P-ISSN 1991-8941
E-ISSN 2706-6703
Vol. 19, No. 2 (2025)

Journal of University of Anbar for Pure Science (JUAPS)

journal homepage: juaps.uoanbar.edu.iq

Open Access

Original Paper

Design and implementation of intelligent testing laboratories based on computer and engineering cloud

Khitam Abdulbasit Mohammed [1*]

[1]Department of Computer Network Systems, University of Anbar, College of Computer Science and Information Technology, Anbar, Iraq

ARTICLE INFO

Received: 26/09/2024
Accepted: 12/12/2024
Available online: 19/11/2025
December Issue
10.37652/juaps.2024.153919.1322

CITE @ JUAPS

Corresponding author
Khitam Abdulbasit Mohammed
khitam.abdulbasit@uoanbar.edu.iq

ABSTRACT

Lately, there has been a growing sense of alarm within the global community due to increasing concerns about the transmission of COVID-19 and the urgent need to contain the virus. An increasing number of higher education institutions worldwide have opted to suspend in-person classes. This global shutdown of face-to-face learning is a response to the escalating concerns about the spread of the coronavirus. Moreover, the pandemic has exposed new weaknesses in education systems worldwide. The requirements to accomplish this task, such as internet access and smart mobile devices, are readily available, and the field of cloud computing is undergoing significant development. On this basis, educators are exerting extra effort to compensate for the shortfall caused by the crisis. In this article, we designed a platform that simulates a laboratory, where students execute their work on four different topics: C++ lab, Python lab, Materials lab, and Civil Engineering lab. The designed labs can fit over 50 students simultaneously without lagging. Data transmission and execution speed were tested, yielding excellent results. Great results were achieved when students logged into the system at different times to complete their academic tasks electronically using the programming languages discussed in this paper. The final outcomes highlighted how well the students' login times aligned with the execution times of the programs.

Keywords: *Cloud computing, Computer Science, Engineering, Laboratory, Remote education*

1 INTRODUCTION

The biggest change took place in the education sector due to remarkable developments in information technology (IT), particularly with the advent of the internet. There has been an expansion in the global coverage of online education. Currently, the majority of distance education courses lean towards the use of e-learning portals, which have gained prominence in recent years due to the rise of virtualization and cloud technologies [1]. Distance education has also seen many institutions offering the same, avoiding traditional physical structures and embracing the benefits of cloud computing. The cost-effective nature of cloud-based education concepts is making them competitive with other distance education services and platforms. The primary factors driving cloud education are the need for cost minimization, increased access, and enhancements in overall education [2]. Remote computer-based labs have also been investigated to seek better models and overcome deficiencies. Researchers are studying the utilization of this technique compared to the growth of education in comparison to the amount of expansion taking place in the educational process [3].

The introduction of such forms as E-learning, distance learning, and mobile learning is regarded as a specific consequence over a number of factors. These factors encompass the generalization of technology applications, the need for continuous updates of information, the increasing need to access information anywhere, and the growing desire for education to be customized for the learner. Such advanced technologies, like wireless and mobile gadgets, have been instrumental in the growth of these forms of learning [4]. Review analysis shows that the great change is connected with the use of CoT technology and digital resources, especially within digital education. This was a direct consequence of prolonged school closure, and most educational institutions turned to an e-learning approach to assist their children in furthering their studies. Such institutions are also taking actions in order to minimize the effect of the current emergency [5].

Cloud computing technology is an innovative technology that is brought on by the internet and future educational practices may greatly benefit from this technology. With cloud technology deployed, the adoption of e-learning becomes efficient due to its dynamic elasticity in the utilization of resources. Here, the construction of the e-learning system is shifted to cloud computing so that providers can utilize the scale efficiency model. This model makes it possible for both the providers and users to construct a win-win situation [4].

Recently, there has been a noticeable change in most universities concerning the adoption of Learning Management Systems. These are various digital venues where instructors and those being instructed interact and communicate. It provides students with institutional tools that are not only effective in the educational process but also facilitate the efficient collection and dissemination of academic knowledge [6].

Conducting experiments through a remote laboratory offers several advantages over traditional practical activities. First, a larger group of students from multiple institutions can benefit from these labs. Second, remote labs offer a wide range of equipment, such as computer network simulators, civil engineering beams, and spectrometers, that are available to students anytime and anywhere. Third, remote labs can generate a significant amount of data that can be collected and analyzed. Fourth, students are afforded more time to interact with the equipment, leading to a deeper understanding of the subject matter. Finally, students can use the results obtained by previous groups to develop better hypotheses. All data and conclusions are also made available to students [7].

The paper's overview structure is as follows: Section 2 provides a review of similar studies from the literature, Section 3 outlines the methodology used in our work, Section 4 presents and explains the results obtained, and Section 5 summarizes our work and draws a conclusion.

2 RELATED WORK

In recent studies, more focus has been given to the spread of internet-based learning resources and activities. The lack of attention is, however, understandable in circumstances that require lab work [8]. People are busy looking for courses that do not have a "heavy" curriculum and can be earned online. Many such subjects can be taught on the world's internet systems, but the science and engineering fields require practical experience to fully grasp the concepts. It is then necessary to address problems and examine perspectives related to the performance of laboratory-based activities in an online mode.

Mishra et al. contributed to the analysis of educational cloud technology usage in institutions of higher education, as well as online and distance education, in 2019. Their results showed that these educational spheres utilize cloud computing services, but they do not function optimally [9]. Within another undertaking, Abramyk examined the management, finance, and legal aspects of cloud computing in regard to the needs of virtual education in 2015 [10]. These papers examine the potential benefits of utilizing cloud computing in education, while also addressing key issues such as costs, organization, and legal aspects. Xu et al. presented a virtual laboratory system called V-lab that enables hands-on interaction in a virtual environment by employing virtualization techniques [11]. They applied Xen as well as KVM implementation over the Cloud, where the system was secured with remote access using OpenVPN. Submitted learners are able to access shared virtual devices and perform their folded-over activities. Another study, Clouds and Their Technology, published in 2020, focused on some of the aspects regarding these technologies, such as ease of use, functionalities, deployment scenarios, and a range of others [12]. Later in 2022, Xie et al. shared a breakthrough concept that can greatly enhance the functionality of remote laboratories and improve their availability [13].

A study in 2016 by Patil focused on the behavioral model of e-learning prior to the COVID-19 pandemic. The research was done on cloud computing and focused on the architecture of its platforms by integrating prospects of an electronic learning system [14]. Additionally, Chen and his colleagues published a review in 2010 that examined various modes of online delivery for the growth of virtual and remote labs [15]. These researchers present a valuable understanding of the opportunities and challenges of virtual learning, beliefs in technology use in education. With the inclusion of necessary labs, cloud technology becomes an effective way of acquiring skills in different areas of computer science. This has been demonstrated by Salah et al. (2015), who used cloud technology to teach seniors a cybersecurity course through a virtual classroom where two campuses were connected via live audio and video [16]. Likewise, Holovnia et al. performed a study of cloud platforms suitable for supporting operating system courses in 2021. They conducted a survey on the use of virtual online laboratories with Linux online environments [17].

The utilization of cloud-based distance e-learning is not limited to certain fields of science, like engineering or computer programming. Other fields can also benefit from this technology. Several research studies have been conducted on distance learning for important subjects, such as physical culture and sports. Denysova et al. have analyzed some of the issues related to the selection of cloud technologies for the remote education of professionals in the field of physical culture and sports [18]. A more recent study has shown that more advanced and visual technologies can be integrated with distance e-learning to achieve better outcomes. They used augmented reality to facilitate the delivery of information to 11th-grade students in the chemistry subject [19].

3 METHODOLOGY

In cases of necessity, disasters, distance learning, lack of physical components, or an increase in the number of students, a mechanism to manage laboratories and operate them accurately and without obstacles should be developed to reduce actual lab requirements. In this research, a website of scientific laboratories was designed for three specializations (Computer Science, Materials, and Civil Engineering)

Each person was assigned a username and a password to access the site. The site was designed to be browsed using a desktop, a mobile device, or any other smart device connected to the Internet from different locations. The site can be used by a large number of programmers without delay in timing between users. This project was programmed with (VIS2019) using C# ASP. Figure 1 illustrates the flowchart of the designed system.

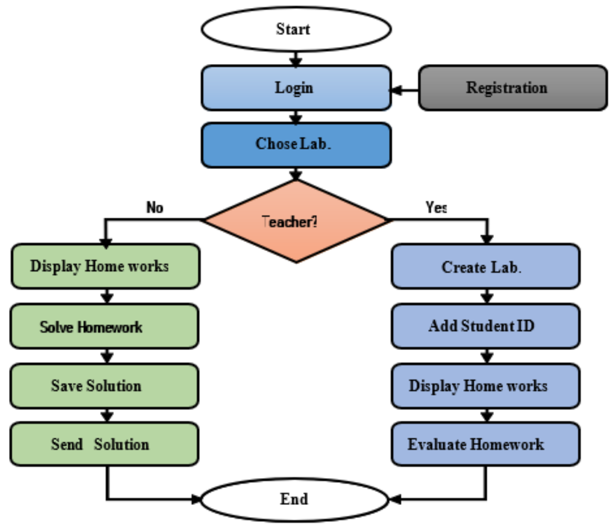

Fig. 1 Flowchart of the proposed approach

A computer science lab was designed to include two programming languages (C++ and PYTHON). The programmer (student) can write his own code, execute it immediately, and view the results in real time.

In the Materials lab, students act as engineers and are responsible for selecting the most suitable building materials for a construction project. To ensure the construction of an energy-efficient home, students were assigned to measure the specific heat capacity of various building materials and determine which materials meet the necessary criteria. Additionally, they conducted a cost analysis to determine the most economical material to use in the project.

The Civil Engineer laboratory provides a historical and practical background in load strain basics through various primary structures, including individual I-beams, tubes, and aerofoils with strategically placed strain gauges. Students were able to load each structure and measure the strain gauges at each position to determine the amount of strain on the component for different loading conditions. This practice helps the students get versed in a rather complicated topic thoroughly but gradually and in an exciting way. The process of the laboratory is presented in Table 1.

The website operates as follows: When the site is opened, the user is logged in with the username and password provided in the registration phase. Then, the laboratory is selected according to its specialization. If the logged-in user is a teacher, a page will be displayed that allows them to create a new class or lab, add students,

Table 1 Processes of labs

Lab	Processes
Computer Science lab	C++ languages for structure programming
	PYTHON languages for structure programming
Materials lab (students)	Act as engineers in determining which materials are the most suitable options for a construction project.
	Compute the specific heat capacity for different building materials.
	Conduct an economic analysis to identify the most suitable material to be utilized in their construction undertaking.
Civil Engineering lab	Progression of primary structures
	Individual I-beam
	Load each structure
	Take note of the strain values at every strain station.
	Upon the application of each structure and the acquisition of strain values at each strain station, an analysis is made regarding the extent of strain that each part is being subjected to under various loads.

and view students' accomplishments on their panels. If a student logs in, then he can use the available labs assigned to him by his teacher. The students can also perform their homework and submit it for review.

In this work, four types of data tables were designed, as shown in Figure 2 and described as follows:

1. Teacher's table: includes a database of teachers' names, passwords, email, mobile numbers, and CVs.

2. The student's table: includes a database of students' names, passwords, email, and mobile numbers.

3. Date table: includes a database for the dates of laboratories and the date on which the student and teacher were logged in.

4. Laboratory table: consists of the laboratory number, laboratory name, laboratory storage field, and evaluation field.

5. Fact table: includes the teacher and student information combined (teacher number and student number). It also includes the laboratory number and the date on which the users are logged into the cloud.

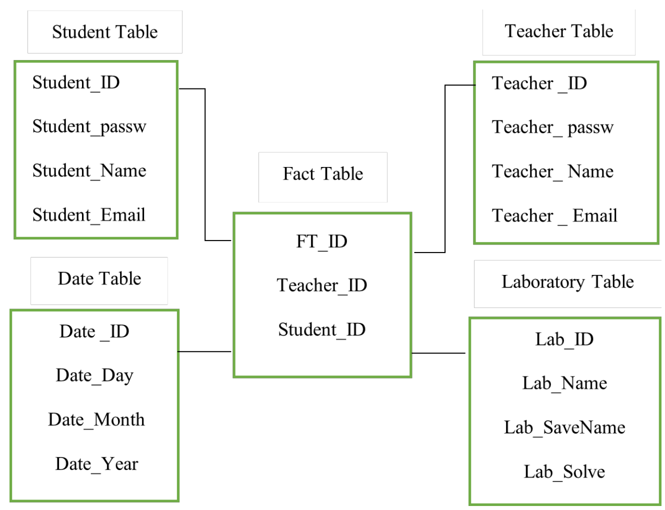

Fig. 2 Data schema of the proposed approach

4 RESULTS AND DISCUSSION

In this work, the results were calculated in two stages, as follows:

A. Data transmission over the network At this stage, the time it takes for data to travel over the network was calculated separately for each application, as shown in Table 2.

Table 2 Data transmission time of each lab

Data (KB)	Time (Second)			
	C++ Lab	Python Lab	Materials Lab	Civil Engineer Lab
200	0.0041	0.0020	0.0293	0.0206
512	0.0087	0.0212	0.0879	0.0785
700	0.0390	0.0101	0.2609	0.1069
1024	0.6590	0.2181	0.8220	0.6188

The differences in laboratories, given the differences in language used and the multiple fields, indicate that the C++ lab is the least efficient in data transfer, followed by Python, the Materials lab, and finally the Engineering lab. The Engineering lab ranks first regardless of the laboratory type. We note that the relationship between the raised and grafted parties has ended.

B. Execution Time In this section, the execution time was calculated for each code written by a user over the network according to the application required, as shown in Table 3. The table shows the effect of the number of students present in the laboratories (C Plus, Python, Material, and Engineering) on the time required to download the data. We note a direct relationship, where more students in the laboratory indicate a greater time required to download data. The engineering lab also ranked first in terms of timeouts, according to the number of students.

Table 3 Data transmission time of each lab

No. of Students	Time (Second)			
	C++ Lab	Python Lab	Materials Lab	Civil Engineer Lab
1	0.2880	0.5713	1.5694	1.5105
10	0.4928	0.7549	1.6461	1.8041
25	0.8735	1.1689	1.8609	2.0611
50	1.1227	1.8476	2.1041	2.1798

5 CONCLUSION

In view of the development in the field of technology and the trend worldwide toward electronic learning and study, a platform that simulates a laboratory for students to execute their work on four different topics, including C++ lab, Python lab, Materials lab, and Civil Engineering lab. The designed labs can fit over 50 students simultaneously without lagging. Data transmission and execution speed were tested, and they showed acceptable results. The results also showed varying percentages according to the different laboratories; more functions used indicate greater transfer of data, as well as a reduction in time. Moreover, when the number of students present in the laboratory is greater, the proportionality is direct with the data, as well as the time saved.

ACKNOWLEDGEMENT

N/A

FUNDING SOURCE

No funds received.

DATA AVAILABILITY

N/A

DECLARATIONS

Conflict of interest

The author declare no conflict of interest.

Consent to publish

Authors consents for publication.

Ethical approval

N/A

REFERENCES

[1] Broisin J, Venant R, Vidal P. Lab4CE: a Remote Laboratory for Computer Education. International Journal of Artificial Intelligence in Education. 2015;27(1):154–180. 10.1007/s40593-015-0079-3

[2] Balobaid A, Debnath D. A Novel Proposal for a Cloud-Based Distance Education Model. International Journal for e-Learning Security. 2016;6(2):505–513. 10.20533/ijels.2046.4568.2016.0064

[3] Zhang Q, Guo H. Investigation on Innovative Models of Computer Laboratories Based on Cloud Computing. Procedia Computer Science. 2023;228:383–390. 10.1016/j.procs.2023.11.044

[4] Talan T. The Effect of Mobile Learning on Learning Performance: A Meta-Analysis Study. Educational Sciences: Theory & Practice. 2020;20(1):79–103. 10.12738/jestp.2020.1.006

[5] Abu Talib M, Bettayeb AM, Omer RI. Analytical study on the impact of technology in higher education during the age of COVID-19: Systematic literature review. Education and Information Technologies. 2021;26(6):6719–6746. 10.1007/s10639-021-10507-1

[6] Papadakis S, Kalogiannakis M, Sifaki E, Vidakis N. In: Access Moodle Using Smart Mobile Phones. A Case Study in a Greek University. Springer International Publishing; 2018. p. 376–385. 10.1007/978-3-319-76908-0_36

[7] Wu W, Plakhtii A. E-learning based on cloud computing. International Journal of Emerging Technologies in Learning (IJET). 2021;16(10):4-17

[8] Papadakis S, Kalogiannakis M, Sifaki E, Vidakis N. Evaluating Moodle use via Smart Mobile Phones. A case study in a Greek University. EAI Endorsed Transactions on Creative Technologies. 2018;5(16):156382. 10.4108/eai.10-4-2018.156382

[9] Mishra JP, Panda SR, Pati B, Mishra SK. A novel observation on cloud computing in education. International Journal of Recent Technology and Engineering (IJRTE). 2019;8(3):5262-74

[10] Abramek E. Distance education with the use of cloud computing. Studia Ekonomiczne. 2015;(234):9-20

[11] Xu L, Huang D, Tsai WT. Cloud-Based Virtual Laboratory for Network Security Education. IEEE Transactions on Education. 2014;57(3):145–150. 10.1109/te.2013.2282285

[12] Bazarbaevna BS. USE OF" CLOUD TECHNOLOGIES" THAT STORE AND TRANSMIT ELECTRONIC INFORMATION IN DISTANCE LEARNING. European Journal of Research and Reflection in Educational Sciences Vol. 2020;8(9)

[13] Xie C, Li C, Sung S, Jiang R. Engaging Students in Distance Learning of Science With Remote Labs 2.0. IEEE Transactions on Learning Technologies. 2022;15(1):15–31. 10.1109/tlt.2022.3153005

[14] Patil P. A study of e-learning in distance education using cloud computing. International Journal of Computer Science and Mobile Computing. 2016;5(8):110-3

[15] Chen X, Song G, Zhang Y. Virtual and Remote Laboratory Development: A Review. In: Earth and Space 2010. American Society of Civil Engineers; 2010. p. 3843–3852. 10.1061/41096(366)368

[16] Salah K, Hammoud M, Zeadally S. Teaching Cybersecurity Using the Cloud. IEEE Transactions on Learning Technologies. 2015;8(4):383–392. 10.1109/tlt.2015.2424692

[17] Holovnia OS, Oleksiuk VP. Selecting cloud computing software for a virtual online laboratory supporting the Operating Systems course. CTE Workshop Proceedings. 2022;9:216–227. 10.55056/cte.116

[18] Denysova L, Shynkaruk O, Usychenko V. Cloud technologies in distance learning of specialists in physical culture and sports. Journal of Physical Education and Sport. 2018;18:469-72

[19] Nechypurenko PP, Semerikov SO, Pokhliestova OY. Cloud technologies of augmented reality as a means of supporting educational and research activities in chemistry for 11th grade students. Educational Technology Quarterly. 2023;2023(1):69–91. 10.55056/etq.44

How to cite this article

Mohammed KA. Design and implementation of intelligent testing laboratories based on computer and engineering cloud. Journal of University of Anbar for Pure Science. 2025; 19(2):171-176. doi:10.37652/juaps.2024.153919.1322

