Hindawi
Mobile Information Systems
Volume 2023, Article ID 9869840, 1 page
https://doi.org/10.1155/2023/9869840

*Retraction*

# Retracted: The Role of Machine Learning in E-Learning Using the Web and AI-Enabled Mobile Applications

**Mobile Information Systems**

Received 26 September 2023; Accepted 26 September 2023; Published 27 September 2023



This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

## References

[1] F. Gazzawe, M. Mayouf, R. Lock, and R. Alturki, "The Role of Machine Learning in E-Learning Using the Web and AI-Enabled Mobile Applications," *Mobile Information Systems*, vol. 2022, Article ID 3696140, 10 pages, 2022.

Hindawi
Mobile Information Systems
Volume 2022, Article ID 3696140, 10 pages
https://doi.org/10.1155/2022/3696140



*Research Article*

# The Role of Machine Learning in E-Learning Using the Web and AI-Enabled Mobile Applications

**Foziah Gazzawe**,[1] **Mohammad Mayouf**,[2] **Russell Lock**,[3] **and Ryan Alturki**[1]

[1]*Department of Information Science, College of Computer and Information Systems, Umm Al-Qura University, Makkah, Saudi Arabia*
[2]*Faculty of Computing, Engineering and the Built Environment, Birmingham City University, Birmingham, UK*
[3]*Department of Computer Science, Loughborough University, Loughborough, UK*

Correspondence should be addressed to Foziah Gazzawe; fhgazzawe@uqu.edu.sa

Received 15 April 2022; Revised 20 May 2022; Accepted 1 June 2022; Published 17 June 2022

Academic Editor: Hasan Ali Khattak



For over two decades, e-learning has been recognized as a flexible and faster method compared to the other established methods, especially in enhancing knowledge. Concurrently, the expansion of information technology applications, such as mobile applications and Artificial Intelligence (AI), has provided well-grounded foundations for e-learning to be more reachable. In particular, education can be seen as the most beneficial sector of advancements in e-learning. Machine learning is considered a form of personalized learning that could be used to give each student a specific personal experience through which students are directed to gain their own experience. Web and AI-enabled mobile applications can be recognized as one of the most broadly used platforms for e-learning where machine learning technology can be applied to measure many influences and predictions regarding the quality of e-learning, but we cannot ignore the complexities of use. This study shows the role of machine learning in the user's ability to make use of the course and its contents to measure ease and clarity. Based on a former study shown previously, this paper attempts to pinpoint realities and complexities associated with web and AI-enabled mobile applications by evaluating user preferences. This paper forms the second phase using two user groups (21–30 years) where data were attained using a survey questionnaire to investigate the user preferences when using an application for e-learning. The analysis shows that the future of e-learning has greater potential in web-based applications, as they have more scope for development and improvements compared to mobile applications. The paper concludes with a conceptual framework that works as a machine that stimulates different information and uses e-learning applications that support artificial intelligence techniques. This research provides a solid underpinning for further research into the future of AI-enabled e-learning education and its implication with respect to cost, quality, and usability.

## 1. Introduction

Information technology-based learning has significantly revolutionized the methods and processes of learning, especially for their capabilities, ease of access, and different functionalities [1]. Inevitably and in particular with the impact of the COVID-19 pandemic, the willingness toward e-learning has certainly improved [2]. In fact, the rapid development of e-learning or online learning is seen as a rich hub for more flexible knowledge facilitation and lucidly more accessible to a wider and more diverse audience [3]. This can perhaps be reasoned by the extensive amount of digital content that is increasingly available, touching on a wide variety of subjects and different areas of knowledge. Educators, therefore, are embedding the use of different technology-based applications to provide easy access and a more structured approach to learning [4]. Students prefer a learning platform that provides the content flexibly, the one that they can access at a time and place which is convenient for them, which is unattainable with a traditional classroom [5, 6]. Furthermore, an e-learning platform allows learners to go at a pace, which is ideal for them, and to skip topics that they have mastered or repeat topics for which they need additional support [7]. E-learning also does not require as

many resources compared to classroom learning, as there is no need to travel or find accommodation, which is beneficial for learners [8]. It also reduces fear of discrimination; for example, age and looks are not as big of a deal virtually. Most importantly, e-learning has yielded a good attitude and impact on learning positively, an aspect outlined by [9] on the effectiveness of e-learning as compared to classroom learning. The recall of taught content is potentially stronger, score tests are higher, and even the applicability of learned knowledge is improved, as they have an opportunity to practice what they learn [10].

However, with the availability of many technological devices to support e-learning, it is argued that the blind reliance on technological applications poses a major challenge in terms of facilitating knowledge and a potential hindrance to student engagement [11]. More importantly, the learning process would require substantial grounds constituted on effective techniques, engagement mechanisms, and user experience to ensure that knowledge is facilitated robustly [12]. The first phase of this study [13] has elaborated on the perspectives of learners and the information representation between web and mobile applications, which subjectively concluded that users (learners) found web applications to be more flexible than mobile devices, but mobiles would still be seen as more flexible tools to access learning remotely. Therefore, this study will tangibly touch on user preferences by examining e-learning using web and mobile applications in an attempt to gauge how users respond to learning and what considerations need to be taken for e-learning in the future. This topic is of exceptional significance due to the COVID-19 pandemic, which has forced educational institutions to make a switch to online platforms, resulting in a major rise in e-learning use [14]. The importance of highlighting students' preferences for the different methods, such as websites and mobile applications, has become more crucial as a result. Therefore, the contribution of this study will be to enable the identification of the parameters which impact the e-learning experience using websites and mobile applications. This study provides a more hybrid mechanism that informs decision-making on the use of mobile AI and website for e-learning. The study will incorporate user demographics (e.g., age and gender), as this will support signifying its role and how it impacts preferences of e-learning applications.

*1.1. Web and Mobile E-Learning: Ups and Downs.* The trend of E-learning is gaining wider popularity, as it offers flexible and accessible means for learning through a variety of technological applications [15, 16]. The ultimate aim of the user is to have the best experience in e-learning with the best flexibility and efficiency and at the lowest cost [17]. It can be argued that deciding which method (web or mobile) is complex; this is because the two channels are not necessarily used exclusively, as learners may use both, which has proven to be a good experience for them. Nonetheless, factors such as personal experience and the benefits and weaknesses of each differ and are dependent on the individual [15].

On the one hand, although e-learning had its initial ground with web-based applications, mobile applications may supersede due to the convenience they offer for learners [18]. Mobile applications can be found on multiple websites, such as Ovi Store, Apple Store, and Google Play Store. This creates flexibility for their market and makes it easy for consumers to buy or order applications through them. For many users, it is perceived that mobile applications tend to have better functionality generally due to the existence of better usability features present in mobile smartphones. Some of these features that could be useful for e-learning include the user's location and camera. Moreover, they have proven to be cost-benefit, as most do not require an Internet connection [19]. On the other hand, learners have also come to find that web applications are beneficial and flexible, as they function across devices, thus having cross-platform compatibility [20]. In spite of these advantages for websites, with reference to [21], they also tend to have some drawbacks in that some mobile features such as the camera, geolocation applications, and face and fingerprinted authentication are inaccessible via websites.

However, as [21] pointed out, some applications fetch resources via the Internet by downloading them while being used, so they do incur additional charges for the consumer, and they are not, therefore, without cost after installation. In contrast, websites have lower technical barriers to entry. This is because they just utilize existing technologies and do not need any installation. Once a website is designed, it is ready for use, and the user does not need to incur more costs in its installation [22]. Moreover, websites are good for e-learning because they are compatible when accessed on all devices and platforms, making them flexible for users regardless of the device used [23]. However, there are a few exceptions where the version of the browser becomes incompatible with some devices. The updates made on websites do not require third-party approval, and they are usually made in real time, whereas mobile applications have a series of approvals. The use of both approaches goes hand in hand, and users cannot rely on one of them exclusively. A study [24] is of the view that as more mobile applications get programmed, website applications also get upgraded to ensure compatibility. This means that the efforts to ensure compatibility of websites and mobile applications for the benefit of e-learners are taking a new pace as more upgrades on websites that tend to be incompatible get enhanced. In the end, e-learning has become much faster, convenient, cost-effective, and manageable over time. The choice of preference on whether to use websites or mobile applications is therefore context-sensitive [25]. This means that it relies on multiple factors, such as cost, flexibility, usability, the type of content, and, most importantly, website-mobile application compatibility [26]. Therefore, it is essential to shed light on indicators that impact the performance of e-learning platforms which will be explained further in the next section.

*1.2. Web and Mobile E-Learning Applications: Performance Indicators.* Broadly, both mobile applications and websites have efficiency and accessibility in general [27]. However, a

difference tends to remain in terms of simplicity in use and flexibility of the two approaches. Switching to technology, it has been designed to make e-learning not only effective but also flexible by making both websites and mobile applications flexible, simple, and accessible [28]. Websites and mobile applications have been designed to provide user satisfaction while at the same time ensuring that the developer gains from maximum profitability. It may be stated that it is plausible for each and every e-learner who needs to adopt a systems approach that is capable of providing an effective learning environment conducive to learning that makes good use of the required learning content, and either website or mobile application use provides a solution to the choice of adoption [29]. A study in Malaysia [30] has discussed the relationship between user satisfaction and learning outcomes from e-learning platforms. Although the study provided important findings regarding content and information quality, this did not consider the difference in understanding levels between users, flexibility of using the application, or even application-related variables (e.g., functions and reliability). Another aspect that impacts the use of an e-learning application is the cost or affordability of the e-learning tool, which poses a major concern for students in terms of accessibility and usage [31]. It can be stated that, irrespective of many factors as mentioned above, in most instances, cost and ease of access for an e-learning tool/application play a major role when it comes to decision-making about usage [15, 32]. It can be stated that demographics (age, gender, sexual orientation, experience, etc.) play a key role in terms of impacting the learning experience of online learning applications [33]. In fact, in recent years, many studies [34, 35] have begun to explore some of the emergent impacts of demographics, such as behavioral patterns and cognition within virtual learning environments. Furthermore, some of these studies have begun to explore the change of behaviors over time and how this impacts the learning experience. A recent study [36] identified the focuses of e-learning studies and demographics, which ranged from geographical location, level of education, learners' age, gender differences, and disability. The study concluded that demographics' role is essential to understand what impacts learners within virtual learning environments. However, like many other studies that incorporated the impact of demographics in e-learning, it lacked looking into the synergy of findings with other indicators, including type of the application or even user experience resulting from using the application.

It may be argued that the most important factors determining the success of future e-learning education are the flexibility and affordability of mobile applications and website technologies [37]. Classroom learning has become a second option for most students as e-learning has provided the possibility of a whole new experience [38]. Apart from the advantages of flexibility and generally good user experience, it is also better to highlight the outcomes of learning, which are related to the efficiency or effectiveness of the websites or mobile applications. It is, therefore, worth identifying which of these two trends in e-learning has the most beneficial impact in attaining the ideal results [39]. A study argued that one major noticeable trend of e-learning is the automation of course authoring, which has led to a major decrease in the cost of managing online courses and the time used to prepare them [21]. This means that e-learning content creation has been automated so as to enable ease in scanning course content. Secondly, it has enabled ease in testing learning content on e-learning platform while improving student and content engagement through access via websites or mobile applications [40]. The level of responsiveness in designed courses and their accessibility is likely to be enhanced and managed even better in the future by students once they identify the best platform to use in accessing e-materials for learning. This will depend on the time saving, efficiency, and cost-effectiveness of the platform [41]. According to a previous study [42], the storage and gathering of large amounts of data will also be facilitated through e-learning systems. However, those trends are reliant on the upgrades and reliability of mobile applications and website technologies [6].

Therefore, regardless of the preferences of learners on which of the approaches is more desired for e-learning, that is, either the use of mobile applications or websites, they have both provided a different user experience in terms of flexibility, data security, cost benefits, usability, and quality of the outcomes for students [43]. The two have different weaknesses and strengths that change based on personal experiences leading to differences in preferences. The future of e-learning is thus dependent on the effectiveness of mobile applications and websites in supporting learning and their ability to provide this continually, thereby making the user experience outstanding [15]. The difference between websites and mobile platforms in terms of user experience varies depending on how convenient they are applicable to the user's situation. One may have superior features over the other, but students in the e-learning platform may prefer either depending on convenience and circumstance [44].

## 2. Methodology

A quantitative research design was applied to determine the perceptions of the participants toward using websites and mobile applications for e-learning. This approach was justified as the research aimed to evaluate the extent to which learners use either of the two e-learning platforms. Participants were randomly selected among groups of e-learners on a willing basis after being requested to participate in the research. The participants were students from a university in the United States which embraced e-learning and classroom learning strategies. A total of 49 master's and PhD students (female, $n = 22$; male, $n = 27$) participated in the study; all of them aged between 25 and 50 years with past experience with e-learning. This sampling approach was preferred as it was found to be the most effective in selecting a sample that is devoid of bias and an appropriate representative of the general population. The number of participants was controlled by the size of the classroom, which included 49 students. Master's and PhD students were preferred over undergraduate students because most of them take their courses through e-learning platforms as compared to the

undergraduate students in the same university. Prior to collecting data from the participants, courses were uploaded on website platforms and mobile apps, and the students requested to undertake them. They were required to select the platform that they perceived to be the most effective in studying the course and then undertake the course through the selected platform, website or app. The intention of the researcher was to compare the two platforms from the perspective of the participants in terms of ease of use and preference.

A survey questionnaire was administered to 49 individuals willing to participate in answering the questions provided to the users of learning applications. It was evident that the mode of answering is motivated by the simplicity with which the various questions are presented. A scale was provided to guide the users in the selection of the range at which the service lies in terms of personal perspective rating. In the 4-part Likert scale, the value 1 represents the highest grade of the response, and 4 the lowest, so lower mean values correspond to higher average ratings and higher mean values to lower average ratings.

The use of a 4-part evaluation and rating was to simplify the compilation of results and their analysis. It was also an effective measure for ease in data interpretation. The decision to use either a 4-point Likert scale or a 5-point Likert scale is dependent on enhancing the reliability of the instrument, where it has been stated that reliability increases when the response alternatives are five or six [45]. There are some items with 5 to 6 options. However, even 4 categories are as reliable as the 5 categories and above, and they are used when the researchers only need specific responses from the participants. Questions were administered to the participants, and their responses were used in compiling data for analysis in the study. It was an interactive session that sought to inquire into the simplicity and nature of e-learning mobile applications and websites. The use of a quantitative methodology and employment of questionnaires was chosen because the insights of each and every participant mattered. Considering that some participants wanted to remain anonymous, a questionnaire without a name and only responses to be used in the study was much more effective in avoiding bias. Table 1 summarizes the themes targeted within this paper.

Figure 1 was designed in order to provide better visualization of the data collection process for this research.

## 3. Findings and Analysis

The research questions aimed to determine, measure, and evaluate the following aspects in regard to mobile applications as compared to websites so as to determine which of the two is a better choice for e-learners: speed, simplicity, flexibility, learnability, user-friendliness, most tasking, convenience, efficiency, explorability, and time-saving capability among e-learning users [46]. The above aspects, based on the questionnaires filled by participants, assisted in the compilation of demographic information for analysis.

*3.1. Demographic Analysis.* All the users participated, only one user failed to select his/her gender and age, and three had incomplete responses, thus showing a high number of complete responses of 45 out of the 49 respondents (92%). For the purpose of analysis, the results have been divided into 4 sections: demographics, learning content, course, and system, and the tables summarize the results accordingly. The demographic profile of the sample is such that almost half (49%) of them are aged 24–29, with 20% aged 18–23 and 24% aged 30–39; 51% of them are males, and 45% are females; see Table 2. Regarding the method used for accessing e-learning courses, 69% are accustomed to accessing them through a website and 24% by using a mobile application. The most common device for accessing the course, however, is a smartphone by 61% of the sample compared to a laptop (31%), and a tablet is only used by a small proportion of 4%.

*3.2. E-Learning Application Usage.* In regard to the e-learning content accessed, the participants were asked to rate their experience in terms of 11 aspects. The aspect of the ability to access learning content using either websites or mobile applications was tested and rated by the participants. For most of the participants, the following results (see Table 3) were collected with regard to their perceptions in relation to using website platforms for e-learning: good (41%), highly satisfactory (100%), reasonably flexible (31%), moderately clear in one way (39%) and very clear (47%) in another, reasonably consistent (27%), organized (47%), sequenced (49%), made use of easy to understand terminology (51%), relevant terminology (51%), and the elements well positioned on the screen (43%). The mean values show that the strongest quality is satisfaction enjoyed by 100% of the participants, followed by organization of the material (mean 1.61) and clarity of the second type (1.71), and the weakest qualities are consistency (2.31) and terminology used (2.18) of the content.

*3.3. E-Learning Application Functionality.* The next set of questions on the ease of using website or mobile application platforms were on the flexibility and the extent of saving time. The variable descriptions used in summary (Table 4) were not mentioned in the survey but are used here to simplify the labels. Results of the survey of the learning content of the 14 aspects pertaining to the course were tabulated and analyzed. The strongest are time saving and flexibility, both with the same lowest mean value of 0.92. All 45 (92%) of those who gave a response viewed the e-learning course as a time saver and being flexible. Besides these two qualities, the course is also viewed favorably for being easy to explore (mean 1.12) and for making tasks straightforward to perform (1.39). On the other hand, the course is also viewed relatively less positively, especially in terms of overall usefulness (1.96) and learning to operate it (1.94). These mean values are not so high, but they do show that there are a few participants who are not as satisfied as others for these particular aspects. Overall, very few participants gave the lowest rating of 4. This shows that the greater majority are in

Table 1: Summary of questions under different themes.

| Theme | Questions |
|---|---|
| Preference of application | (i) Which of the two, between websites and mobile applications, have you had the best experience with?<br>(ii) What devices do you like to use most in e-learning and why? |
| Ability and usability to use different applications | (i) Which of the two applications makes your ability to explore research aspects much easier?<br>(ii) How would you rate the overall usefulness of websites as compared to mobile applications in e-learning? Which is your overall preference? |
| Supporting and functionality to complete studies | (i) Between websites and mobile applications, which one do you think has higher flexibility and time-saving capability?<br>(ii) Which of the two applications helps you complete your assignments or research faster? |

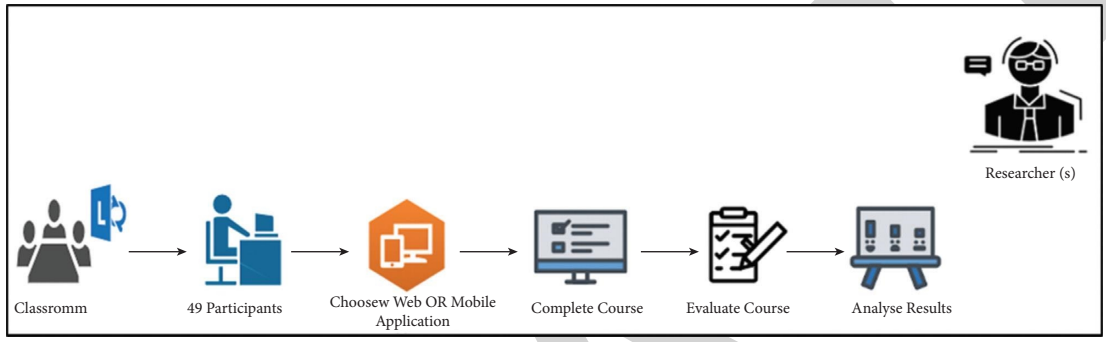


Figure 1: Data collection phases.

Table 2: Demographic characteristics of the sample.

| Variable | Response | Number | Percentage |
|---|---|---|---|
| Age | 18–23 | 10 | 20.41 |
| | 24–29 | 24 | 48.98 |
| | 30–39 | 12 | 24.49 |
| | 40–60 | 1 | 2.04 |
| | Undisclosed | 2 | 4.08 |
| Gender | Male | 25 | 51.02 |
| | Female | 22 | 44.90 |
| | Undisclosed | 2 | 4.08 |
| Method | Website | 34 | 69.39 |
| | Mobile application | 12 | 24.49 |
| Device | Laptop | 15 | 30.61 |
| | tablet | 2 | 4.08 |
| | Smartphone | 30 | 61.22 |

Table 3: Results of the survey pertaining to learning content.

| Variable | Response | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | 1% | | 2% | | 3% | | 4% | | |
| Ease | 15 | 31 | 20 | 41 | 8 | 16 | 1 | 2 | 1.69 |
| Satisfaction | 49 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 1.00 |
| Flexibility | 14 | 29 | 14 | 29 | 15 | 31 | 2 | 4 | 1.94 |
| Clarity | 16 | 33 | 9 | 18 | 19 | 39 | 1 | 2 | 1.94 |
| Consistency | 10 | 20 | 12 | 24 | 13 | 27 | 10 | 20 | 2.31 |
| Organization | 17 | 35 | 23 | 47 | 4 | 8 | 1 | 2 | 1.61 |
| Sequencing | 11 | 22 | 24 | 49 | 6 | 12 | 4 | 8 | 1.90 |
| Terminology | 6 | 12 | 25 | 51 | 5 | 10 | 9 | 18 | 2.18 |
| Relevance | 9 | 18 | 25 | 51 | 5 | 10 | 6 | 12 | 2.00 |
| Positioning | 10 | 20 | 21 | 43 | 11 | 23 | 3 | 6 | 1.98 |

agreement or are satisfied with the various aspects of the e-learning course in general.

The last few questions (see Table 5) of the survey pertained to 5 aspects of the system used for delivering the course. The mean values for all five system aspects are roughly the same with only a small variation of 0.27 between the lowest and highest values of 1.63 for consistency and 1.90 for learning to use it, respectively.

Most of the e-learners were found to prefer the use of smartphones in learning rather than other devices, as it is easily portable and can be used for websites in places where a connection to the Internet is available or else mobile applications for which no connection to the Internet is required. The needs of the user seem to be well addressed, and none of them are dissatisfied with the services offered by the e-learning course. It is quite clear that the majority appreciate the ease with which the course is delivered while it is put to use. While using smartphones, the two platforms were found to be different in terms of ease of use and flexibility of the e-learning course [46]. Similarly, it has high flexibility and lacks inconsistencies that can complicate the progress of the users. A small number of users disagree with the success of using the course, although most of them agree that it is successful. Some individuals appreciate being able to learn to use the course quickly. Many are satisfied with the skills acquired and are willing to recommend the course to their friends, which suggests their overall satisfaction with the e-learning course. Finally, many users believe that the course is satisfactory to use regardless of the opinion being collected

Table 4: Results of the survey pertaining to the course.

| Variable | (Higher) ← response ⟶ (lower) | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | 1% | | 2% | | 3% | | 4% | | |
| Learnability | 17 | 35 | 22 | 45 | 6 | 12 | 4 | 8 | 1.94 |
| Explorability | 47 | 96 | 0 | 0 | 0 | 0 | 2 | 0 | 1.12 |
| Rememberability | 4 | 8 | 22 | 45 | 11 | 22 | 2 | 4 | 1.82 |
| Tasking | 34 | 69 | 5 | 10 | 0 | 0 | 6 | 12 | 1.39 |
| Speed | 10 | 20 | 31 | 63 | 2 | 4 | 1 | 2 | 1.67 |
| Level suitability | 9 | 18 | 28 | 57 | 6 | 12 | 2 | 4 | 1.86 |
| Usefulness | 6 | 12 | 28 | 57 | 10 | 20 | 1 | 2 | 1.96 |
| Time saver | 45 | 92 | 0 | 0 | 0 | 0 | 0 | 0 | 0.92 |
| Met needs | 14 | 29 | 27 | 55 | 3 | 6 | 0 | 0 | 1.57 |
| Met expectations | 11 | 22 | 30 | 61 | 2 | 4 | 0 | 0 | 1.57 |
| Ease of use | 9 | 18 | 30 | 61 | 5 | 10 | 0 | 0 | 1.71 |
| Simplicity | 10 | 20 | 30 | 61 | 4 | 8 | 0 | 0 | 1.67 |
| User-friendly | 9 | 18 | 31 | 63 | 3 | 6 | 1 | 2 | 1.71 |
| Flexibility | 45 | 92 | 0 | 0 | 0 | 0 | 0 | 0 | 0.92 |

Table 5: Results of the survey pertaining to the system.

| Variable | (Higher) ← response ⟶ (lower) | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | 1% | | 2% | | 3% | | 4% | | |
| Reliability | 9 | 18 | 32 | 65 | 3 | 6 | 1 | 2 | 1.76 |
| Consistency | 11 | 22 | 30 | 61 | 3 | 6 | 0 | 0 | 1.63 |
| Usability | 9 | 18 | 32 | 65 | 3 | 6 | 0 | 0 | 1.67 |
| Learnability | 7 | 14 | 27 | 55 | 8 | 16 | 2 | 4 | 1.90 |
| Mastery | 9 | 18 | 31 | 63 | 4 | 8 | 0 | 0 | 1.69 |

from users in different locations, which suggests the satisfaction may be universal, that is, not confined to a particular place.

## 4. Discussion

*4.1. E-Learning Applications: Website or Mobile?* Referring back to the analysis, it was illustrated that websites were much preferred because websites were found to be more user-friendly, flexible, faster, compatible with any device, and user-friendly. The level of ease and flexibility of websites makes users appreciate the technology. The differences can be classified based on the content arrangement, flexibility, initial cost, speed of access, reliability of the site, compatibility with any device, display of the content, and the sequencing of the operation and steps. In short, websites present more useful advantages over mobile applications generally when accessing an e-learning platform [47]. On the contrary, the majority of recent research is looking into mobile-based e-learning, as it is claimed to be providing a more flexible means toward learning. For instance, a recent study [48] has looked into six variables (screen size, supportive software, screen zooming, video playback control, touch screen keyboard, and language predictive tools) that affect mobile learning. The study identified that screen zooming is the most influencing factor for mobile-based learning, which poses another difficulty that would face future mobile application developers. Another study showed that mobile applications usually need to be supported and maintained much more over time in comparison to websites, which are easier to modify without requiring much programming knowledge [15]. Websites may be seen as a more direct means to access information that is up-to-date when compared to mobile applications [46], which require constant updating. All in all, with the continual growth of data and the need for efficient storage, the future of e-learning would require a continual feedback loop [49] to ensure long-term improvement and more user satisfaction. Hence, in the current era, bearing in mind the expansion of mobile-based applications, websites can be recognized as essential infrastructure to ensure more effective mobile applications for e-learning. The rationale for this can be backed by major efforts [50], which look into more data to be retrieved by diverse users who utilize mobile applications for e-learning but would be much more complex to do so on mobile applications when compared to websites. Hence, the main complexity lies in what would make learning more effective, and the answer goes beyond technology itself.

*4.2. E-Learning Applications: The Dilemma of Learning.* Based on the analysis, it can be stated that E-learning applications present an opportunity for learning to many users, whether this will be using mobile applications and/or websites. Based on an independent samples $t$-test distinguishing between mobile application and website users to compare the means, it is noted that there are significant differences, especially in terms of ease of use and flexibility of the e-learning course. Analysis showed that more than 70% of the participants found it easier to engage in e-learning by using websites for accessing e-learning portals rather than using the mobile application. Despite the extensive research in E-learning-related applications, it is important to reserve the importance of engaging the learner's profile, learning, and context. This is because developments in E-learning applications often focus on the application itself and then attempt to provide means of adaptability to the use of these applications [51, 52], where this suggests a more technology-informed approach with limited focus on users' preferences. In response to this, many recent studies began to acknowledge user profiles and contexts in an attempt to understand how mobile applications can be more user-centered. For instance, a recent study [53] provided a critically insightful analysis of adaptive learning of mobile applications through the use of machine learning. Although the study suggested a robust mechanism in terms of optimizing the learning content based on different users, it did not provide a conclusive approach on how to engage learners with the content, which illustrates that a "perfect" e-learning application does not exist. A recent study [54] that attempted to point out performance indicators for e-learning based courses, which primarily were underlined by service, quality, and efficiency, showed that perceptions of the users are essential but did not indicate whether the change of application does play a role in engaging with the content/material and whether these indicators are transferrable between different

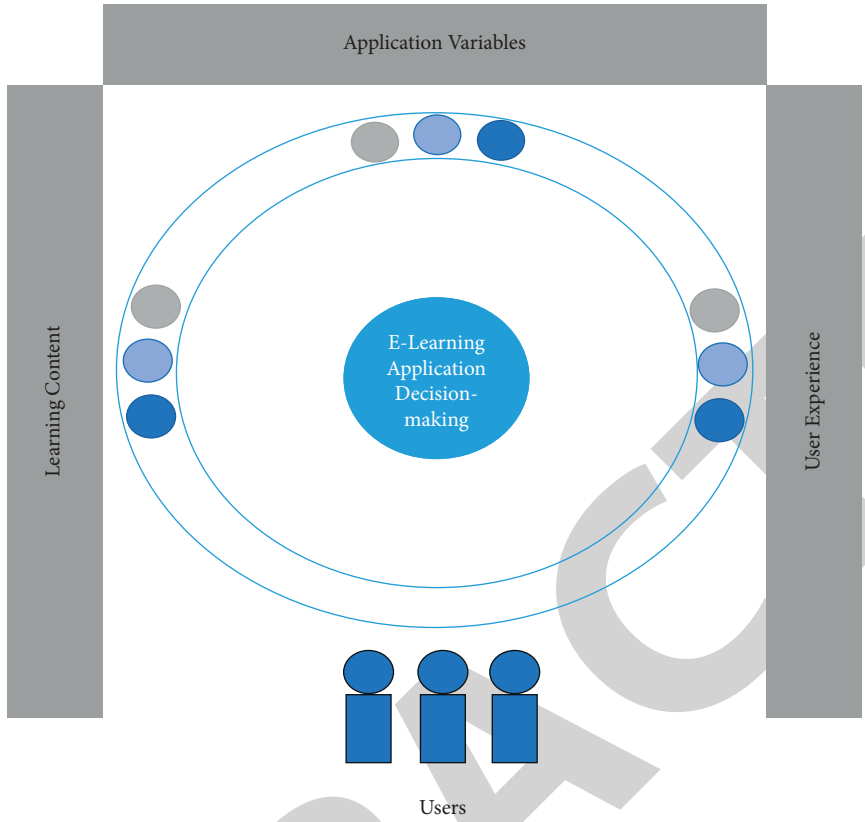


Figure 2: E-learning conceptual framework.

applications. Therefore, in this study, the focus attempted to provide a more overarching application-specific variable that can perhaps be used as a mechanism for more informed decision-making to use web and/or mobile application for e-learning.

*4.3. E-Learning Application Conceptual Framework.* This study along with the first phase [13] highlighted the importance of understanding the complexities and considerations that need to be taken into account when making a decision about an e-learning application. Based on both studies, it can be stated that a sustainable and well-informed decision on e-learning application should be a balance of understanding user experience, application variables, and learning content. User experience would highlight the considerations that need to be taken into account when choosing an application for e-learning. This implies the necessity to understand users' familiarity and experience of using e-learning applications and how this would impact the use of future e-learning applications. For instance, if a user has been using web-based e-learning only and they will be exposed to mobile-based e-learning, then more emphasis should be put on user experience. As for application variables, this will highly rely on the technical and functional capabilities of the e-learning application, which in other words refer to "what can the application offer to the learner" in terms of capabilities, functionalities, and options of viewing the content. This variable is more critical in mobile applications because of the variety and the wide spread of mobile applications. Learning content may be perceived as the most critical component when compared to the previous two; this is because it is directly impacted by user experience and application variables. This is because implications from the learning content would impose whether the application would require technical improvements or even an entire change or would necessitate that users need to be trained in order to engage with the learning content. Hence, based on the above, this study suggests the following conceptual framework (Figure 2) as a mechanism to support providing more informed decision-making on e-learning applications.

In contrast to many studies in the literature, the proposed framework provides a more solidified ground to inform decision-making about the use and deployment of e-learning application for end-users. More importantly, the framework exemplifies the role of stakeholders' preferences and use of e-learning applications. Although the number of studies that elaborate on e-learning and user experience is considerably extensive, they are often contextualized and do not conclusively provide a generic framework that can be applied in other environments or contexts. The dimensions (learning content, user experience, and application variables) provided in the above framework would need further work in terms of prioritizing their importance and what level of influence they have across different e-learning applications. A recent study [55] summarized a number of challenges that impact e-learning, but the major challenge outlined was maintaining the balance between new ideas and

practicing them regularly. This can reflexively show the value of the proposed framework as a mechanism that supports more holistic recognition of different considerations related to different e-learning applications. Therefore, it is necessary to suggest a framework used as the main reference mechanism for e-learning applications and thus obtain more robust and sustainable results.

The framework acts as a prompting mechanism that informs decision-making when deciding to choose mobile AI or websites for e-learning. It sheds light on integrating different stakeholders' perspectives into account so that the benefit and value of using a particular platform for E-learning can be maximized. Whereas many studies tend to focus on one of the platforms to expose the benefits, the framework provided in this study proactively incorporates different considerations (user experience, application variables, and learning content) to make informed decision-making. This framework can be utilized by both educators and e-learning platform developers. For educators, the framework can support identifying which consideration is more significant and, based on this, select the appropriate e-learning platform (mobile AI or website) to serve the purpose. For platform developers, it can support them in identifying areas of focus that require attention and how they can serve a wider audience.

## 5. Conclusions

E-learning is an educational service that can be delivered via both websites and as a mobile application. Both mediums differ, however, in the way they make e-learning available in terms of their accessibility and several other ways for learners identified in this study. The overall importance in terms of effectiveness in learning was also highlighted. Mobile applications have their uses, but they are more restricted and lack flexibility in use. Websites serve the same purpose as mobile applications, but usually with greater flexibility and accessibility. It is hard to conclude which of the two, mobile applications or websites, is the most appropriate. Each is suitable in various situations depending on the end goal of the user but would require an extensive amount of data that support understanding better users' profiles. However, in this case, e-learning service providers tend to be more inclined toward the use of mobile phones, thus making websites more favorable as a medium for e-learning. The reason behind this is that it is harder to create a mobile application without having a website already in place. The main limitation of this study is the use of a small sample size that might compromise the generalizability of the results. Hence, future research should use a bigger sample size that is highly diversified in terms of age, gender, courses, and technological skills.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

## References

[1] X. Cao, A. Masood, A. Luqman, and A. Ali, "Excessive use of mobile social networking sites and poor academic performance: antecedents and consequences from stressor-strain-outcome perspective," *Computers in Human Behavior*, vol. 85, 2018.

[2] R. Radha, K. Mahalakshmi, V. S. Kumar, and A. R. Saravanakumar, "E-Learning during lockdown of covid-19 pandemic: a global perspective," *International Journal of Control and Automation*, vol. 13, no. 4, pp. 1088–1099, 2020.

[3] R. K. Shah and L. A. Barkas, "Analysing the impact of e-learning technology on students' engagement, attendance and performance," *Research in Learning Technology*, vol. 26, 2018.

[4] T. Anghel, A. Florea, A. Gellert, and D. Florea, "Web-based technologies for online E-learning environments," in *Proceedings of the 7th International Scientific Conference "eLearning and Software for Education*, Bucharest, Romania, April 2011.

[5] O. Viberg and A. Grönlund, "Understanding students' learning practices: challenges for design and integration of mobile technology into distance education," *Learning, Media and Technology*, vol. 42, no. 3, pp. 357–377, 2017.

[6] M. R. Simonson, *Teaching and Learning at a Distance: Foundations of Distance Education*, Allyn & Bacon, Boston, Massachusetts, MA, USA, 2012.

[7] M. H. Miraz, M. Ali, and P. S. Excell, "Cross-cultural usability issues in E/M-Learning," 2018, https://arxiv.org/abs/1804.02329.

[8] J. Mason, S. Popenici, L. Blackall, and P. Shaw, "The new smarts in teaching and learning," in *Emerging Trends in Learning Analytics*Brill Sense, Paderborn, Germany, 2019.

[9] J. Summerfield, "Mobile website vs. Mobile application (application): which is best for your organization?," 2013, https://www.hswsolutions.com/services/mobile-web-development/mobile-website-vs-applications/.

[10] H. Xie, H. C. Chu, G. J. Hwang, and C. C. Wang, "Trends and development in technology-enhanced adaptive/personalized learning: a systematic review of journal publications from 2007 to 2017," *Computers & Education*, vol. 140, 2019.

[11] H. Rettie and J. Daniels, "Coping and tolerance of uncertainty: predictors and mediators of mental health during the COVID-19 pandemic," *AM Psychology*, vol. 76, 2020.

[12] B. Means, "Technology and education change," *Journal of Research on Technology in Education*, vol. 42, no. 3, pp. 285–307, 2010.

[13] F. Gazzawe, "Comparison of websites and mobile applications for E-learning," in *Proceedings of the 2017 International Conference on Technology in Education*, New York, NY, USA, July 2017.

[14] S. Dhawan, "Online learning: a panacea in the time of COVID-19 crisis," *Journal of Educational Technology Systems*, vol. 49, no. 1, pp. 5–22, 2020.

[15] A. Leyden, "Why mobile learning apps are the future of education | ExamTime," 2015, https://www.goconqr.com/en/examtime/blog/mobile-learning-apps-future-of-education/.

[16] G. García Botero, F. Questier, S. Cincinnato, T. He, and C. Zhu, "Acceptance and usage of mobile assisted language

learning by higher education students," *Journal of Computing in Higher Education*, vol. 30, no. 3, pp. 426–451, 2018.

[17] A. Gregg, C. Holsing, and S. Rocco, "Quality online learning: e-Learning strategies for higher education," in *Leading and Managing E-Learning*Springer, Berlin, Germany, 2018.

[18] P. Prougestaporn, T. Visansakon, and K. Saowapakpongchai, "Key success factors and evaluation criterias of e-learning websites for higher education," *International Journal of Information and Education Technology*, vol. 5, no. 3, pp. 233–236, 2015.

[19] M. J. Kintu, C. Zhu, and E. Kagambe, "Blended learning effectiveness: the relationship between student characteristics, design features and outcomes," *International Journal of Educational Technology in Higher Education*, vol. 14, no. 1, p. 7, 2017.

[20] J. Hird, "The fight gets technical: mobile apps vs. mobile sites| Econsultancy," 2011, https://econsultancy.com/blog/7832-the-fight-gets-technical-mobile-apps-vs-mobile-sites/.

[21] C. Pappas, "Top 6 eLearning trends for 2016-eLearning industry," 2016, https://elearningindustry.com/6-top-elearning-trends-2016.

[22] Information Resources Management Association, *Wireless Technologies: Concepts, Methodologies, Tools and Applications*, Information Science Reference, Hershey, PA, USA, 2012.

[23] H. Avci and T. Adiguzel, "A case study on mobile-blended collaborative learning in an English as a foreign language (EFL) context," *International Review of Research in Open and Distance Learning*, vol. 18, no. 7, pp. 45–58, 2017.

[24] C. Lai and D. Zheng, "Self-directed use of mobile devices for language learning beyond the classroom," *ReCALL*, vol. 30, no. 3, pp. 299–318, 2018.

[25] G. Aceto, D. Ciuonzo, A. Montieri, and A. Pescapé, "Multi-classification approaches for classifying mobile app traffic," *Journal of Network and Computer Applications*, vol. 103, pp. 131–145, 2018.

[26] M. David, "Converting websites into native apps using phonegap," *Converting Websites Into Native Apps Using Phonegap*, vol. 1, pp. 173–197, 2012.

[27] K.-B. Ooi, J.-J. Hew, and V.-H. Lee, "Could the mobile and social perspectives of mobile social learning platforms motivate learners to learn continuously?" *Computers & Education*, vol. 120, pp. 127–145, 2018.

[28] H. Hills, *Individual Preferences in E-Learning*, Routledge, Abingdon, UK, 2016.

[29] M. Hortsch, "How students choose E-learning resources-the importance of convenience and familiarity," *The FASEB Journal*, vol. 32, no. 1, 2018.

[30] T. Saba, "Implications of E-learning systems and self-efficiency on students outcomes: a model approach," *Hum. Cent. Comput. Inf. Sci.*vol. 2, 2012.

[31] M. Hortsch and L. Rodenbarger, "When students choose E-learning resources—the importance of ease and convenience," *The FASEB Journal*, vol. 33, no. 1, 2019.

[32] M.-H. Ko, "Learner perspectives regarding device type in technology-assisted language learning," *Computer Assisted Language Learning*, vol. 30, no. 8, pp. 844–863, 2017.

[33] J. Xu and T. Rees, "Distance learning course design expectations in China and the United Kingdom," *American Journal of Distance Education*, vol. 30, no. 4, pp. 250–263, 2016.

[34] Z. Cai, X. Fan, and J. Du, "Gender and attitudes toward technology use: a meta-analysis," *Computers & Education*, vol. 105, pp. 1–13, 2017.

[35] N. P. Morris, S. Hotchkiss, and B. Swinnerton, "Can demographic information predict MOOC learner outcomes?" *Proceedings of the European MOOC Stakeholder Summit*, vol. 1, 2015.

[36] S. Rizvi, B. Rienties, and S. A. Khoja, "The role of demographics in online learning; A decision tree based approach," *Computers & Education*, vol. 137, pp. 32–47, 2019.

[37] H. Al-Samarraie, B. K. Teng, A. I. Alzahrani, and N. Alalwan, "E-learning continuance satisfaction in higher education: a unified perspective from instructors and students," *Studies in Higher Education*, vol. 43, no. 11, pp. 2003–2019, 2018.

[38] K. M. Kapp, "5 learning tech trends to watch in the next 5 years," 2016, https://www.td.org/publications/blogs/learning-technologies-blog/2016/02/5-learning-tech-trends-to-watch-in-the-next-5-years.

[39] E. Anohah, S. S. Solomon Sunday Oyelere, and J. Suhonen, "Trends of mobile learning in computing education from 2006 to 2014," *International Journal of Mobile and Blended Learning*, vol. 9, no. 1, pp. 16–33, 2017.

[40] Q. Ma, "A multi-case study of university students' language-learning experience mediated by mobile technologies: a socio-cultural perspective," *Computer Assisted Language Learning*, vol. 30, no. 3-4, pp. 183–203, 2017.

[41] R. Shadiev, W. Y. Hwang, and Y. M. Huang, "Review of research on mobile language learning in authentic environments," *Computer Assisted Language Learning*, vol. 30, no. 3-4, pp. 284–303, 2017.

[42] A. R. Lauricella, C. K. Blackwell, and E. Wartella, "The "new" technology environment: the role of content and context on learning and development from mobile media, media exposure during infancy and early childhood," in *Media Exposure during Infancy and Early Childhood*Springer, Berlin, Germany, 2017.

[43] S. Papadakis and M. Kalogiannakis, "Mobile educational applications for children: what educators and parents need to know," *International Journal of Mobile Learning and Organisation*, vol. 11, no. 3, pp. 256–277, 2017.

[44] A. Tarhini, R. E. Masa'deh, K. A. Al-Busaidi, A. B. Mohammed, and M. Maqableh, "Factors influencing students' adoption of e-learning: a structural equation modeling approach," *Journal of International Education in Business*, vol. 10, no. 2, pp. 164–182, 2017.

[45] L. M. Lozano, E. García-Cueto, and J. Muñiz, "Effect of the number of response categories on the reliability and validity of rating scales," *Methodology*, vol. 4, no. 2, pp. 73–79, 2008.

[46] C. Chilivumbo, "Mobile e-learning: the choice between responsive/mobile websites and mobile applications for virtual learning environments for increasing access to higher education in Malawi," in *Proceedings of the IST-Africa Conference*, Lilongwe, Malawi, May 2015.

[47] B. Zou, X. Yan, and H. Li, "Students' perspectives on using online sources and apps for EFL learning in the mobile-assisted language learning context," in *Handbook of Research on Integrating Technology into Contemporary Language Learning and Teaching*IGI Global, Pennsylvania, PA, USA, 2018.

[48] D. D. M. Dolawattha, S. Pramadasa, and P. M. Jayaweera, "Mobile learning: modelling the influencing factors on mobile devices," in *Proceedings of the International Conference on Advances in ICT for Emerging Regions*, vol. 24, Colombo, Sri Lanka, November 2020.

[49] J. Parsola, D. Gangodkar, and A. Mittal, "Post event investigation of multi-stream video data utilizing hadoop cluster," *International Journal of Electrical and Computer Engineering*, vol. 8, no. 6, 2018.

[50] J. Parsola, D. Gangodkar, and A. Mittal, "Mobile application for storage and retrieval of e-learning videos using hadoop," in *Proceedings of the 4th International Conference on Communication and Electronics Systems (ICCES 2019)*, Coimbatore, India, July 2019.

[51] V. Arkorful and N. Abaidoo, "The role of e-learning, the advantages and disadvantages of its adoption in Higher Education," *International Journal of Educational Research*, vol. 2, no. 12, pp. 397–410, 2014.

[52] R. Garg, "Optimal selection of E-learning websites using multiattribute decision-making approaches," *Journal of Multi-Criteria Decision Analysis*, vol. 24, no. 3-4, pp. 187–196, 2017.

[53] M. Daoudi, N. Lebkiri, and I. Oumaira, "Determining the learner's profile and context profile in order to propose adaptive mobile interfaces based on machine learning," in *Proceedings of the IEEE 2nd International Conference on Electronics, Control, Optimization and Computer Science (ICECOCS)*, Kenitra, Morocco, Devember 2020.

[54] A. Caione, A. L. Guido, R. Paiano, A. Pandurino, and S. Pasanisi, "KPIs identification for evaluating E-learning courses through students' perception," *EAI Endorsed Transactions on e-Learning*, vol. 4, no. 13, Article ID 152743, 2017.

[55] S. Choudhury and S. Pattnaik, "Emerging themes in e-learning: a review from the stakeholders' perspective," *Computers & Education*, vol. 144, Article ID 103657, 2019.