for a long time to quantify specific concerns of interest. Computer system interfaces can also be studied using conventional experimental methods, according to academic and industrial researchers in the HCI field.

The following elements of this scientific technique should be considered when conducting experiments in the field of HCI:

- Deal with a practical problem in the context of the theoretical framework;
- State a clear and testable hypothesis;
- Identify some independent variables that are to be manipulated;
- Carefully choose the dependent variables that will be measured;
- Select subjects and carefully or randomly assign subjects to groups;
- Avoid the influence of the biasing factors;

- Apply statistical methods to analyze the data;
- Resolve the practical problem, refine the theory, and advise future researchers.

Model-Based Evaluation Method

Model-based assessment techniques provide system designers with the ability to assess and forecast expert performance of error-free tasks in terms of the physical and mental processes that the system must perform. These procedures can be used even if a formal or semiformal specification describes the interface of the system. Thus, these methodologies may be used for UE purposes in the early development stages of an e-learning system.

Observational Methods

Real users of e-learning systems engage using observational evaluation techniques. Users may be observed in their natural environment or complete a series of planned activities under labor-like circumstances. The two primary observational approaches used in usability assessments of computer systems are think-aloud and protocol analyses, which uses protocol analysis, audio and video recordings, and computer logging.

Usability Testing

UT focuses on measuring the performance of typical users in typical tasks. However, the systematic observation and recording of user(s) in the laboratory is the most typical type of UT. Other types of UT include realistic observations and subjective judgments. The following attributes apply to UT:

- They focus on usability;
- The participants think aloud as they do the required tasks;
- Data is recorded and analyzed for results;
- Participants are end users or potential end-users;
- There are artifacts to be evaluated, such as prototypes, designs, or operational systems.

What kind of equipment should be placed and utilized depending on where the testing will occur? For example, many cameras are deployed for recordings in usability laboratories. Another participant would concentrate on the mouse and keyboard operations, while a third might take a wide-angle shot of the participant and capture their body language. Certain recording tools focus on facial expressions, mouse movements, and keyboard usage.

Query Technique

The theory of query strategies states that directly asking the user is the most effective way to identify usability issues in an e-learning system. These techniques are easy and inexpensive to implement and can immediately acquire a user's perspective. Two primary inquiry methods—interviews and questionnaires—are widely established in social science, market research, and HCI research. Users may employ various interviewing methods, including group, unstructured, and organized interviews.

Expert Evaluation Methods

Expert evaluations are a type of assessment in which specialists examine the HCI to predict the issues that users would encounter when interacting with it. Experiential analyses and walkthroughs are two examples of the approaches used in expert evaluations. In addition to being affordable, these methods are simple to learn and are efficient in detecting usability issues. Expert evaluations are based on an evaluator assessing the usability-related elements of a UI. They are also known as usability inspections or interface-developer methodologies.

Figure 6 shows the UE paradigm for e-learning websites. It includes user (primary and secondary), assessment, and evaluation models for e-learning systems. Feedbacks, surveys, and interviews are the quantitative techniques used in e-learning websites.

E-Learning Web-Based Applications

Posting instructional materials online is not sufficient to create high-quality e-learning web applications. Alternatively, it is similar to creating a virtual school in which individuals can learn and improve their talent. The design process should consider aspects of graphic, instructional, and site designs with materials that satisfy the educator's objectives and the demands of the target learners.

Different e-learning management systems exploit the growing communication capabilities of computers (table 5). Adobe Connect, Sakai, WebCT, Blackboard, Moodle, and other computer-based online educational platforms are currently available. Among them, Blackboard and Moodle are the two most popular web-based learning management tools used in higher education. The Blackboard Learning Management System has taken the lead as the industry standard and is always accessible on the internet. Assignments, lecture notes, and other course resources are made accessible to students through the online system. As soon as their tasks

Figure 6. Usability evaluation model for e-learning websites

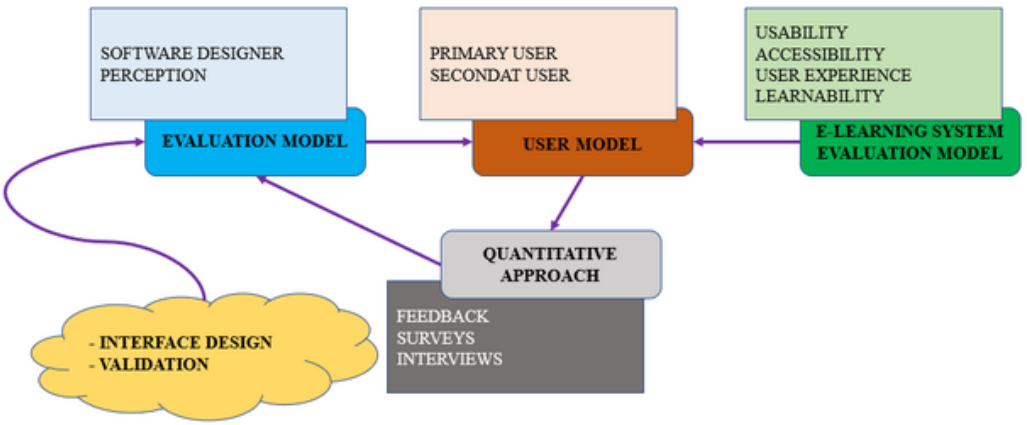


Table 5. Comparison of e-learning web-based applications

Features	WebCT (Blackboard)	Moodle
Software Compatibility	Internet Explorer, Firefox, Google Chrome	Any browsers supporting HTML 3 minimum.
Operating Server	Linux, Windows,	Windows, Linux,
Usability	User Friendly	User Friendly
Tools	Whiteboard	Workshop, Journal, Blog.
Content Sharing	File Sharing, IMS Import	File Sharing, Meta-course tools, Import Quiz Questions.
File Uploading	Single Zip, All web file types	Single Zip, All web file types.
Database	Oracle	Oracle, MySQL.

are completed, the students can submit them. However, Blackboard has several drawbacks in addition to its benefits.

Moodle is an LMS; it is an open-source software that is freely available. It is intended to assist educators in developing efficient online learning programs. The transmission of course information is the primary focus of Moodle. A large and vibrant community of users actively contributes to new system functions and improvements. Moreover, its feature sets are equivalent to those of the largest commercial systems and are simple to expand.

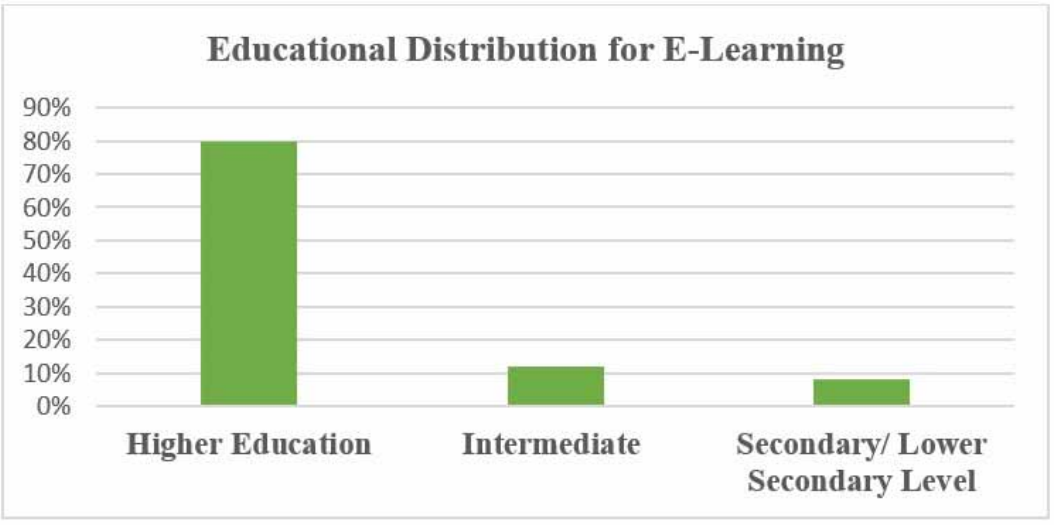
Several distance-learning systems use e-learning, and each of these operates uniquely. However, universities must consider their needs before implementing a distance education system. This study's explanation of online education is suitable for continuing education programs that benefit teachers and students in their courses. The e-learning distance education platforms of Moodle and Blackboard have also shortened the deadline for turning lectures into notes.

Blackboard is a costly e-learning system. Therefore, educators can use Moodle if they wish to employ a variety of modules in their classes and desire a free web-based distance learning system.

RESULTS

Student responses were assessed and evaluated based on survey questions regarding the acceptability and awareness of online learning tools. The survey conducted a systematic analysis of learners' knowledge and acceptance of e-learning applications in higher education by examining their demographic backgrounds and educational experiences. The results were collected online using a questionnaire that included several questions on online education. The interactive stage aimed to raise students' awareness and comprehension of the online learning environment. According to the overall findings of the experimental investigation, only 65% of the participants believed that the e-learning educational system offered an appropriate quantity of information. Figure 7 shows the participants' demographics for e-learning. Moreover, 80% or more of users with college degrees supported the e-learning software. The remaining students were from lower elementary and intermediate education divisions.

Figure 7. Graph for e-learning education distribution



It was observed throughout the study that students in higher education primarily utilized the LMS. Figure 8 illustrates that the majority of students (approximately 55%) used Zoom, 25% utilized Google Classroom, and the remaining amount was split between Facebook and the other online platforms.

E-Learning Usability Evaluation Outcome

Usability experts use a checklist or set of principles called heuristics to compare e-learning website interfaces and discover usability issues through an inspection approach. Real users must use it to detect usability issues with a website. Usage data are gathered through data-gathering methods, such as surveys, and then examined. Some studies have used online and automated tools to evaluate the usability of e-learning websites compared to industry norms and standards, including SEO, WCAG, and site security. The assessment of e-learning websites was carried out using automated tools in 45% of the studies, practical techniques in 32%, and inspection methods in 13%, as shown in Figure 8.

The assessment techniques applied in this study were divided into three groups: inspection approaches, practical methods, and tool-based methods, as shown in Figure 9.

Figure 8. Different educational apps for e-learning system

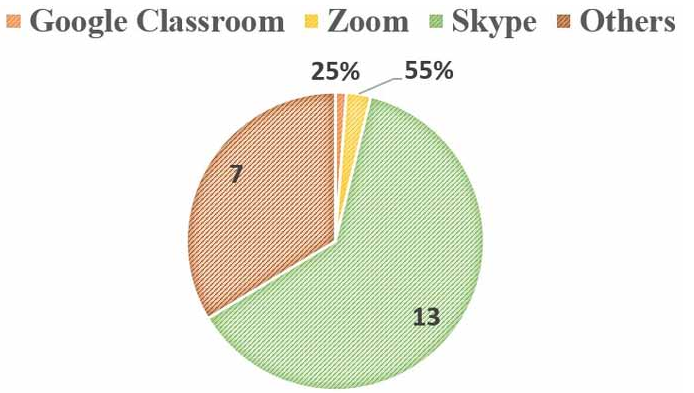
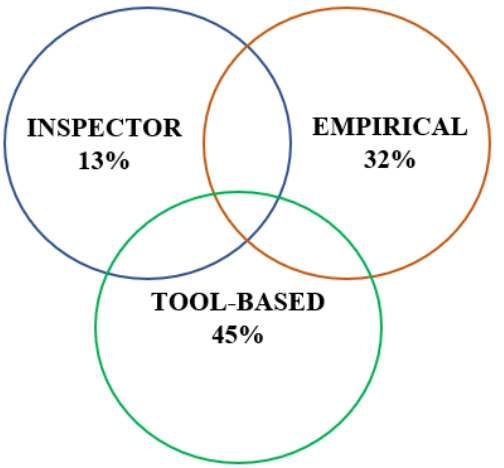


Figure 9. E-Learning website usability methods



As shown in Figure 10, most quantitative approaches, including think-aloud exercises, focus groups, observations, and interviews, were utilized in the e-learning website's UE adoption method.

Various usability issues are encountered when browsing e-learning websites. The usability issues included accessibility, performance, content, and interface design, as shown in Table 6.

Usability Evaluation of Moodle and Blackboard

The Blackboard Learning System was developed as a web-based learning management system for instructors and students to engage in online classes. Blackboard is a comprehensive and adaptable e-learning platform offering a complete course management system. A web-based questionnaire was used for this investigation. The metrics are as follows:

Figure 10. Data collection mode

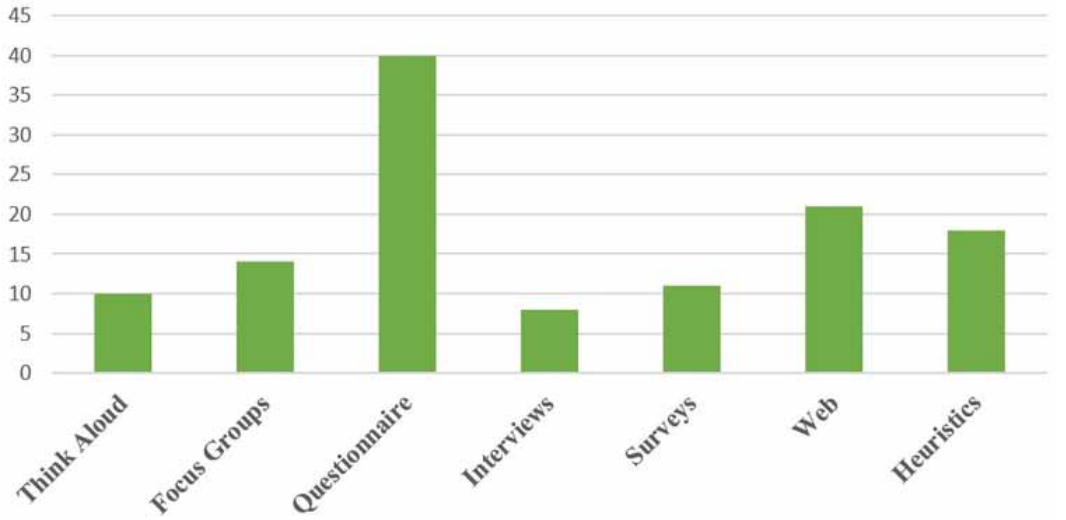


Table 6. E-Learning website usability problems

Usability Problems	Types of Problems
Navigation	- Broken connections - Page Not Found - Incorrect labelling
Interface Design	- Missing alternate text - Coding issues (e.g., HTML mistakes) - Outdated design - Empty labels - Not mobile-friendly - Lack of icon description - A search box is too tiny
Performance	- Lack of security owing to outdated app - Slow loading time
Content	- There is no instant feedback - There is no FAQ - Incomplete information - The search gives no results
Accessibility	- Following WCAG standard

- A course's organizational structure, including its format and subheadings' accessibility, is essential for learning.
- Interactivity, color, and text size are all UI components.

Figure 11 shows the research conducted to examine the usability of two rival LMSs—Blackboard and Moodle. The study comprised three surveys using an investigation technique. The survey results show that Moodle has a more precise organization of course items and a more sophisticated content structure than Blackboard; in addition, Moodle subheadings are simpler to access.

Approximately 79% of people agree that Moodle subheadings are much easier to access than Blackboard subheadings, with 15% remaining neutral and approximately 6% disagreeing with this usability metric. Regarding the LMS with a more advanced structure, approximately 82% agreed that Moodle has an advanced design, 8% disagreed, and 10% remained neutral.

Furthermore, the third and final usability metrics indicated that the LMS had a straightforward arrangement of course items: approximately 85% favored Moodle, approximately 12% remained neutral, and 7% disagreed.

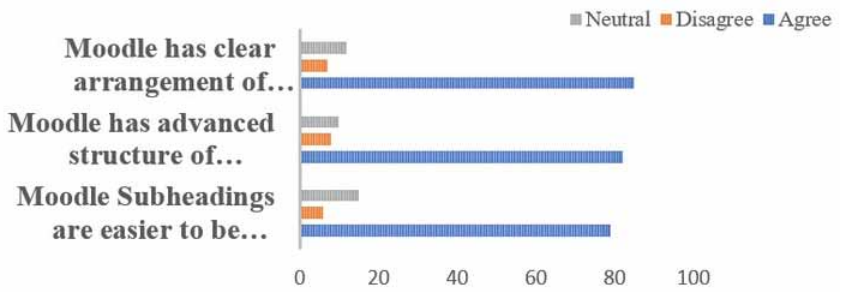
In summary, most students chose Moodle over Blackboard for all three elements in the UE of e-learning.

DISCUSSIONS

Based on 26 research publications, this study evaluated the usability of an e-learning system's UI. It presents the findings based on four aspects: educational distribution for e-learning, various applications for e-learning systems, e-learning website usability methodologies, and UE of Blackboard and Moodle platforms.

Software usability is the ability of users to easily observe, utilize, and learn software. Much of the relevant literature has been published in the last 10 years, owing to the importance of usability and software stability in e-learning systems. According to the results of this study, several research areas require further investigation, although extensive research is being conducted to increase the usability of software programs. For instance, most studies have relied on limited trials, surveys, and

Figure 11. Comparison between blackboard and moodle



	Moodle Subheadings are easier to be accessed	Moodle has advanced structure of Material as Compared to Moodle	Moodle has clear arrangement of course Items
Neutral	15	10	12
Disagree	6	8	7
Agree	79	82	85

questionnaires to assess software usability. Future research should emphasize field studies in which the usefulness of an application is assessed in a real-world setting. The evidence shows that e-learning systems continuously evolve by using this strategy for UE software in various academic contexts and settings. These systems, known as LMSs, can be categorized based on their technological capabilities and instructional objectives. The wide-ranging field of HCI emphasizes the development, evaluation, and use of interactive computer systems for human use. A UE was performed to identify and meet the user needs. A comprehensive overview of the user experience design, user-friendliness, and user-centered design concepts is presented. The usability design should be based on careful observation of current users and supported by early, detailed, and thorough prototypes, as well as usability and acceptability testing on e-learning platforms.

Additionally, the study discovered that Moodle and Blackboard, two of the most widely used web-based LMSs, are commonly used in higher education. Blackboard is the most widely used e-learning management system and can be accessed online from any global location. Moodle is a free open-source software platform that helps teachers create practical online learning courses. Blackboard has several disadvantages, such as difficulty in learning and adding features and upgrades. Another benefit of this technology is the availability of a unique e-learning management system. E-learning distance education systems, such as Moodle and Blackboard, are suitable for continuous education. These platforms help both students and instructors achieve greater success in their courses. Teachers can use Moodle rather than Blackboard because it is less expensive and saves time when providing classroom notes. The survey provided an in-depth analysis of student knowledge, awareness, and acceptance of e-learning instructional applications in higher education. A questionnaire that included several questions on online education was used to collect responses. The study found that 65% of the participants felt that the e-learning system provided an appropriate amount of information. Those with higher educational backgrounds were more likely to prefer e-learning applications, whereas students from intermediate and primary education systems were less likely to prefer e-learning applications. Additionally, most students in higher education use e-learning programs, with Zoom being used by 55%, Google Classroom by 25%, and Facebook and other online platforms by the remaining students.

The Blackboard Learning System and Moodle are separate e-learning management systems. Blackboard demonstrated a more logical organization of course materials, a more sophisticated content structure, and straightforward access to Moodle subheadings. The findings showed that 79% of users preferred Moodle subheadings that were easier to identify, 6% disagreed with the usability metrics, and 15% were undecided. Additionally, 82% of students felt that Moodle had an advanced structure, 8% disagreed, and 10% needed clarification. Finally, the third and final usability measure revealed that the LMS provided a precise organization of course materials, with 85% in favor of the module, 12% neutral, and 7% in disagreement.

CONCLUSION

In summary, the primary objective of this research work was to assess the user interface and usability strategies employed in e-learning systems, specifically emphasizing web-based applications utilized in the context of online education. This study investigated the usability characteristics and efficacy of various e-learning systems, including Moodle, Blackboard, LMS, Zoom, Google Classroom, Skype, and others. The examination of several e-learning systems revealed that the design of the user interface had a pivotal role in augmenting the overall usability of these platforms. The efficacy of an e-learning system is significantly contingent upon the quality of its user interface design and its level of user-friendliness, particularly with regards to student users. An optimally designed user interface guarantees that students can effortlessly traverse the platform, get course materials, engage with instructors, and communicate with peers. Additionally, the study emphasized the significance of performing usability assessments in order to collect user input.

The objective of this study was to assess the user interface and usability methodologies employed in e-learning systems within the context of higher education. The survey was done to examine the level of awareness and acceptability among learners regarding e-learning apps. The study considered the participants' demographic backgrounds and educational experiences. The findings derived from the administered questionnaire indicated that a majority of the participants, namely 65%, expressed the belief that the e-learning educational system effectively delivered a satisfactory quantity of knowledge. Furthermore, the research revealed that those possessing college degrees had a greater inclination towards endorsing e-learning software, as seen by 80% or more of these individuals expressing their support. While the study objectives were only partially achieved, the survey yielded valuable insights into learners' impressions of e-learning systems. However, it is crucial to acknowledge that further research is required to thoroughly investigate the elements that impact user interface and usability in the context of e-learning. The findings indicate that there is potential for enhancing the dissemination of knowledge via e-learning platforms. The findings suggest that the user interface and usability of e-learning systems have a significant impact on learners' happiness and acceptability. This study emphasizes the necessity of improving both the quantity and quality of information that is sent to learners via online education platforms. In addition, the increased level of support demonstrated by persons who have obtained college degrees underscores the need of considering diverse educational backgrounds and experiences throughout the development of e-learning platforms. The findings of this study have substantial ramifications for the field of research. This study elucidates the significance of ongoing evaluation and enhancement of user interface and usability in e-learning systems, with the aim of optimizing learners' experiences and facilitating successful learning. By acknowledging the issues mentioned by participants, educational institutions and developers of e-learning may work towards developing user-friendly and customized platforms that meet the demands of a wide range of learners. Furthermore, this study has the potential to make a valuable contribution to the wider domain of educational technology by providing guidance for future advancements in e-learning systems, ultimately leading to an improvement in the general standard of online education.

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Jehad Alqurni received an M.S. degree in computer science (software engineering) from the University of Wollongong, Wollongong, Australia, in 2009, and a Ph.D. degree in computer science from the Heriot-Watt University, U.K., in 2020. From 2005 to 2010, he was a Teaching Assistant with the Imam Abdulrahman Bin Faisal University, Saudi Arabia, a Lecturer from 2010 to 2019, and has been an Assistant Professor since 2020. His research interests include software engineering, human-computer interaction, usability, web usability, E-Learning, and information systems.