

E-Learning Based on Cloud Computing

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Abstract

Modern technology paradigms of learning allow educators the capacity to promote the development of highly professional human resources. For this reason, professors at higher educational institutions find new technology more and more valuable. The rapid adoption of cloud computing into pedagogical practice requires a professional to examine the technical capabilities of cloud-based learning services to pick the best educational solutions among accessible variations. In light of this, the present study gives a theoretical overview of e-learning cloud architectural layers and their implementation models in the education system. To assess the applicability of learning management systems (LMSs) to a collaborative distant learning paradigm, a study among educators of I.M. Sechenov First Moscow State Medical University (Russia), Prydniprovsk State Academy of Civil Engineering and Architecture (Ukraine) and Wuxi Institute of Technology (China) was carried out utilizing the Blackboard Learn LMS as a case study. This research includes 100 persons who tested the Blackboard Learn teaching skills. The performed analysis defined the critical benefits of using computer-based e-learning apps to arrange and support the educational process. Among them are comfortable methods of processing educational information, effective educational process organization, effective instruments for knowledge monitoring, and adequate security and confidentiality systems. The current analysis also sheds light on the advantages of implementing cloud-based e-learning in higher educational institutions as

producers of an integrated educational product. The research verified that integrating cloud computing in education leads to the progress of the training material and may significantly increase students' academic outcomes owing to current learning technologies, ideas, and tools.

Keywords Cloud computing, e-learning, distant education, cloud computing architecture

1 Introduction

In contemporary culture, appropriate education is crucial for business and socio-economic success [1]. The extensive use of different Internet services, particularly social networks, has boosted the digital literacy of the global population. Therefore, modern technology learning paradigms like mobile learning are becoming increasingly popular [2]. Worldwide trends in the growth of the digital economy have resulted in greater technical complexity and the extinction of many old professions due to the automation of human activities and the introduction of new personnel requirements. Now, the virtual world includes many labor relations and even employment sectors. As a result, creating new competencies and reforming the overall education system becomes required [3].

With the tremendous development of the Internet in educational activities, curriculum delivery has migrated from local PCs to online apps. Recent technology breakthroughs have encouraged institutions to create unique instructional techniques. New technologies offer higher education institutions numerous fascinating tools that may be utilized to enhance the educational process [4]. The extensive use of technology, continuously updated information, the necessity for students to access information everywhere, and the customization of education have led to the rise of remote learning, e-learning, and mobile learning. Wireless technology and mobile devices are crucial in popularizing these themes [5].

A key trend in universities has been the development of so-called Learning Management Systems (LMS), which are utilized as a shared platform on which students and professors may communicate digitally [6]. LMS offers

academic institutions good learning tools and facilitates the efficient organizing and exchange of scholarly information [4].

Cloud computing is among the rising technical advancements that may dramatically affect education by employing dynamic scalability and resource efficiency. The cloud-based e-learning model features a scale efficiency mechanism that delegates the responsibility of developing the e-learning system to cloud computing suppliers. This allows suppliers and consumers the chance to create a beneficial connection. For education, such a model becomes a tool that may save a large portion of expenditures for offering an innovative educational process. Partnerships and cost-effectiveness continue to be a privilege of cloud-based e-learning because academic institutions are responsible only for the learning process, content management, and knowledge delivery. At the same time, the vendor deals with the construction, maintenance, development, and management of the educational system. The cloud-based environment may operate on various hardware devices and facilitate the building of next-generation e-learning systems. Modern consumers do not need any specific understanding of cloud computing to connect their PCs or laptops to the server [7].

Various educational organizations are expanding the presence of e-learning in educational activities. Since e-learning typically demands the deliberate use of networked technology in educational processes, cloud computing is a good solution for academic institutions with fewer budgets to host and administer online learning systems. The advantages of cloud computing in education, particularly in e-learning, garner the attention of many developers and software suppliers [12].

Recently, many institutions, universities, and even schools have implemented cloud-based e-learning software in their educational process. However, many of them utilize them as support for their major learning management systems (LMS) [13]. The introduction of cloud computing into higher educational institutions' pedagogical practice generates a professional necessity to research the technical capabilities of cloud services to identify appropriate educational solutions

among analogs. In this respect, the present study aimed to prove the adaptation of cloud computing applications for e-learning and highlight the advantages of employing systems to ensure a quality educational process.

2 Methods

Today, cloud computing has become the primary technology that may present infinite computing for numerous social or economic applications [14]. At the current level of the educational sector's development, cloud computing technologies are cost-effective services that allow the production of learning quality [15]. The E-learning cloud symbolizes a new cloud computing technology transition to the e-learning field, which consequently develops educational infrastructure with all the required hardware and software computer resources [7].

E-learning cloud architecture may be generally separated into various tiers. - The infrastructure layer of e-learning is positioned in the lowest level of cloud service middleware and comprises information infrastructure and instructional materials. Information infrastructure comprises system software, information management systems, and universal software and hardware. Educational resources are generated from training materials developed in the conventional teaching paradigm and are dispersed across the educational system. Using the cloud-based e-learning paradigm, physical servers, storage, and networks create a virtualization group — a pool of physical hosts. The software resource layer is built by the operating system and middleware. Here, various software resources are connected to give a standard interface for e-learning software developers. Specialized apps are produced based on software resources and incorporated into the cloud, making them accessible. The resource management layer is essential for interaction between software and hardware resources. Service layer contains three tiers of cloud computing services designated as SaaS (Software as a Service), PaaS (Platform as a Service), and IaaS (Infrastructure as a Service).

2.1 SaaS (Software as a Service)

SaaS is a software license and delivery mechanism that distributes software goods to clients by request [16]. Its services are hosted by a cloud computing provider and are built of software apps [17]. SaaS offers services such as e-mail, conferencing software, and corporate programs, including enterprise resource planning, customer relationship management, and supply chain management [18]. A single application is executed on the server side and is accessible by one or many runs on the cloud services and various end-users or client companies. The most commonly recognized SaaS examples include salesforce.com, Google Apps, Dropbox, MailChimp, ZenDesk, DocuSign, Slack, and Hubspot [19]. SaaS is also considered a fundamental service paradigm to access the program over the cloud [20]. Artificial intelligence (AI) in SaaS is represented in the form of machine learning (ML), which is engaged in Machine-to-human processes [21]. The presence of AI in SaaS takes the shape of hyper-customization. It represents bespoke instructional material that evolved when the user worked with ML [22].

Cloud computing users do not alter data quality, integrity, and availability. They have to depend on security precautions established by cloud providers [23]. Thus, cloud service vendors' reputation primarily rests on fulfilling the Service Level Agreement they undertake throughout operational operations. To deliver the greatest

Nowadays, big enterprises are inclined to adopt several cloud application services, dubbed the Hazy Cloud process. Due to these measures, cloud service companies must lock their services occasionally, and customers should simultaneously transfer from one service to another. In any event, introducing vendor-user interactions always augments access to services, and both should endeavor to prove mutual security im- [19]. SaaS solutions give a constrained approach at the client end, making the server end considerably resourceful. In such a way, it provides minimum integrated control for service-based capabilities to the client's end-users [24].

2.2 PaaS (Platform as a Service)

PaaS gives the user an electronic environment for constructing cloud infrastructure utilizing platform-level and software-level resources such as operating systems and application platforms. PaaS services are generally employed because of the less optimum solutions or outcomes of IaaS or owing to the requirements included in the network IT applications [25]. In PaaS, AI accelerates connections between the ecosystem and the user [26].

2.3 IaaS (Infrastructure as a Service)

In IaaS, the cloud service provider shares a pay-as-you-go facility to access the numerous characteristics of network servers, computational applications, and storage via the Internet [27]. IaaS is an architecture that balances the quantity of resources given to the service with real users' demands. For this reason, IaaS utilizes a load balancer, PHP, and MySQL servers [28].

In the early phases of establishing a cloud architecture, cloud services were delivered online in three core modalities: SaaS, PaaS, and IaaS. Subsequently, such domain-specific services as BPaaS—business process as a service—arose [29]. In BPaaS, the function of AI is associated with the interaction between Education 4.0 and Cloud-based e-learning [28].

The final one, the application layer, works based on apps that integrate educational resources into the cloud-computing paradigm and assist in building interactive courses and disseminating learning materials. This process comprises content production and delivery, educational goals' construction, and knowledge assessment and management. The distribution of academic resources comprises instructional material and information resources in digital libraries and information centers [7] (Fig. 1).

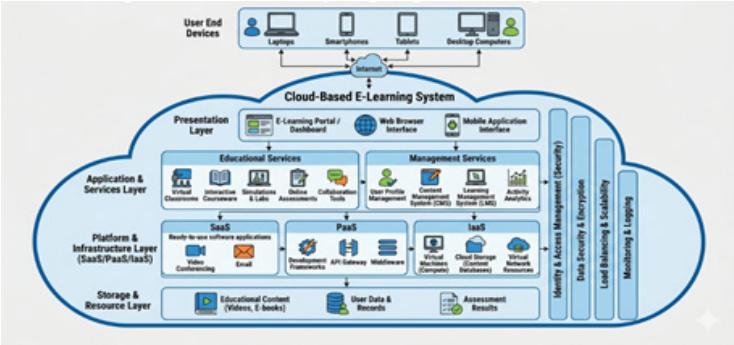


Fig. 1. E-learning cloud architecture

*Developed by the authors based on [7]

There are four typical examples of cloud deployment methods. All of them are illustrated in Fig. 2.

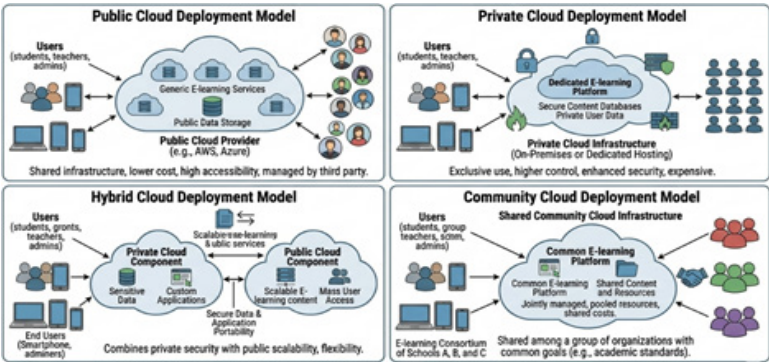


Fig. 2. Cloud deployment models

*Developed by the authors based on [19]

Cloud-based e-learning delivers user-centric adaptive hardware resources, a computing environment, and software services. In the cloud, customers may access digital services transparently at any time and anywhere [9]. Often, e-learning cloud systems consider educational institutions' needs regarding training resources' virtualization, centralized data storage, low operational costs, scalability, flexibility, and availability. Therefore, the cloud-based e-learning

architecture comprises the cloud management system, hardware and software computing resources, and services given by the cloud [22,30].

Most software suppliers deliver their services on cloud platforms. Blackboard Learning is one of the brightest examples of cloud-based LMSs that supply online education services. In a similar spirit, open-source e-learning applications are also hosted on different cloud platforms, such as Moodle Cloud [2].

3 Results and Discussion

Blackboard Learn is an open, cloud-based education platform that improves the learning experience by delivering online training possibilities in synchronous and asynchronous situations. In a synchronous environment, students and instructors are given the option to engage in real-time. A prominent example of synchronous technology is Blackboard Collaborate, where one may schedule study sessions, hold spontaneous conversations, and welcome guest lecturers. In an asynchronous setting, students may use the hourly calendar for reminders about impending activities [31].

Blackboard Learn enables learners to take three courses: online, hybrid, blended, and conventional, with extra web components (Fig. 3).

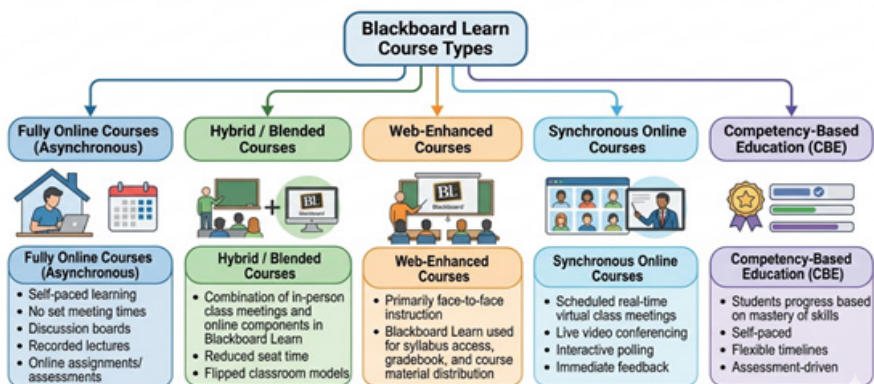


Fig. 3. Types of online courses in Blackboard Learn

Higher educational institutions should embrace digital technology in teaching and learning to allow learners to develop digital competence, which is essential to encourage innovation and employment. The educational process management in universities and colleges should incorporate the utilization of modern interactive teaching techniques based on

Innovative digital software [3]. Adopting a more flexible knowledge management system based on cloud services can enhance education quality. In addition, deploying cloud computing technologies is crucial for achieving the lifelong learning concept [15]. However, with the fast and widespread deployment of next-generation mobile networks (4G, 5G, 6G), the popularity of cloud computing in the educational sector will be boosted.

While e-learning is built on modern digital technology, it will not replace existing teaching techniques. At the same time, it may considerably boost the efficacy of education by deploying sophisticated technologies, concepts, and tools that provide new material, models, and teaching techniques. The key benefits of adopting cloud servers in the educational process are strong computing capabilities, large-capacity data storage, virtualization, and high availability and security of cloud services. The cloud-based e-learning architecture delivers tremendous computing power and ample data storage space by placing the computation and data in many dispersed machines. In the cloud computing paradigm, administrators protect the security of user data and, to the maximum degree feasible, manage unified data, distribute resources, balance load, install the software, and execute dependable real-time monitoring [7].

Due to decreasing enrollment rates and reduced physical presence of students in courses, numerous schools and institutions provide the chance to attend specific courses in a distant mode. Research on the adaptation of cloud-based e-learning in Malaysian institutions has found that the choice to deploy this model is mainly driven by the necessity and perceived utility of the technology. In the meantime, innovation is not significant in implementing cloud-based

e-learning. Cloud computing has become appealing to many educational institutions because it has numerous benefits, particularly geographic distribution and effective cost allocation related to automated systems and open-source software. Systematic communication between learners and instructors in diverse geographic areas enables the creation of vivid and engaging learning platforms, permits active group work, and implements more effective teaching approaches [33].

Despite the increasing emergence of cloud technologies in university teaching practices, there are questions regarding whether these technologies are employed as effective teaching tools or just as a store of electronic papers [6,34]. Results from various studies reveal that while many university personnel throughout the globe utilize LMS to varied degrees, the great majority cannot use the potential pedagogical advantages afforded by the program's full capabilities [6].

The cloud computing paradigm has transformed the computer science horizon and has drawn significant interest from academia, business, and government agencies. Recent technical breakthroughs such as the Internet of Things, Serverless Computing, Software-Defined Networking, and edge processing have opened new prospects for cloud computing and set the framework for expanding the digital economy. However, they have also generated a need for new research methodologies to assess and enhance approaches to scalability, elasticity, dependability, security, and resilience [35].

With the emergence of cloud computing technologies in higher education, many difficulties with security, privacy, poor professionalism, and sluggish Internet connections have developed. According to research conducted in Bangladesh [36], some significant variables that substantially affected the adoption of cloud computing at the University of Dhaka include lack of suitable infrastructure, service availability, and usefulness in education. Studies of the potential for using cloud computing in higher education in Sudan also highlight the problem of privacy and security [37].

Adopting cloud computing into academic practice is tied to technical preparedness and cultural considerations. Research towards a comparison between the Middle East and Europe regarding implementing cloud computing into the educational process has explained that European nations have a higher tendency to adopt advanced technologies. At the same time, the Middle East still prefers traditional ways of learning. As for security difficulties that are still to be handled, Europe already has specific centers for this objective. Middle Eastern nations, particularly Oman and Qatar, are still grappling with security challenges. In addition, cloud-based education in the Middle East is just beginning its first phase, whereas several European institutions are actively adopting modern educational technologies [38]. Numerous primary considerations impact the choice to employ cloud-based e-learning in a specific nation. Among these are perceived usefulness, convenience, trust, security, necessity, and purpose to learn in such a manner [11].

Conclusion

Modern technology paradigms of learning are becoming increasingly popular among instructors of higher educational institutions, whose activities are geared at training highly professional workers of the digital era. Cloud computing considerably influences the teaching and learning environment by utilizing dynamic scalability and resource efficiency, extending the bounds of educational opportunities, and ensuring the availability of educational services. Introducing advanced technology and training standards based on cloud computing provides a new level of remote education organization. The current paper gives a theoretical overview of the architectural layers of the e-learning cloud and its implementation models in the education sector. To investigate the adaptation of LMSs to a collaborative distant learning paradigm in 2019-2020 among instructors of I.M. Sechenov First State Medical University (Russia), Prydniprovsk State Academy of Civil Engineering and Architecture (Ukraine), and Wuxi Institute of Technology (China) experimental study was carried out using the Blackboard Learn application for interactive e-learning, creation of

online communities, and virtual knowledge exchange. This research enrolled 100 educators who were supposed to test the teaching capabilities of the Blackboard LMS. Within the investigation, the main advantages of using Blackboard Learn in organizing and supporting the educational process were outlined: convenient means of processing educational content, effective educational process organization, practical tools for knowledge monitoring, and adequate security and confidentiality system. Furthermore, the current article offers the

Benefits of implementing cloud-based e-learning in higher educational institutions. The study proves that introducing cloud computing into the educational process positively changes academic content quality and can considerably increase training efficiency due to updated learning technologies, concepts, and tools that render new teaching content, models, and methods.