

METHODS

A comprehensive study on online teaching-learning (OTL) system and platforms

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Received: 18 January 2023; **Accepted:** 28 January 2023; **Published:** 10 February 2023

Online Teaching Learning (OTL) systems are the future of the education system due to the rapid development in the field of Information Technology. Many existing OTL systems provide distance education services in the present context as well. In this paper, several types of existing OTL systems are explored in order to identify their key features, needs, working, defects and sectors for future development. For this, different aspects, types, processes, impacts, and teaching-learning strategies of various OTL systems were studied. In addition, the paper concludes with some future insights and personal interest in the further development of OTLs on the basis of previous research performed.

Keywords: Online Teaching Learning (OTL), Learning management system (LMS), web conferencing, E-learning, distance learning.

Introduction

A Teaching-Learning System (TLS) refers to the process and components that contribute to sharing of information/knowledge within a group of individuals (students, members of a program) within the same or between different organizations. In general, the circulation of knowledge between a teacher and a learner is considered a teaching-learning process. The teaching-learning system requires interaction between teachers and learners through various means. The most basic means is the physical interaction between teachers and learners in a classroom or in a common venue. Various technologies contribute to those interactions in the present context such as PowerPoint presentations, Animations, Smartboards, labs, and simulations of real-life scenarios. The teaching process deals with the implementation and planning of curriculum activities and experiences to meet the expectations of the targeted learner according to a teaching plan and the plan incorporates all the components of the teaching-learning system, whereas learning refers to acquiring information by following all the teaching-learning components which are

later reflected in learners' behavior and bring changes to his/her intellectual horizon (1).

The traditional teaching-learning process is shown in **Figure 1**. In this process, the teacher implements a course according to a syllabus or teaching plan and provides necessary assignments, labs, and internal exams. Students on other hand, enroll in the course and take part in discussions during the teaching-learning process in a classroom. Students perform the task allocated by the instructor. A final evaluation is done based on the final exam, class performance, and the tasks allocated by the instructor.

Online Teaching Learning refers to the teaching and learning process where all the courses are delivered completely online. It is a form of distance education that works on top of computer networks or the internet. An OTL system can be designed for a handful of enrolled students or can be made open and accessible to all the participants via MOOC.

Today, various tools and services are available to facilitate OTL systems where the teacher and the learner interact through a common platform. The channels, required tools, and privacy concerns are handled by the platform/system

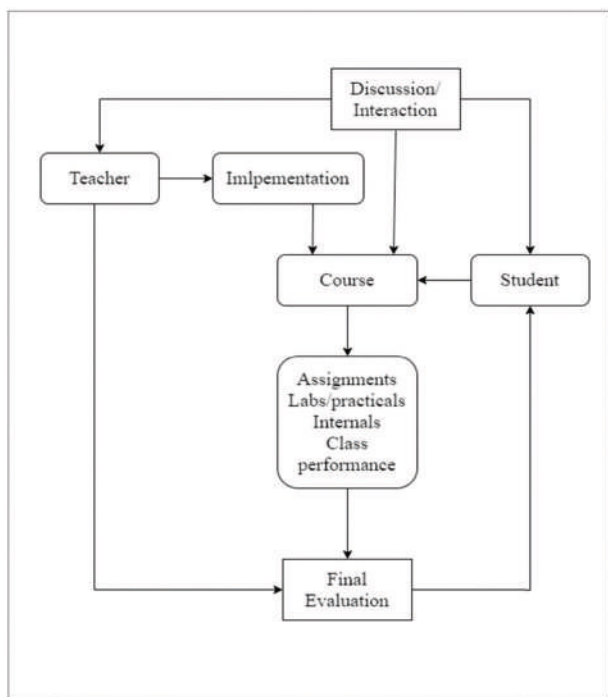


FIGURE 1 | Traditional teaching-learning process.

they are on. The OTL system also incorporates the components of traditional teaching-learning systems but in a different way that enables it to structure, plan, and implement the course more easily and effectively. The online teaching-learning process is depicted in **Figure 2** along with various components taking part in the process. In this process, an online teaching-learning software is used to facilitate the learning process known as a Learning management system (LMS). Teachers and students can interact with each other using LMS about the course materials and resources. An LMS can be made by an organization (such as colleges or universities) themselves or can be purchased from a vendor. It has professionals and a management team hired for its management and maintenance. An online LMS maintains a server and database to serve users and store data. They communicate with each other through a computer network.

Vital components of online teaching learning

An effective online teaching-learning should incorporate all the vital components/features (2). Some of them are as follows:

Users

Online Teaching Learning systems usually require users and managers in order to function effectively. Students and Instructors are the direct users whereas the system management team are indirect users.

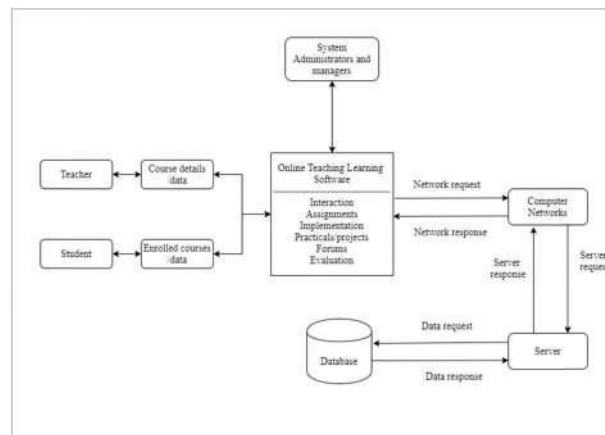


FIGURE 2 | Schematic diagram of Online Teaching-Learning system.

Content structure and course materials

The content structure plays a vital role in the walkthrough of an application. The application should be structured in chunks and various roadmaps and graphics should be used to navigate through different options around course materials. The manageable chunks should correspond to different course content. Instructors provide e-books, PPTs, podcasts, and webcasts featuring lectures and instructional videos that are found in different sections of the application and can be managed efficiently.

Multidirectional communication

There must be a means or channel for bidirectional communication between the instructor and the learner. It can be verbal or written communication as per the design of the platform. This helps in resolving doubts and increases interaction between instructor and learner.

Assignment and group projects

Assignments and group projects are vital components to understanding the concepts and testing the intellect of the learner. These are designed according to the course syllabus and are provided after the completion of a course or its part. It also enables the instructor to create a basis for evaluation.

Feedback

Feedback is one of the vital factors in distance education because the students are not physically present and the coordinator must provide feedback from time to time regarding students' performance, discussions, and graded assignments. There should be provision for students to pass feedback to the instructor as well regarding the methodology of teaching, language, and ease to understand the speed of lectures.

Guidance and support

It includes technical and online help. Instructors should provide guidance to the students about the courses, how

to start and proceed further, and more. In case of any problem or query, the instructor should tackle the problem face-to-face in real-time and provide necessary solutions/documentation (3).

Learner control

It suggests a learner-centered approach where teachers are facilitators rather than lecturers and view the learner as an active participant in the learning process.

Evaluation/Grading

There are many evaluation techniques and they vary with the instructor and the course. The grading system depends on the institution enrolled and the rules that are defined to evaluate the course.

Importance of online teaching learning

Online Teaching Learning systems have vastly improved nowadays and hold great importance in this digital world (4). Some of the importance is given below.

Flexibility in time and location

Online Teaching Learning is flexible to use as time and location can be adjusted as per tutors' and learners' mutual requirements.

Accessibility to course resources

Course materials can be accessed via the internet from any location. And all the required materials can be found in one place.

Availability of offline resources

Videos and other multimedia are available offline on some platforms. They can be downloaded and saved in some cases.

Cost-effective

E-learning systems are less costly than traditional methods in most cases. But there are some courses and certifications that cost similar or more than traditional ways.

Environment

Online teaching learning provides a more comfortable learning environment and innovative teaching style (5).

File sharing

File sharing is easy and efficient. Texts, pdf, video, audio, etc., can be shared among users through the Learning Management System.

Types of online teaching learning

Blended learning

Blended learning is a teaching practice that combines or blends classroom and online learning as shown in **Figure 3**. The instruction of a lesson occurs with both teacher interaction and computing devices (6). It is also known as hybrid learning. It requires the physical presence of both teacher and student. For example, a student learns about a topic in class and goes to the lab to practice that topic using a computer program. There are various blended learning models suggested by some researchers and education professionals (6).

Face-to-face driver. In this model, the teacher teaches the students by using digital tools.

Rotation. In this model, students move on a fixed schedule between traditional classroom instruction and self-paced online learning.

Flex. In this model, most of the course resources are delivered through an online system and teachers help to tackle problems that arise, face-to-face and provide support.

Online Lab. In this model, courses are taught entirely online, but in a physical (brick-and-mortar) location. Students are also supervised by some professionals.

Self-blend. In this model, learners have the option to take online courses to enhance their traditional classroom training.

Online driver. In this model, students complete a full course through a digital platform. They are taught online and all the course materials are provided through online platforms. If necessary conditions arise, face-to-face meetings are scheduled.

Active learning

Active learning is a process in which learners participate in the learning process rather than passively acquiring information (7). Students learn more effectively if they interact in discussions, group projects, practice, and forums than by listening to the information only (8). While taking part in such activities, more sensory neurons are triggered and it increases the cognitive skills, understandability, and problem-solving skills of students. For example, a topic is given for discussion, a group is formed to work on the topic and present their analysis and findings, and presentations and animations are submitted online. **Figure 4** also depicts the concept of active learning in online teaching-learning systems where information is extracted, processed, and applied to provide a meaningful interpretation of the topic.

TABLE 1 | Comparison of various OTLs based on different parameters.

Parameters	Synchronous learning		Asynchronous learning	
	Web conferencing	LMS	MOOC	Self-directed
Usability	High	High	High	Moderate
Scalability	High	High	High	High
Security	Strong	Strong	Moderate	Strong
Supporting multimedia	Supports all types	Supports almost all types	Supports video lectures, texts	Supports almost all types
Heterogeneity	Heterogeneous	Heterogeneous	Heterogeneous	Heterogeneous
Reliability	Moderate	High	High	Moderate
Availability	Online, Limited availability	Both online and offline, Available to teachers and students	Online, Open and available to all	Both online and offline, Available to learners only not teachers
Privacy	Strong	Strong	Moderate	Moderate
Affordability/cost QoS	Freemium	Free, Freemium, Premium	Free	Freemium, Premium
	Good	Good	Average	Good
Platforms	Windows, Mac, Linux	Windows, Mac, Linux	Windows, Mac, Linux	Windows, Mac, Linux
Deployment	Cloud-based, Mobile, Desktop	Cloud-based, Self-hosted, Mobile, Desktop	Mobile, Self-hosted, Cloud-based	Mobile, Cloud-based
Customers	Large enterprise, Small/Medium businesses, Academics, Freelancers	Freelancers, Large enterprise, Small/Medium businesses, Academics, Educational institutes	Academics, Freelancers, Large enterprise, Non-profits, Public, Administration, Small/Medium businesses	Freelancers, Public, Enterprise
Training	Documentation, Online tutorials	Documentation, Online tutorials, Webinars	Documentation, Live, Online tutorials, Webinars	Documentation, Tutorial walkthrough
Support	Email, FAQ, Documentation, Online help	Email, FAQ, Online community	24/7, Email, FAQ, Knowledge base, Live online, Online community	FAQ, Online community, Email, Online help

Engaged learning

Engaged learning is a practice in which students actively take part in the learning process. In this learning model, students engage in research, discussions, and projects and use technology to make discoveries based on their choices where teachers act as facilitators or guides rather than lectures to help students achieve their mission (9).

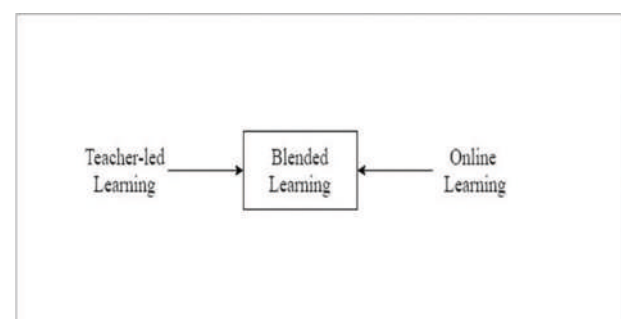
Personalized learning

Personalized learning focuses on individuals' strengths, interests and skills as shown in [Figure 5](#). It is in contrast to the traditional teaching-learning process as each student is individually guided and the teacher doesn't lead all students through the same lessons (10).

The learning rate of each student is different and the way he/she understands, analyzes, and interprets is also different. So, the way of teaching is optimized for the needs of each learner. The Online Teaching-Learning system helps each student to facilitate the effort needed to master the concept. Each student can learn at their own pace and practice until they master the concept. In case of confusion, they can personally ask for suggestions and learning techniques as per their intellect and convenience.

Design issues

The online teaching-learning system should incorporate all the factors that contribute to an effective design of a system. While designing an online system, the designers should be aware of the operability, understandability, and robustness of the system. Users, environment, social and legal issues, policies, etc., should be taken into consideration during design specifications. The following are some of the design issues related to online teaching-learning systems:

**FIGURE 3** | Components of blended learning.

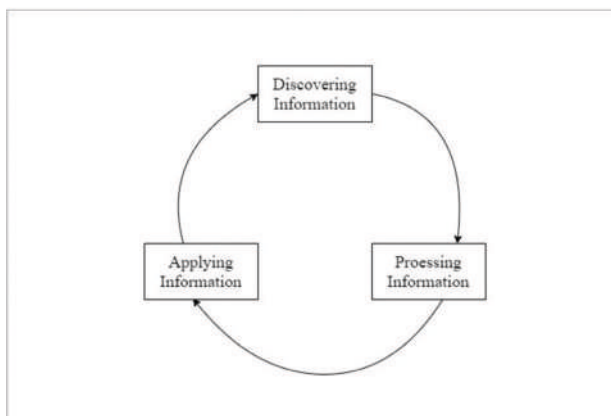


FIGURE 4 | Active learning process.

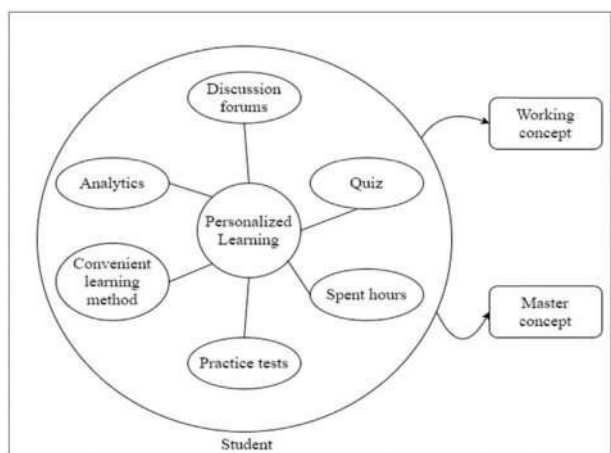


FIGURE 5 | Personalized learning process.

Ease of use

The online teaching-learning system must be easy to use in terms of navigation and interface design. Various types of users with different backgrounds use this system, so it must be user-centered, customizable and understandable by every group. Navigation to the different pages, features or settings should be clear and easy. The interface design should also be simple, specific and to the point without fancying simple things.

Reliability

Reliability of software is defined as the probability of the program working without failure. In this case, it is referred to as consistency over time, and dependability of the system. In software engineering, a simple measurement of reliability is mean-time-between-failure (MTBF) (11).

$$MTBF = MTFF + MTRR$$

Where MTTF and MTRR are mean-time-to-failure and mean-time-to-repair.

It shows that the system is performing as desired or not in terms of request responses, server responses, execution time and accessibility.

Platform

Nowadays, almost all digital devices are smart. With the advancement of smartphones, tablets and PC, a lot of possibilities have emerged. But it has also increased the task of the developers as these devices use different operating systems. So, developers have to design and maintain the application for different platforms.

Scalability

Scalability is the ability of the system to cope with the growing needs. If the number of users increases, the system should also adapt according to the users and if the system is to be migrated to a large enterprise from a small enterprise, it must be scaled according to the needs of the organization.

Security and privacy

Security and privacy are the major issues in this digital era. The online teaching learning platforms are also prone to various attacks and data manipulation. Security breaches such as Man in the middle attack (MITM), Cross-site scripting (XSS), Ip spoofing, Session hijacking, Brute force and DOS attacks, etc., are very common nowadays and online systems must have the mechanism and manpower to defend against such attacks. Preventing unauthorized access, Password protection, Data encryption, Using antimalware, and using a secured protocol (HTTPS and SSH) for online transmission and remote access are some of the preventive measures.

Consistency and quality

The system should be consistent and provide quality services to the users. The system should not behave differently under varying circumstances. Quality services and system optimization must be done in order to achieve smooth performance.

Challenges

Online Teaching Learning is the future of the education system, yet it is not possible to implement OTL in each and every region. Most developed countries have implemented OTL in their education system in addition to the traditional

teaching-learning system. But still, there are regions where these systems are not implemented, are in the developing phase, and in some institutions, they are implemented in parts (specific purpose) (12). Therefore, there are many challenges that should be addressed. Some of them are addressed below:

Monotonous

Online teaching learning is meant to reduce the boredom of the existing traditional classroom-style teaching process. But in some cases, it turned out to be passive as lecturers only provide resources which are not attractive and understandable completely. Lengthy texts, MCQs, and complex choices of words fail to engage students. It is more like e-reading rather than e-learning.

Accessibility

Some online platforms are not accessible by most people. Moreover, students don't have enough resources to participate in OTL. The absence of connectivity or the internet is one of the many reasons for this. The time factor is also another cause where students are not able to attend the class in real-time. In many regions, the complete course resources are not accessible to everyone.

Infrastructure and technical issues

Infrastructures needed for OTL are not within everyone's reach. In poor and developing countries students lack basic hardware and software requirements. In some regions, there are cellular network problems, low bandwidth/poor internet connection and continuous 24-hour electricity service is also not available. Such problems make real-time interaction impossible.

Security and privacy

Security is a major concern in any online application. Privacy is more valuable than anything in this digital world. Making a platform and all the connections secure is a tough task. Various technologies contribute to the management of security protocols on the application. Maintaining those technologies requires software and manpower. If the online system doesn't pay enough attention to security, there are chances of user data and course resources being breached exposing the entire community.

Adaptability

Entering a new online learning environment can be more intimidating than entering a new physical learning environment. It takes time and effort to completely adapt to a new style of learning so there must be enough guidelines, tips, and examples in order to ease the students and instructors to adapt to the platform.

Familiarity

Familiarity with hardware, software, and computer networks is a major key element in implementing OTL systems. Many students lack computer literacy and feel difficult to work with basic programs like PowerPoint, Word, etc. Not only students, but instructors who are more comfortable with traditional teaching-learning systems also are prone to lack these skills as well. They are also not able to troubleshoot minor problems and handle basic errors. OTL systems require students and teachers to manage files, assignments, and course materials in an organized manner.

Online teaching-learning system

The hierarchical diagram in **Figure 6** depicts the various types and categories of online teaching-learning systems (13). There are several parameters to distinguish OTL systems from one another. There are different bases for categorizing the online system according to our understanding, analysis, and the resources found on the internet.

At first, the online teaching-learning process is divided into three categories based on the teaching methods/process (14). In many colleges and universities teaching processes are different and it is still in practice. They are broadly categorized as Web-enhanced, Web-based, and Hybrid systems (15). The web-enhanced learning process is similar to traditional methods as it takes place in a classroom with instruction facilitating the course at a scheduled time and day but the course resources are available to students 24/7 using a Learning Management System (LMS). Online activities are performed as per instructor and course requirements. Hybrid learning is referred to as blended learning where a significant amount of courses are available online. Here, more focus is given to web-based learning.

Web-based learning is referred to as online classes or online learning processes through a learning-driven system (16). It is called web-based because all the activities are performed online through the web. These activities include online classes, file transfer, course activities, resource management, assignments, discussions, etc. Web-based learning is also categorized into two learning types because mainly two modes of communication are responsible for the transmission of data for online teaching-learning or any

other system. So, based on the type of service these modes of communication provide, web-based learning systems are Synchronous learning and Asynchronous learning.

Synchronous learning

Synchronous learning is based on a synchronous mode of data transfer in which the client waits until the server responds with the processed data. It requires the instructor and students to interact in real-time simultaneously. It is similar to a webinar where participants interact with each other through text, audio or video. In synchronous learning, a group of students and instructors are engaged at the same time. Real-time interactions such as live chat, online instant messaging and video conferencing are supported by synchronous learning. **Figure 7** depicts the working of synchronous learning in an online teaching learning system. Based on the needs of learning, synchronous learning is also known as web-conferencing.

Web conferencing

Web conferencing refers to a virtual meeting hosted on a server. Those server providers are third-party suppliers. Web conferencing is different from video conferencing as anyone with the link can join from any location as long as they have the link to the meeting or a meeting code (17). Some of the web conferencing platforms are Zoom, Google Meet, Cisco WebEx, Skype, Microsoft Team, etc. All these applications follow the process shown in **Figure 8**. The UI, presentation, and pricing policy may differ but the basic architecture of all these applications are similar (18).

The working of real-time meeting/web conferencing (19, 20) is shown in **Figure 8**. The system works in three steps.

Step 1: The instructor or teacher creates or schedules a meeting. This will generate a meeting link or meeting ID that he/she can share with the participants. The participants cannot join the meeting without a link or ID.

Step 2: The students or learners should go to the meeting link or join the meeting using a meeting ID to participate in the meeting.

Step 3: After the completion of steps 2 and 3, the instructors and students both participate in the meeting and perform necessary activities. The meeting is held on third-party software which provides various functionalities as shown in **Figure 8**.

The features of the web conferencing platform include face-to-face meetings over the web, screen share and whiteboard services, collaboration on the same screen using a virtual whiteboard, recording and saving meetings,

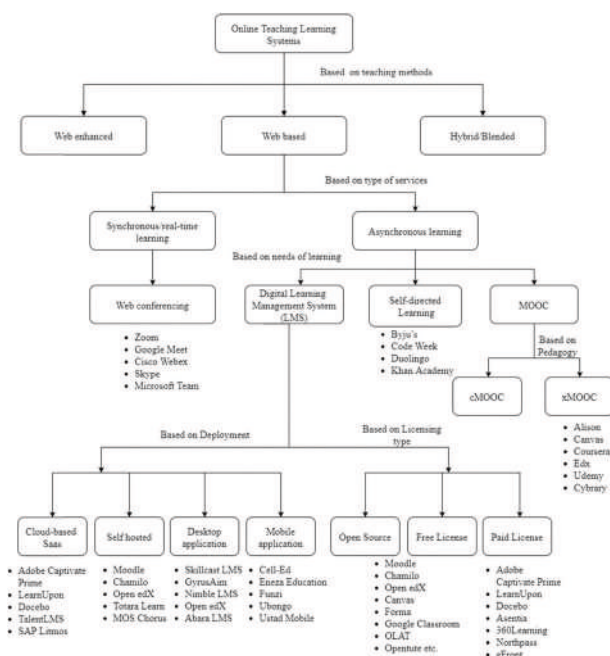


FIGURE 6 | Hierarchical diagram showing the classification of online teaching-learning systems.

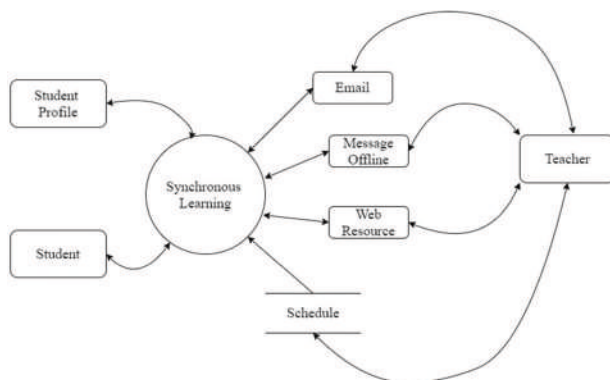


FIGURE 7 | Schematic diagram showing synchronous learning process.

calendar, chat and online instant messaging, strong security and privacy, etc.

Asynchronous learning

Asynchronous learning is a self-paced learning strategy based on the asynchronous mode of data transfer in which the client does not wait until the server responds. The client-side program proceeds further while the server request is being processed in the background. In this type of learning, the course interaction does not take place in real time. It is an online practice in which students are provided with all the resources and can interact with the learning management system at any time according to their convenience. It supports both online and offline features as shown in

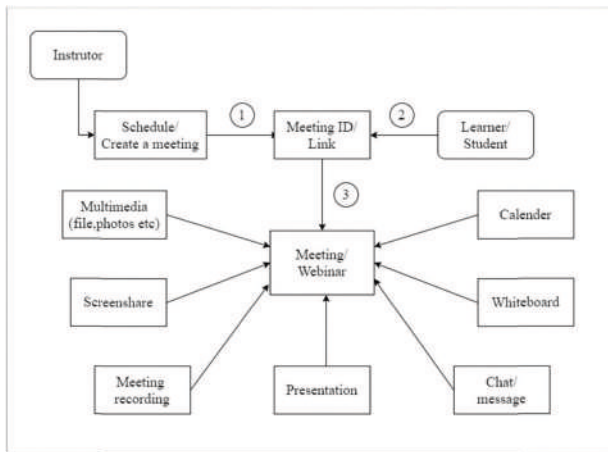


FIGURE 8 | Working of web-conferencing application.

Figure 9. Based on the need for learning, asynchronous learning is categorized into three types.

Digital learning management system

Digital Learning Management system is a platform/software where online courses and training materials are delivered to students/participants and helps to manage online courses, their participants, their evaluation technique and the effectiveness of the course (21). All kinds of organizations benefit from LMS. Learning Management Systems are used by large enterprises, small and medium businesses and freelancers as well. In this digital era, the education system depends on LMS to provide education online. Many colleges and universities use LMS for remote access to courses online. In the education and higher education markets, an LMS will include a variety of functionalities that are similar to those of the corporate sector but will have features such as instructor-facilitated learning, a discussion board and often the use of a syllabus.

The learning management system with required components and features are shown in Figure 10. LMS deals with the overall management of the teaching-learning process. The teachers and students are authenticated using a login management system. After successful login, the users can perform various course-related and management activities. Students and teachers have different functions and work according to the availability and access to the LMS. The LMS supports online class lectures and group involvement/discussion. Various activities in LMS are managed by different components according to their functionalities. The assignment management component manages all the assignment-related activities. Similarly, other management components manage their respective activities. The LMS system also tracks the activity of students and provides various evaluation measures. The Learning Management System is categorized into two types based on deployment

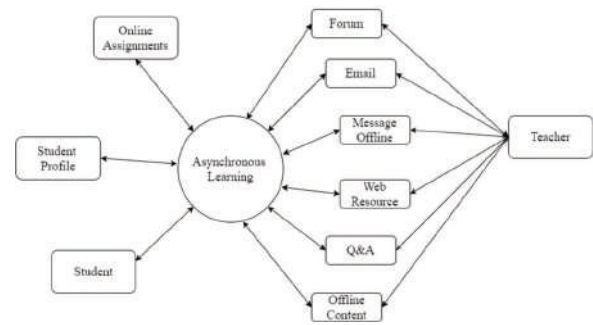


FIGURE 9 | Schematic diagram showing asynchronous learning process.

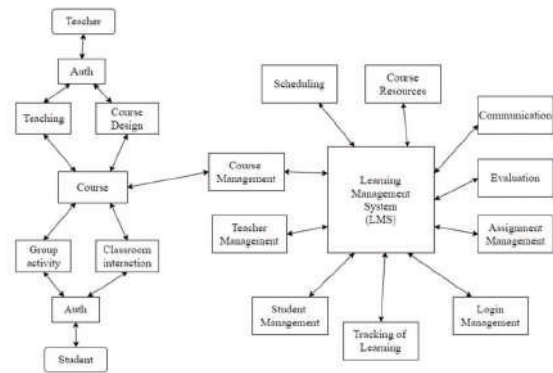


FIGURE 10 | Block diagram showing components of Learning management system (LMS).

and licensing (22). LMS is categorized on such a basis because there are a lot of different types of digital devices such as smartphones, and PCs with different architectures and the LMS system comes with a wide range of prices. Based on deployment, the LMS can be categorized into four groups.

Cloud-based

The LMS software is hosted on the servers of the vendors and the users can access the LMS online (23). The vendor is responsible for the maintenance, management and upgrading of the system. Online learners can access the course resources and engage in the learning process via the web. They can even download the course for offline access to the resources. Generally, the LMS maintains login management for the authentication of users. Teachers and students can log in and perform their activities, interact using discussion forums and more. Some of the existing cloud-based LMS are Adobe Captivate Prime, LearnUpon, Docebo, TalentLMS, SAP Litmos, and Loop.

Self-hosted

The LMS software is hosted by the organization itself and has full control of the server. In this type, the organization should be responsible for maintaining, upgrading and managing

servers and the security of the system (23). Some of the self-hosted LMS systems are Moodle, Chamilo, Open edX, Totara Learn, MOS Chorus, Sofia Learn, and Schoolbox.

Desktop application

The LMS software is installed on the desktop. Some of the desktop-based LMS are Skillcast LMS, GyrusAim, Nimble LMS, Asentia, Open edX, and Abara LMS.

Mobile application

Mobile-compatible LMS software is installed in smartphones. It makes access to the resources easier and time convenient. Some of the mobile-based applications are Cell-Ed, Eneza Education, Funzi, KaiOS, Ubongo, and Ustad Mobile. Based on licensing types, the LMS can be categorized into two groups.

Open source/Free license. They are generally free and open to everyone (24). Some of the open-source and free software are Moodle, Chamilo, Open edX, Canvas, Forma, Google Classroom, OLAT, and Opentute.

Paid license. They require a monthly or yearly subscription. Some applications with paid licensing are Adobe Captivate Prime, LearnUpon, Docebo, Asentia, 360Learning, Northpass, eFront, and LatitudeLearning.

Some of the features of LMS include a virtual learning environment, technical support, course management, teacher and student management, communication management, assignment management and evaluation schemes, security and privacy.

MOOC

MOOC refers to Massive Open Online Course. They are massive courses where a large number of enrollments are possible which are open to everyone and anyone can access the course online for free. MOOC is a platform where a large group of participants with similar interests in a topic can interact, learn new skills, and advance their careers (25). Millions of people around the world use MOOCs for career development, college preparation, supplemental learning, e-learning, and more. MOOCs provide interactive courses with user forums or social media discussions to support community interactions among students, professors, and teaching assistants (26). It also supports immediate feedback on quick quizzes and assignments.

cMOOC

cMOOC (accessibility MOOC) is open-licensed and based on the learning idea of social interaction where information is produced and shared by the members involved in the course. cMOOC provides the control of the course to the students

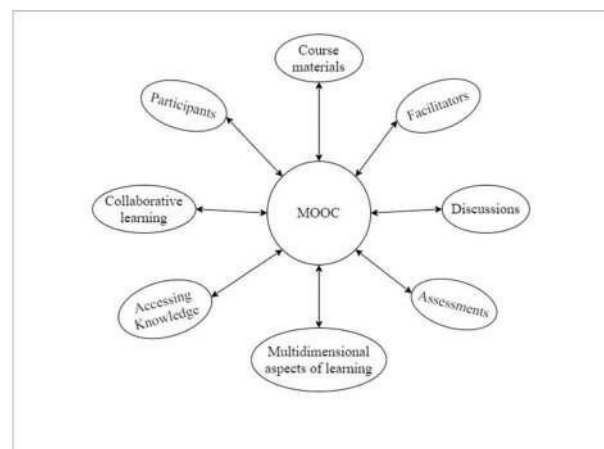


FIGURE 11 | Diagram showing various components of Massive Open Online Course (MOOC).

where they can set objectives and goals, make contents and exercises of the course and team up to share information through various mediums such as wikis, web gathering, social networks and more.

xMOOC

xMOOC stands for extension MOOC and is based on behavioral learning. Behavioral learning theory is based upon the idea that behaviors are acquired through conditioning. It is a teacher-based and centralized learning method (27). xMOOC uses video presentation, content-based reading, tests and assignments. The instructor guides the lessons of the course and the students use discussion forums to share ideas and discuss learning together. Some of the existing MOOC platforms are Alison, Canvas, Coursera, Edx, iCourse, Udemy, Cybrary, and TED-Ed Earth School.

All these MOOC platforms follow the components shown in **Figure 11** and have similar architecture. The above figure shows the general overview of all the MOOC platforms. Some of the features of MOOC (28) include global- scale interaction, a large number of user support, open to everyone, free course content and resources, provides courses from recognized institutions and instructors, facilitates academic preparation for colleges, provides course completion certificates and boosts career prospects, attractive and meaningful classes, and supports distributed learning.

Self-directed Learning

Self-directed learning is a process where individuals take the initiative, with or without the assistance of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes (1975, Malcolm Shepherd)

(29). Self-directed learning uses a learning management system to provide resources such as videos, slideshows, texts, and quizzes. The reason behind the concept of self-learning is the desire to be in control of deciding what to learn and how to learn it. In self-directed learning, the learner can decide what to learn, how to learn, and what should be the outcome of learning. It applies to different contexts of learning whether it is learning to ride a bike, play a musical instrument, cook, learn academic content or learn a new language. In summary, the main elements of self-directed learning (30) include students acting alone without any interaction with teachers or peer groups and being available at any time. Self-directed learning with respect to an online college student incorporates (31) the following.

Self-motivation

Students are required to have a certain level of self-motivation because a well-motivated student has the ability to cope with course materials and a clear vision of the course. They use their experience to deal with a new problem, and when their experience comes up short, they seek out learning opportunities to help them overcome the problem.

Developing strategy and goals

A successful completion of a course requires students to have commitment, discipline, and desire to learn. Self-learning provokes self-directed learning terms. So, students must set their strategy, goals, and procedures to achieve those goals. It includes activities such as time scheduling, course activity management, practice strategy, and regular reflection on goals.

Start learning

All the plans and strategies developed are implemented using the online resources to assist students. These resources include course materials, technology support, practice sets, quizzes, and accessibility services. Students also need to understand the various approaches to studying.

Self-evaluation

Self-evaluation is very important in self-directed learning as it gives insight into the performance and progress of the students. Self-evaluation helps in measuring the completion of goals and engaging in self-reflection of their achievements. The evaluation also provides feedback on the areas where improvements are to be done.

Some of the existing Self-directed learning platforms are ABRA, British Council, Byju's, Code It, Code Week, Duolingo, Khan Academy, OneCourse, Siyavula, and Youtube. Moreover, the features of self-directed learning include easy and effective adaptation to the learning environment, self-reflection of performance and progress, new challenges, comfortable learning, a good critical and intellectual thinking platform, etc.

Comparative analysis of online teaching learning systems

Usability

According to ISO usability is the extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency, and satisfaction. Technical usability and learning usability best define/justify the usability of online teaching learning (OTL) systems. Technical usability deals with the ease of interaction with the learning platform such as UI, navigation, and plugins whereas learning usability is about minimizing the learning-related frustration for users. Based on these facts, usability (Technical and Learning) can be rated as **High, Moderate, and Low**.

Scalability

Scalability is a parameter that justifies the system's ability to handle growing amounts of work and be flexible to accommodate that growth (32). In this context, the system is an online teaching-learning system. It deals with growing the application significantly as the size and complexity of the software increases. Scalability gives answers to some questions such as

- Q1.** Can OTL software be implemented on a large scale?
- Q2.** Can it cope with transferring the system architecture from a small enterprise to a big enterprise (33)?
- Q3.** Does the OTL system support rapid and additional growth or changes in data?

With changes in needs, the OTL system should be able to adapt according to it by managing a large amount of data, a large number of users, response time, and system needs. Based on these facts, scalability can be rated as **High, Moderate, and Low**.

Security

Online teaching learning systems should come with highly secure protocols and technologies. In this digital era, security is a major concern in every field. Authentication, restriction, Encryption, backup, Malware protection, and cyber-attack protection are some of the essential elements of security in OTLs (34). Attacks such as Man-in-the-middle attack (MITM), Cross-site scripting(XSS), Rootkits, Session hijacking, SQL injection, Bruteforce, and DOS are some of the security risks proposed by attackers. Based on such capabilities of the system to defend against such attacks, the security of OTLs can be rated as

High security

Strong Authentication, Good encryption, Strong firewalls and anti-malware.

Moderate security

Strong Authentication, Moderate encryption, Moderate firewall and anti-malware services.

Low security

Poor Authentication, Simple or no encryption, Weak firewall.

Supporting multimedia

An OTL system provides services to share multimedia such as texts, videos, audio, pdfs, live streaming, and screen share. OTL systems are of different types and support different multimedia types based on their functionality. For instance, web conferencing OTLs provide video streaming, live screen sharing, and online Instant Messaging facilities, LMS provides asynchronous file transfer rather than live streams, and MOOC delivers video lectures and discussion forums only.

Heterogeneity

Online teaching learning platforms have to deal with heterogeneous data. Heterogeneous data such as graphical data, voice/video, text, and numerical data contained in a compound document should be organized and accessed as a single data structure rather than a collection of separate files.

Reliability

Reliability in OTLs refers to consistency over time, dependability, the efficiency of the system, and its capability to achieve its goal. The main objective of OTLs is to effectively deliver online training materials and facilitate easy interaction between instructors and learners without failure (35). Reliability of such systems can be measured by incorporating some of the following points:

- User Interface workflow, usability, and accessibility of the platform.
- Measuring the mean time between failures (MTBF) (11).
- Evaluation of the learners' track reports to identify the faults and reliability issues related to performance (speed, execution and response time, etc.).
- Performing expert-based reviews and heuristics evaluation.

Based on these facts and issues reliability of OTLs can be rated as:

Highly reliable

Fluent workflow, easy accessibility, high usability, great performance, less MTBF.

Moderately reliable

Average MTBF, moderate usability, satisfactory performance.

Less reliable

High MTBF, low usability, poor performance, not easily accessible.

Availability

Availability of a system/program in terms of e-learning refers to whether the program/course can be accessed. If the program/course can be accessed then, what will be the basis for its availability. System availability can be categorized as follows.

Based on connectivity

Online, Offline, or Both

Based on the user

Available to students and instructors only, Open for everyone

Privacy

Privacy and security are different and it has a different and transparent set of policies. In the OTL system, teachers and students should have a private place to perform their activities online. While doing so, teachers should be able to criticize without fear and students should not fear to comment freely on controversial matters (36). Moreover, the OTL system should protect the personal data collection of students by the private sector for commercial use and prevent government agencies from tracking student learning activities. Personal details of users (students and teachers) should not be exposed without permission and data should be encrypted while transferring from client to server. With all these factors in mind, the privacy of the OTL systems can be categorized as **Strong, Moderate, and Weak**.

Affordability/Cost

Online systems provide a more affordable option than traditional colleges. LMS used by colleges and universities provides online education for their students' college fees whereas some LMS is provided free of charge by some colleges and universities. In some cases, course resources such as textbooks are available online at no cost. Many MOOC courses provide course resources and materials for

free but charge for certifications. These OTL platforms come up with different pricing options. Based on the cost of the OTL system it can be categorized as

Free

It's completely free.

Freemium

All the basic requirements are free but have to pay for additional features.

Premium

It has pricing ranges and is not available for free.

Quality of Service (QoS)

Quality of Service in OTLs refers to the measure of the overall performance of the learning system (37). There are various factors contributing to the quality of services but in this case, we mainly consider three parameters (38): Service quality, Information quality, and System quality. Service quality incorporates reliability, assurance, tangibility, and responsiveness of OTL systems. Information quality deals with quality learning content such as presentation, structure, interactivity, and delivery modes and system quality refers to the quality of website/software in terms of UI, Navigation, and ease of use. Based on these facts, QoS can be categorized as **Good, Average, and Poor**.

Platforms

Online teaching-learning platforms come with various types of platform support. The platforms are based on the architecture of the system/hardware. Based on the popularity and most used operating system, some of the platforms are **Linux, Mac, and Windows**.

Deployment

Based on the deployment of software on various platforms and architectures (23), OTL systems can be categorized as **Cloud-based, Self-hosted, Mobile application, and Desktop applications**.

Customers

The e-learning systems have various types of customers based on the functionality and need of the system. Some of the customers using these systems are Academic institutions, Freelancers, Non-Profit organizations, Public, Administration.

Training

Training refers to the materials to learn and be familiar with the e-learning systems. These systems are used by various industries as per their need and requirements. Some of the industries using OTL systems are Banking, Education, Management, and e-Learning.

Support

The online teaching-learning systems provide various support to the customers in case of errors, training, and usage of the system. Some services provided by OTL systems for support are 24/7 helpline, Email, FAQ, Knowledge Base, Live Online, and Online Community.

Discussion

The online teaching learning system plays a vital role in distance learning. It supports almost all the requirements needed for efficient online interaction between users. Today, education is about giving students the skills they need to succeed in this new world and helping them grow the confidence to practice those skills. The new education system focuses mainly on Creativity, Critical thinking, Communication, and Collaboration. The online teaching-learning system should incorporate all these components and design systems that provide a learning system that fulfills the needs of the present and future. Such systems are used by direct users and managed by indirect users. Students and teachers are the direct users of the system. There are certain requirements that an online teaching learning system should fulfill with respect to both types of users for present and future contexts.

Interactive learning objects

Interactivity has long been seen as a necessary and fundamental mechanism for knowledge acquisition (Sims 1997). Students interact with various objects in the system to participate in the learning process. Interactive labels and tools should be provided with enough guidelines and well-labeled components. The Interactive Numeric Exercises tool allows the creation of interactive exercises in any subject domain that requires the user to follow a set algorithm to solve a numeric problem.

Collaborative learning

A platform with discussion boards, file sharing, and Virtual chats enable learners to collaborate and share ideas. Collaborating learning describes a variety of different

learning situations. It supports the discussion of groups of students and instructors about a concept using online forums. Collaborative learning increases the cognitive and intellectual capabilities of the participants.

Error handling

Many tasks such as file download, transfer, video playback, and web conferencing may fail at any time depending on whether the user is mishandling data, or the server is overloaded with requests which may trigger software or hardware failure. For instance, a user may accidentally try to login again after being logged in which creates a double session for the current user. This may bring unnecessary problems to both the user and the system.

Reliability and scalability

Reliability of software is defined as the probability of the program working without failure. In this case, it is referred to as consistency over time, and dependability of the system. Scalability is the ability of the system to cope with growing needs. The online teaching learning system should be reliable and scalable. Reliability and scalability also facilitate management and administrative teams to monitor and maintain the system effectively. Response time, execution time, adaptability, accessibility, and usability help to determine the reliability and scalability of the system.

Cognitive skills

Students and teachers that are involved in an online teaching-learning system should master a complex range of skills to achieve their goals. Various cognitive tools - computer applications such as computer conferencing, expert systems, databases, and spreadsheets are used which requires users to interpret and organize personal knowledge.

Security and privacy

Security and privacy are major issues because data should be confidential and server reliable. Users should be provided with privileges according to their needs. Students and teachers should be provided with the necessary security and privacy services such as authentication and data encryption whereas system managers and administrators should be given the necessary tools to defend against attacks.

IT Law

IT law (cyberlaw) is related to information technology and activities on the internet. It deals with the legal and illegal

issues in the IT field. IT law is related to law and order and its consequences if anything illegal or unauthorized activities are done using the world wide web or the internet. IT laws have sections and subsections for different types of unofficial, violating, or theft issues and impose necessary punishment according to the crime. Online teaching-learning (OTL) systems are operated on the top of the internet so there is a high chance of security breaches, privacy theft, and data manipulation issues. In case any illegal or violating activities in the OTL system leads to cybercrime, necessary punishments are imposed on the guilty.

Infrastructures

Basic infrastructures such as electricity, internet connection, and cellular service are needed for running an online system. The government and private sectors have worked on and proposed plans and policies in the communication sectors. Various government and private Internet Service Providers (ISPs) have emerged in recent years. Cellular network companies have also facilitated connectivity in different regions. But there are still some problems such as availability of hardware and software, poor connection, low bandwidth, and poor cellular networks, which make it difficult for users to access the OTLs at any time. The internet service is expensive in developing countries and 24/7 electricity service is also not available in various regions.

Conclusion and future work

An online teaching learning (OTL) system consists of various components and learning strategies as discussed in the previous sections. Information about such systems was obtained through surveys and online research. Various sites, papers, and videos contributed to help find necessary information about OTL systems. Some of those OTL systems were used to find out the working and features of those systems. The research helped to find out the impacts of online teaching learning processes on various users and educational institutions. Various existing types of learning management systems, their services and architecture were studied for this work. The study of such OTLs has led us to think about their improvement and bring changes to such systems. Some of the works that can be carried out in this domain are as follows.

- Focus on the new learning strategy while developing a new learning management system that incorporates the needs of the 21st-century education system.
- Study the various environmental issues for better adaptation to the learning environment.
- Focus on the cognitive skills of the users and study the intellectual behavior of users for better usability and understandability of the system.

- Study the reliability and scalability factors and create a model which is less prone to bugs and lags.
- Implement distributed learning in the learning management system more efficiently.
- Integrate synchronous and asynchronous learning in a single platform.
- Explore various security breaches and study their causes to analyze the upcoming risks and threats.
- Study the socio-economic aspects that directly or indirectly affect the performance and usability of the system to enhance the system quality and consistency.

References

1. Stern J. *Introduction to Online Teaching and Learning*. (2021). Available online at: <http://www.wlcc.edu/online/documents/otl.pdf> (accessed May 8, 2021).
2. *4 Basic Components of an Online Course*. (2021). Available online at: <https://www.usnews.com/education/online-education/articles/2013/04/24/4-basic-components-of-an-online-course> (accessed May 8, 2021).
3. *Six Key Components of Effective Online Instruction*. (2021). Available online at: <https://www.gettingsmart.com/2017/01/six-key-components-effective-online-instruction/> (accessed May 9, 2021).
4. *10 Advantages of Taking Online Classes*. (2021). Available online at: <https://oedb.org/ilibrarian/10-advantages-to-taking-online-classes/> (accessed May 9, 2021).
5. *5 Advantages Of Online Learning: Education Without Leaving the House*. (2021). Available online at: <https://elearningindustry.com/5-advantages-of-online-learning-education-without-leaving-home> (accessed May 10, 2021).
6. *Blended Learning*. (2021). Available online at: https://en.wikipedia.org/wiki/Blended_learning (accessed May 10, 2021).
7. *What is Active Learning?* (2021). Available online at: <https://www.smartsparrow.com/what-is-active-learning/> (accessed May 11, 2021).
8. *Active Learning*. (2021). Available online at: https://en.wikipedia.org/wiki/Active_learning (accessed May 11, 2021).
9. *Engaged Learning*. (2021). Available online at: <https://www.centerforengagedlearning.org/engaged-learning/> (accessed May 11, 2021).
10. *What Is Personalized Learning*. (2021). Available online at: <https://www.understood.org/en/school-learning/partnering-with-children/school/instructional-strategies/personalized-learning-what-you-need-to-know> (accessed May 12, 2021).
11. Pressman RS. *Software Engineering: A Practitioner's Approach*. 5th ed. New York, NY: The McGraw-Hill Companies (2001).
12. *5 Common Problems Faced By Students In eLearning*. (2020). Available online at: <https://elearningindustry.com/5-common-problems-faced-by-students-in-elearning-overcome> (accessed May 12, 2020).
13. *Importance and Types of Online Learning*. (2021). Available online at: <https://www.eztalks.com/elearning/importance-and-types-of-online-learning.html> (accessed May 12, 2021).
14. *Types of Online Learning*. (2021). Available online at: https://www.fordham.edu/info/24884/online_learning/7897/types_of_online_learning (accessed May 13, 2021).
15. *Types of Online Courses*. (2020). Available online at: <https://online.uoregon.edu/types-of-online-courses-2/> (accessed May 13, 2020).
16. *Web-based Learning Management System*. (2021). Available online at: <https://www.paradisosolutions.com/web-based-learning-management-system> (accessed May 15, 2021).
17. *What is Web Conferencing and How does it Work?* (2021). Available online at: <https://startups.co.uk/what-is-web-conferencing/> (accessed May 13, 2021).
18. *What is Zoom and how does it work?* (2021). Available online at: <https://www.pocket-lint.com/apps/news/151426-what-is-zoom-and-how-does-it-work-plus-tips-and-tricks> (accessed May 13, 2021).
19. *How does VoIP and Skype work?* (2021). Available online at: <https://www.explainthatstuff.com/how-voip-works.html> (accessed May 14, 2021).
20. *How to Use Microsoft Teams for Free*. (2021). Available online at: <https://www.pcmag.com/how-to/how-to-use-microsoft-teams-for-free> (accessed May 14, 2021).
21. *What Is A Learning Management System? LMS Basics*. (2021). Available online at: <https://elearningindustry.com/what-is-an-lms-learning-management-system-basic-functions-features> (accessed May 14, 2021).
22. *Types of Learning Management Systems*. (2021). Available online at: <https://mindflash.com/elearning-glossary/types-of-lms> (accessed May 15, 2021).
23. *Web-Based VS Installed LMS: Which Is the Best LMS*. (2021). Available online at: <https://www.allencomm.com/blog/2017/01/web-based-vs-installed-lms/> (accessed May 15, 2021).
24. *The Top Open Source Learning Software*. (2021). Available online at: <https://elearningindustry.com/top-open-source-learning-management-systems> (accessed May 15, 2021).
25. *Massive open online course*. (2021). Available online at: https://en.wikipedia.org/wiki/Massive_open_online_course (accessed May 15, 2021).
26. *About MOOCs*. (2021). Available online at: <https://www.mooc.org/> (accessed May 16, 2021).
27. *MOOC: Advantages and Disadvantages*. (2021). Available online at: <https://www.igniteengineers.com/mooc-advantages-and-disadvantages/> (accessed May 19, 2021).
28. *Benefits and Challenges of MOOCs*. (2021). Available online at: <https://guides.library.utoronto.ca/c.php?g=448614&p=3404949> (accessed May 16, 2021).
29. *Self-Directed Learning*. (2021). Available online at: <https://www.uis.edu/online/getting-started/self-assessment/self-directed-learning/> (accessed May 16, 2021).
30. *How to Use Self-Directed Learning*. (2021). Available online at: <https://www.learnupon.com/blog/self-directed-learning/> (accessed May 16, 2021).
31. Garrison D. Self-directed learning: toward a comprehensive model. *Adult Educ Q*. (1997) 48:18–33. doi: 10.1177/074171369704800103
32. *LMS Scalability: What You Need To Know*. (2021). Available online at: <https://elearningindustry.com/lms-scalability-what-you-need-to-know> (accessed May 16, 2021).
33. *Scaling Online Learning: Obstacles on the Way to the Summit*. (2021). Available online at: https://evollution.com/programming/program_planning/scaling-online-learning-obstacles-on-the-way-to-the-summit/ (accessed May 17, 2021).
34. Sharma D, Karforma S. Risks and remedies in E-Learning system. *Int J Netw Secur Applic*. (2012) 4:51–9. doi: 10.5121/ijnsa.2012.4105
35. *7 Ways To Measure Your LMS Reliability*. (2021). Available online at: <https://elearningindustry.com/ways-measure-learning-management-system-lms-reliability-check-fulfills-business-goals> (accessed May 17, 2021).
36. *Security and privacy: Teaching in a Digital Age*. (2021). Available online at: <https://opentextbc.ca/teachinginadigitalage/chapter/9-9-the-sections-model-speed-and-security/> (accessed May 17, 2021).
37. *Quality of Service*. (2021). Available online at: https://en.wikipedia.org/wiki/Quality_of_service (accessed May 17, 2021).
38. Uppal M, Ali S, Gulliver S. Factors determining e-learning service quality: ELQ factors. *Br J Educ Technol*. (2017) 49:doi: 10.1111/bjet.12552
39. UNESCO. *Distance Learning Solutions*. (2021). Available online at: <https://en.unesco.org/covid19/educationresponse/solutions> (accessed May 13, 2021).