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The role of web engineering in e-learning application development: a review study

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ABSTRACT

Web engineering is a growing multidisciplinary paradigm that has hardly begun to curiosity the interest, researchers, and other key actors involved in developing web-based systems. Therefore, the effect of web engineering applications on e-learning systems should be investigated to guarantee that the web's potential for supporting the learning process is appropriately used. The objective of the study highlights the advantages, benefits, and contributions of web engineering in developing e-learning systems. This is qualitative research. The primary data was collected via an in-depth study of pertinent research studies. The second tool was an interview with the e-learning systems developers. The results showed that the most influential web engineering tools to develop e-learning systems. Moreover, the main areas of development of e-learning systems include changing the learning environment characteristics, changing student behaviour, changing roles, and incorporating artificial intelligence (AI). The results also showed that web applications' main challenges in e-learning systems include technologies, adaptability, lack of experience and training, lack of funding, changing student preferences and needs, the gap between the mobile and computer versions, and security threats, job-overload, and time. It was found that web engineering has a significant role in developing e-learning applications.

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1. INTRODUCTION

Web engineering applications and technologies are increasingly being utilised in the distribution of learning and teaching resources, as well as in facilitating and supporting these activities. This kind of usage has progressed from the supplementation of traditional courses via remote learning and web-based training to e-learning and web-based education, among other things. The field of e-learning extended to provide easy access to the learning resources, anywhere, anytime, through learning resources, and support those features as the learning goals personal definition and the asynchronous and synchronous collaboration and communication, amongst learners and amongst instructors and learners [1]–[3].

Lately, web engineering has become one of the essential and most interesting topics within e-learning and the internet community. Recent advancements in e-learning systems, the knowledge society's requirements, and the increasing need for students to be reflective, independent e-learners have argued for the condition of understanding the function of constantly updated web engineering applications. This study will illustrate the advantages, benefits, and contributions of web engineering to the development of e-learning systems and will conduct a review of the study in addition to eliciting expert opinion on the subject.

2. MATERIALS AND METHODS

This study began with a review of the related literature that discussed the role of web engineering applications and tools in e-learning systems development. The second part of the study was based on interviewing web e-learning systems developers. They were asked for their opinion on the ongoing problem regarding the different roles of web engineering applications in the development of e-learning systems.

2.1. The review

The review part aimed at interpreting, evaluating, and identifying all available related research to the study problem (The role of web engineering applications in the development of e-learning system). This study's data sources were available on different websites, including science direct, wiley interscience, emerald insight. The search strategy was focused on the identification of synonyms and the selection of keywords. The studies selection process was conducted with the technique of fast reading for the primary study candidates, where this technique included reading the abstract of studies.

A total of almost 250 articles were identified from the search results as main candidates for present research, which was conducted using the fast-reading method. Then, after the second screening, 130 articles were found to have the correct title. Final, selection was made from among 84 articles that passed the final screening process based on their eligibility under the inclusion and exclusion criteria.

2.2. The interview

The interviews aimed to better understand the web engineering tools and applications that affect the e-learning system development, the areas of effect, and the challenges facing them. In this study, interviews and consent forms were sent to 15 web developers who developed e-learning systems in schools and universities. Twelve web developers responded in the period between April and May 2021.

All the interviews were conducted using online channels, including Facebook messenger, Zoom meeting, and skype, due to the circumstances of the COVID-19 pandemic. The interview took on its longest time, about an hour, and lasted for half an hour in its shortest time. The interview was recorded for analysis purposes. This interview consisted of four main questions. The first question included the developer's opinion on the possibility of web engineering to cause evolution and change in the e-learning systems in the next few years. The second one was about the most effective web engineering tools that can currently develop the e-learning systems. The third question was about the main areas of development e-learning systems have shortly. At the same time, the last one included asking about the main challenges facing the deployment of web technologies in developing e-learning systems. There were 10 men and two ladies among the participants. Five of the participants were between the ages of 20 and 25, six were between the ages of 26 and 30, and one was beyond the age of 30. Nine participants have experience of fewer than five years, while the other three have more than five years of experience.

2.2.1. Data analysis

The subjects addressed in this study were organised into "themes" in order to make it easier to analyse the information gathered throughout the investigation. Following the development of the interview questions, those subjects were further split into sub-themes based on the answers given by the study participants, which resulted in the final set of topics. The MAXQDA program was used for the coding process during data analysis.

3. THE LITERATURE REVIEW

3.1. Web engineering

According to engineering and scientific principles, web engineering establishes systematic approaches to successfully maintain, deploy and develop high-quality Web-based systems. Moreover, it includes well-known software engineering practices and regulations [4] from varied areas. In addition, it has other areas such as hypermedia-engineering, re-requirements engineering (RE), project management, testing, graphic design, arts, the social sciences, system analysis, design, data structures, and human-computer interaction (HCI).

When model-based initiatives such as model-driven software development (MDSD) developed in acceptance within the software development community, many web engineering methods changed their processes and notations to be MDSD compliant. N. Koch *et al.* [5], such change implied a redesign in Web modeling languages; a reorganization of the models set to be constructed in a platform and a modular independent method; the development processes planning regarding model transformations; and implementation standards, including meta-object facility (MOF), unified modeling language (UML) [6], query/view/transformation (QVT), or XML metadata interchange (XMI), while Figure 1 explains and describes most model-driven software engineering (MDWE) techniques suggest a structural model to

represent the data, a navigation model to describe the pages and how to traverse between them, and a presentation model to define the human-computer interface (HCI) aspects.

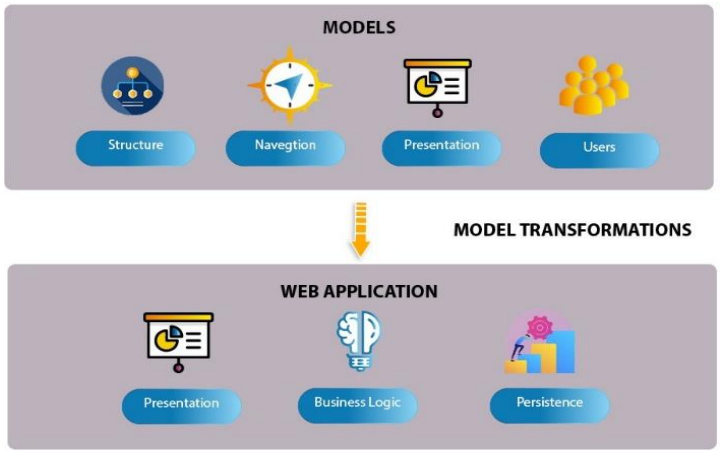

Figure 1. The general scheme of an MDWE method [6]

MDWE handles the approaches to producing running Web applications by converting conceptual models onto models recognized by computers or programs. The critical examples of this model are the Web application models or the models describing diverse Web application aspects. Hence, part of the MDWE facets has become the Web modeling languages' developer. Such languages allow construction models of the web application Furthermore, languages typically are conveyed with guidelines or methods for their utility and the instrumentation that reinforce the previous transformations [7].

The key MDWE approaches contributions to the general field have been chiefly the modeling concerns' identifier that is precise to the Web domain, including user interface interactions and navigation. In detail, the techniques for dealing with interface interaction concerns while present in each interactive application are considered the vital contribution of MDWE approaches within software engineering. The MDWE processes showed how a simple separation of such matters from conventional concerns favours evolution and flexibility. Moreover, MDWE methods showed many concepts that were lost after the web's emergence, mainly the ones related to hypermedia [8].

3.2. Web technologies and tools designed for e-learning applications

To begin with this review, the most critical and influential designed web engineering tools, as well as technologies for the e-learning applications that are implemented in the existing e-learning solutions, would be reviewed. The primary purpose of web engineering technologies is simplifying the learning process by using teaching, learning, and testing solutions, in addition to electronic materials [9]. Such technologies use encyclopedias (wikis) dictionaries, electronic books, educational movies, multimedia, maps, tutorials, tests, virtual laboratories, and simulation models [10].

The existing e-learning systems should be developed through the latest web engineering technologies available to be compliant with the up-to-date web browsers and attractive to users. Usually, a suitable programming language server-side and a database server create dynamic web pages. The application database is tied to a server that should be a fast and solid platform for hosting professional-level databases [11], [12]. Using a well-known browser such as Opera, Google Chrome, Safari, Firefox, and Internet Explorer, the client can access the web-based e-learning system [13].

Generally, different tools and technologies can be solutions for the development of e-learning management tools. A quiet and proper recent tool that changed the way the world conducts webinars and web meetings is zipcast [14], [15], where it is a meeting platform SlideShare, which allows users to conduct secure private, inexpensive meetings and unlimited free open meetings throughout the web browser [16]. It showed how to share presentations through the web, where it was the first site, allowing users to share keynote and powerpoint files on the web. The meetings usually are social and interactive, where they are conducted through a browser window thoroughly. The users with a SlideShare login [14] have a personalized meeting room, which provides group chat, audio, and streaming video facilities. Moreover, Zipcast is a social, fast, and candid web conferencing system [17], [18]. The user in Zipcast can keep other tabs in the

browser open and invite people by sending the meeting room uniform resource locator (URL) to them by social networks, email, or instant messaging, unlike in the case of traditional online meeting systems [19].

Moreover, Microsoft offered new opportunities for online e-learning presentations, like it's Microsoft Office versions. A PowerPoint presentation session is available for other users for one condition: opening the web browser [20]. Furthermore, Microsoft has created updated online versions for excel, word, onenote, and powerpoint. The user can share, edit, and create documents through the web browser, with no need to buy the expensive office suite [19], [21].

3.3. Web services oriented for dynamic e-learning systems

The features of Web engineering's tools are convenient for implementing the e-Learning systems interoperability because of the exchanged information between the systems of e-Learning, including IMS content packaging, learning object meta-data (LOM), besides the standard extensible markup language (XML) binding [22]. Moreover, web engineering tools and applications are languages that are considered to be platform-independent [23]. So they are able to guarantee compatibility and extension amongst the current frameworks, applications, and platforms in the e-learning ecosystem [24]. Finally, the tools and applications of web engineering provide an incorporated programming model that can develop the websites [25]. As a consequence, the customer and the creator of an e-learning system may be completely unaware of the network technology selection. Figure (2) explains the web services initiated for the e-learning system [26].

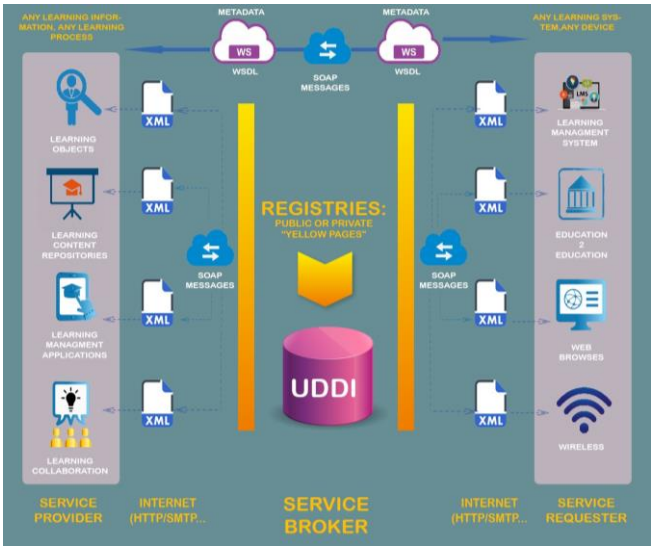

Figure 2. Web services initiated for a dynamic e-learning system [26]

The previous figure shows that by interacting with web service agents in every system, e-learning systems can exchange messages or information [27]. The web service provider is defined as a platform hosting that has access to the service, known as the service execution environment, or the service's container [28]. It's the role within the exchange patterns of the client-server message is the same as the server. In contrast, a function requestor is an application that is responsible for looking for and starting or invoking contact with a service [29].

The discovery agency is a set of searchable service descriptions, and it can be either distributed or centralized. It is worth noting that the service providers publish the service descriptions [29]. The information about standard-compliant learning is communicated between the supplier and the requester using XML, which is infolded with the simple object access protocol (SOAP) definition. The service provider makes the web service definition language (WSDL) file accessible to the public. It contains a description of the endpoint information and message that the requester must utilise in order to construct the SOAP message and deliver it to the appropriate destination [30].

3.4. Emerging web technologies for e-learning mobile applications

Regardless of the various advantages that web engineering technologies offer, a key challenge for e-learning systems developers arises from the vast fragmentation of the tools and applications of web engineering. The widespread use of various tools and applications of web engineering on mobile devices is a challenge that developers of e-learning systems have to deal with. [31] One of the most significant issues is

the lack of a consistent way for accessing resources and functions on mobile devices, especially when sensors differ from one operating system to another. Such variation can be found even between identical mobile versions of devices and operating systems [32]. Furthermore, the programming languages that are used to access mobile sensors vary across different mobile device models and platforms, requiring developers to spread their efforts among a number of languages in order to support a broad variety of mobile devices available on the market [33].

The emerging web engineering technologies, such as new JavaScript approaches and HTML5, offer some requirements to deal with the different challenges [34]. Moreover, due to the fast growth of web technologies in the area of mobile apps, it has become imperative to offer end-users with the ability to install and build their own mobile applications. Such an issue in e-learning systems is well used where mobile applications and devices can be used effectively in schools for field trips to improve the learning experience [35]. However, it cannot be assumed that each, especially teachers, who create an application designed for mobile devices can have programming and technical skills for composing applications and scenarios suiting their requirements. Therefore, one central area of concern researchers and developers are exploring is how to provide end-users with the possibility to create their mobile applications. An encouraging concept is to offer an authoring tool for scenario design [31].

Current projects in the e-learning systems address the end-user programming problem and as well for cross-platform and mobile applications. For example, promising methods for end-user programming besides mobile Mashup development were proposed [36]–[39]. Given an authoring instrument to allow end-users to design their mobile Application is the shared approach. On the other hand, in mobile learning applications that have an authoring tool landscape, it is challenging to discover the projects that include an addressed cross-platform solution [36]. The learning environment for mobile network-able devices (LEMONADE) project presented a unique method for data visualization that can be collected throughout the mobile application execution [38]. The "nQuire" project is another innovative method to mobile learning that incorporates web-based apps for assistance [40]. However, it has an authoring tool.

The projects mentioned above represent a primary indication of the possibilities to support the mobile learning applications flow from designing into visualizing. On the other hand, there is a need for a cross-platform solution to assist the designing mobile learning flow related to data visualization. Current JavaScript and HTML5 help develop desktop web applications quickly, and mobile web applications lack restrictions. Nowadays, HTML5 offers access to internal resources in modern mobile devices, including Android and iOS [31]. Another advantage related to the web-based approach is the Web services/APIs use, including Google Maps, which can be incorporated in mobile applications to create mobile

Mashup applications. Such web services/API such as amazon web services or google maps usually provides a JavaScript interface. For that reason, a mobile web application depends on JavaScript, and HTML5 provides a suitable developing platform for these web services/APIs. Furthermore, HTML5 applications run on any device that has a browser on it; therefore, developers will not need to take a particular O.S. considering deploying and developing their application. Also, HTML5 applications develop the address of the different screen resolutions and size requirements [31].

3.5. Shifting from knowledge transmission to knowledge construction

Web-based learning environments influence educational structures that enable lifelong learning and distant education programs because they combine comprehensive academic resources with digital communication technologies [41], [42]. The organized learning processes by web means generally assist a self-directed and personalized learning process, that allows students to individually study the interest fields in a well-established manner [43]. Web-based learning delivers the essential potential for education improvement; however, it is just an instrument with little use unless certain instructional objectives are clearly stated. Online learning is a broad notion that is based on pedagogical concepts and may be divided into many categories [44].

The study, Govindasamy [45] indicated that one of the primary successful e-learning process implementations of prerequisites is the necessity for underlying pedagogy careful consideration, or the way learning occurs online. One of the significant results of the work based learning (WBL) is the collaboration and communication increase amongst students and teachers to share and exchange the educational practices and content of teaching/learning [46], [47]. Cook *et al.* [48], the web-based learning term includes a broad range of instructional approaches (asynchronous discussion, cognitive interactivity, tutorial, practice exercises, live conferencing, and a presentation blending in with additional instructional activities).

The delivered e-learning instruction relies on particular features presented by Uzunboylu [49]: i) specific instructional methods used, ii) specified appropriate material in relation to learning objectives, iii) designing instruction to build new required skills and knowledge to achieve the goals of individual learning and improve total organizational performance, and iv) used media elements to provide instructional

methods and content. Wang and Jiang [50] stated that the action of WBL occurs in an extensive learning system comprising content management, learning management, virtual learning communities, and learning object libraries. Learning and teaching processes management can implement online learning by using a software that is called the content management systems (CMS) or learning management systems (LMS) [51]. Different environments meet the features successful web-based learning courses, including TelEduc, Moodle, WebCT, BlackBoard, TopClass Server, Toolbook [52].The required steps to implement, design, and install an LMS in the educational organization can cover software engineering methodology aspects that are up to the technology specialist [53]. On the other hand, the biggest WBL system challenge represents the structured learning framework from the socio-constructivist paradigm to generate learning diversity, flexible learning resources, skills, and practices in a practical learning community. The constructivist learning theory recognizes learning as a process where individuals accumulate new knowledge according to experience [44].

The learners can recognize new mental concepts and models through the previous experience that also can help them to shape a consequent experience. Therefore, knowledge is not received in a passive way as an active learning process can build it; thus students won't only have the ability to attain knowledge, but also to make decisions, create hypotheses, and employ their mental models.

Guo [54] stated that learning theories, according to the constructivist approach's value, is student-centered. However, teachers are changed from transmitters of knowledge into facilitators of knowledge who inspire students to knowledge construction learning. Many studies on e-learning, had practiced a considerable experience of pedagogy-related activities, including unity, collaboration, and interactive teaching [55]–[59].

The Researches [55]-[59], an e-learning environment uses a contemporary communication link amongst students and teachers that guarantees knowledge transfer to achieve the objectives of students' personal learning. In addition, it supports the critical success factors, including computer training, university support, web-based technology awareness, qualitative learning resources, skills, and ability. On a broader measure, WBL model development is subjected to main implementations regarding priorities of learning theories, pedagogical issues, educational leadership, quality assurance, learning patterns, and ethical concepts that represent unavailable opportunities for academic institutions to make the most of their education effectively. Such particularities are considered a challenge to every organization that supports instructional technology, practical techniques, and e-learning technologies related to LMS pedagogical principles [52].

Critical e-learning systems share some features, including accessibility, interactivity, flexibility, student-centered, constructivist approach, the resources, economy, and students' motivation should be paid the most incredible attention. Overall, the literature review indicated that web-based learning's patterns play an essential role in developing learning processes by providing real opportunities and benefits for knowledge building along with learner-teacher interaction. Furthermore, the flexible procedure supplying e-learning must simplify the management and administration of learning and teaching [44].

3.6. Educational collaboration

The novel educational paradigm is not considering students as educational content passive consumers. Still, it views them as active knowledge co-producers, where learning production is regarded as a networked, social, and participatory process that supports personal life needs along with goals [60]. As a result, web services can use systematic and methodological approaches in education, and several studies suggested that [61]–[64]. Web services in the e-learning systems are used as the context educational environment that provides the following opportunities [65]: i) the opportunity to share access between educational process participants: students and teachers and ii) the opportunity to edit and share documents that enable reorganizing information within its development and accumulation process.

Students' available technologies must replace the role of teachers in the learning process. Teachers may currently utilise and produce free educational materials in partnership with students. Thus, cloud computing creates a platform for collaboration, since several users may operate concurrently. Consequently, collaborative lesson plans and group projects for all stakeholders in the educational environment[66]. Cloud resources use the users to i) organize the overall disk space to re-position hosted educational content in Moodle. Access is available both to students and teachers; ii) to manage required documents free exchange for the project, including instructions needed for project development, reports of students regarding practical assignments progress. The model of cloud computing is very encouraging for programming learning. For instance, the study of Afzalova and Golitsyna [67], provided the learning activity with the cloud service. Ideone' is considered one of the leading integrated development environments (IDE). It offers syntax highlighting besides sharing and saving code snippets, which support over verse languages. Ideone aims to be a multipurpose tool for testing code fragments. Additional additionally is compileonline.com, which is a website enabling running and compiling simple programs It supports overseas programming languages where the user can get registered or use an IDE account on Google or Facebook. Due to Google collaboration possibilities and Facebook, the teacher can make collaborative processes.

Some electronic educational resources are needed for collaborating with students that include the cloud portal "Obrazovatel'noe oblako (Educational cloud)" [68] or Wikibooks [69]. Furthermore, educational resources use and create different types of educational activities [65]:

- Learning activities: Discipline-based curriculum and governmental standards, determine the content of educational resources, while developers have no constraints in choosing their sources for course construction, thus creating their educational content, which allows the use of Internet resources widely.
- Project activities: producing educational resources as the project, including students during its implementation.
- Practical use: the development results can be used (1) in the distant education frame where they enable bringing the mobile training elements into the educational process. (2) for the individual activity of students in educational organization; and (3) as the educational process part in the traditional training context with unlimited access to the internet.
- Collaboration: resource happening creation in cooperation of teachers and students.

S. Hamid *et al.* [70], the thematic analysis showed that students acknowledged some positive outcomes from social networks used to interact with others besides their interaction with the teachers. In educational activity methods and forms, the organizational field, teachers can drastically change the class's situation by social networks. Social networks deliver a collaborative environment where students can discuss and collect data for the joint project; for instance, in ordinary events, parties, concerts, and performances. It can be used productively at all the educational process organization levels besides extracurricular activities [70]. Moreover, the social network can be used as an online message for extracurricular activities, the association of alumni, educational schedules, pedagogical community meetings, actual issues discussions with parents. It can also be used to enable students to do their different activities individually and do different things where there is no time for them in a classroom [65]. On the other hand, some other contributions of web engineering in e-learning application development can be summarized as shown in Table 1 summary of the assistance of web engineering in e-learning application deveopment (developed by the author).

Table 1. Summary of the assistance of web engineering in e-learning application development (developed by the author)

No	Web engineering can contribute e-learning application development through	Reference
1	Enhance knowledge distribution and acquisition.	[71]
2	The e-learning system enables dynamic features to deal with new adaptation trends.	[72]
3	Remote communication with the instructor.	[73]
4	Perzonalised user interfaces and recommended course contents.	[72]
5	Enhance search personalization.	[74]
6	Recognize learners' characteristics and learning styles to produce adaptations.	[72]
7	Increase e-learning system flexibility.	[75]
8	Include emotional dimensions to improve the interactions between humans and machines.	[76]
9	Reinforce user preferences approach.	[77], [78]
10	Meet the requirements of the e-learning system, including relevant, just-in-time, and fast learning.	[79]
11	Distribute knowledge items or learning materials over the web.	[75], [80]
12	Approve service language that eases coordination among agents with learning materials proactive delivery within the context of the actual problem.	[75], [80]
13	Provide an integration platform for all the learning processes.	[75], [80]
14	Extend the knowledge availability by semantically defined navigation.	[75], [80]
15	Provide active information delivery depending on personalized agents.	[75], [80]
16	Authorize active cooperative content management.	[75], [80]
17	Link the material learning characteristics and the user needs.	[75], [80]
18	Providing knowledge in different forms through semantic content annotation.	[81], [82]
19	Create E-learning courses efficiently and assess effects.	[82]
20	Provide an e-learning system configuration method in a mobile.	[81], [82]
21	Obtain information more conveniently and directly.	[81], [82]
22	Present through a mobile client application that presents coursework in all formats besides social media information.	[81], [82]
23	Improve user stickiness and activeness.	[81], [82]
24	Use the fragmented time for learning.	[83]
25	Manage and build the servers as super users.	[84]
26	Cloud computing and choosing a suitable solution.	[85]
27	The ability to be accessed from any device by the web.	[86]
28	Teachers, students besides other participants within the current e-learning system.	[85]
29	The speed of used connection to provide a suitable content and enable learners to use the updated software versions, on their hardware.	[85]
30	Process all the requests of the learners and handle them according to the stored learner's preferences	[87]
31	Provide content, virtual laboratory, content delivery, management, and assessment features as well as collaborative learning.	[88]
32	Enable knowledge sharing for resources between teacher and learner.	[75], [80]

4. RESULTS

4.1. Do you think that web engineering will cause an evolution in the e-learning systems in the next few years?

The potential of the web engineering will revolutionize e-learning systems in the future. According to, the participant's web engineering applications play a critical role in e-learning systems. Web engineering applications have the ability to bring e-learning to another level where the roles of the learner and instructor will be overlapped. On the other hand, the potential of web services allows the learning sources to be expanded. Consequently, the availability of information will be unlimited. Web engineering also employs "threads" of conversation to classify and record both the instructor and online students. Such a medium will allow the thoughts to be captured for future extension, examination, and elaboration. Through web engineering, the instructor will be able to stimulate and orchestrate the learning environment. Moreover, most of the participants agreed that web engineering has the ability to change the role of learning facilities and make the virtual environment the primary source of learning. One of the participants put it this way: "Through web engineering, learning can become a daily routine".

4.2. What are the most influential web engineering tools that can develop the e-learning systems currently?

The participants have mentioned the most effective web engineering tools, and the majority of them mentioned the following tools: i) ThingLink, ii) Draw.io, iii) Padlet, iv) Adobe spark, v) Baamboozle, and vi) Prezi. Selecting such web engineering tools allowed them to add the virtual reality features to learning sources for increasing collaborative and interactive features.

4.3. What are the main areas of development e-Learning systems have in the near future?

According to the participants, the central area of developing e-learning systems is changing the characteristics of the learning environment. This change can involve making the learning environment more interactive, in addition to changing students' behavior during the learning process and importing all the learning styles. Also, overlapping the roles of the learner and instructor is another area of development where the learner and instructor can be in charge of the learning environment. With the incorporation of artificial intelligence (AI) into the machines, they become more adaptable to new inputs and can learn from their mistakes. Additionally, it enables robots to do activities that are similar to those performed by humans.

4.4. What are the main challenges facing web technologies in developing e-learning systems?

4.4.1. The technical challenge

According to the participants, this challenge was based on the capabilities and resources of the learning institutions to cope with developments. One of the participants said: "Most schools do not even have a proper internet to work, "Even with the existence of new applications, most learning institutions in the developing countries cannot buy them. You need a strong infrastructure to deal with any advancement".

The issue of technical support was increased during the COVID-19 pandemic, as a comprehensive transition to distance learning occurred and the technical support for the students was absent. The technical challenge in coping with new advancements in web applications, is not a new problem. Each update faced several complaints in the first time of running; however, training is the best solution to overcome such issues. Moreover, the platforms of online technical support should be expanded and enhanced to enable the users to ask for it in any language. "One of the participants remarked. When the pandemic occurred, no one could give technical support", "I think that COVID-19 quarantine revealed the weaknesses and gaps in the online technical support. The availability of technical support is the main issue of web-based e-learning, especially in the times when the student is detached from the physical learning environment".

4.4.2. The adaptability challenges

During the time when the legacy system is being phased out and the new one is being implemented, the majority of the newly developed software has trouble being suited to the classroom setting. One of the attendees put it this way when describing the situation: "both kids and instructors are experiencing block-out moments because they cannot cope with the apps.". Another one of the participants "described the time needed to with the applications".

4.4.3. Experience and training

Any advancements in web-based e-learning should be equipped with the right experience and enhanced through training, however, such efforts require time that is lost during the process. However, these kinds of efforts need time, which is wasted throughout the process itself. "you cannot implement any update unless you train the involved parties", "we need time to get experts to work on any new application".

4.4.4. Lack of funding

The incorporation of new innovations calls for major changes, which should be funded by the government. This provides a huge obstacle for learning institutions, as they are unable to get the appropriate financing for such goods. It was remarked by one of the attendees that "there is also a shortage of funds from the government."

4.4.5. Changing students, preferences, and needs

With rapid changes in social media and applications, students are no longer short receivers. Instead, they are now opened to a wide range of possibilities to interact with. The challenge is to keep up with this world for communicating with the students effectively. One of the participants articulated this way: "Nowadays, students are different, and any new system should take this into consideration. The big challenge is to come up with things that students are familiar with".

4.4.6. The gap between the mobile and computer versions

The differences in versions between the computer and mobile applications are not a new challenge for web developers. Web developers are faced with a variety of challenges every day, one of which is the disparity responsible in versions between mobile and desktop apps depending on different types of languages of development use. One of the participants said: "there is a gap between the mobile and computer applications because of the big differences in the interface and updates that are not installed at the same time".

4.4.7. Security threats

According to one of the participants: "with the importance of building the right development infrastructure, it is essential that it has enough security services and options for us to implement the proper security measures".It is essential that it offers sufficient security services due to the fact that it is quite significant while using systems with a large number of users coming from a variety of areas. Due to the fact that risks to security are highly critical and need thorough, rigorous, and ongoing monitoring.

4.4.8. Job-overload

In the words of one of the participants: "one of the main challenges that face us in the e-learning systems design is job-overload where we have to work as developers and designers at the same time".The an unending need for developers to continue working on development. If this is the case, a team consisting of designers, specialists, and programmers will need to be assembled so that they may collaborate on development and progress while also preparing any essential adjustments that will support and assist with the progression of development.

4.4.9. Time

Time is a vital challenge that faces the developers when they have to deal with raw material. Moreover, they have to go through many steps, including drawing up a design, research, production, testing, content creation, making up the developing processor and practical e-learning course. The management change is also one of the stalling points that hinder the developers from working on e-learning systems.

5. DISCUSSION

Today’s most significant educational challenge is to assist students in acquiring information and enabling them to succeed in the workplace and lead to the improvement of their abilities artistically, creatively, and innovatively in order to contribute to the supply of knowledge. Thus, in a knowledge society, the educational system must allow learners to acquire new information on a consistent basis.

Furthermore, the continual development of digital technologies, such as online and mobile technologies, opens up new possibilities for developers and researchers to cooperate and learn from one another and to share their findings. Numerous advancements in the web, networking, cloud programming, social networking, and continuous Internet access have shifted the typical characteristics of contemporary e-learning systems, resulting in the system’s ongoing development.

This study contained many limitations; the first and major one was the lack of studies that examine the role of web engineering applications and tools on the development of e-learning systems from its comprehensive point of view. The second limitation was on the specificity of the effects of the web services on e-learning systems.As well as limiting in this study to the number of expert developers who have been interviewed and met, where face-to-face interviews opened the door for further questions and explanations.

The use of web engineering applications in e-learning systems offers vast opportunities to access a massive amount of information and knowledge. The teachers' role is to ensure that the provided learning environment considers the needs of the learners and that they are supported and prepared effectively. However, some challenges face the web engineering application in e-learning systems, including inadequate equipment that can negatively affect the student learning ability; therefore, web engineering tools should be applied appropriately.

For future studies, the role of web engineering tools and applications should be studied in a more specific way where each update should be reviewed solely to come up with the most suitable applications to be used. Furthermore, further studies can also focus on higher education, where e-learning systems are more advanced and complicated. Again, having similar quantitative studies will support the results of this study. Finally, it is vital to study the role of web engineering applications and tools in light of the COVID-19 pandemic due to the increased dependency on online learning.

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