**GHANA COMMUNICATION TECHNOLOGY UNIVERSITY (GCTU)**

**FACULTY OF ENGINEERING**

**DEPARTMENT OF COMPUTER ENGINEERING**



***Topic:***

DESIGN AND DEVELOPMENT OF AN ENHANCED E-LEARNING PLATFORM FOR AN INTERACTIVE EDUCATIONAL EXPERIENCE

A Project Work Submitted in Partial Fulfillment of the Requirements For

BSc. in Computer Engineering

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APRIL ,2024

**CHAPTER ONE**

**INTRODUCTION**

**1.1 Overview**

E-learning is a learning system based on leveraging the capabilities of technology in teaching and learning practices. It has been on the rise in the past few years. Many e-learning platforms have been developed to solve problems that arose due to the pandemic. According to the Ghana Journal of Higher Education, the modern landscape of higher education is undergoing a shift towards digital platforms, allowing for a wider accommodation of students across a relatively broader geographical area for teaching and learning. Amidst the necessities that arose because of the pandemic, e-learning rose to become a basic form of education at all teaching levels, which actually led to an increased accessibility and flexibility and also enabled a broader reach for students across different locations. However, there is the question about the sustainability of this e-learning trend post-pandemic, and whether there will be a return to traditional teaching and learning methods, or that the development of e-learning platforms will be continued by innovators.

The emergence of e-learning in the traditional teaching and learning presents its own sets of opportunities and challenges. Gyamfi and Addo discuss the limitations of the traditional model, especially in addressing the modern demands of education. This approach has struggled to accommodate the evolving needs of the modern digital age, particularly in providing access to education, especially in remote regions, contributing to a gap in effective online learning as compared to traditional learning. They emphasize the importance of acknowledging the limitations of traditional teaching methods and embracing innovative approaches to education, such as e-learning. One such approach would be in the development of a comprehensive, integrated learning platform that caters to the modern demands of education:- personalize the learning experience for each student, catering to their individual strengths and weaknesses; incorporate opportunities for students to develop critical thinking skills through interactive activities, simulations and project based learning;developing of digital literacy skills as well as fostering collaboration and communication among students and tutors.

There are many such e-learning systems in the world we live in today. Such platforms like Udemy, ALX SE, Edureka, Scrimba, Harvard Extension, among others, have played a vital role in facilitating access to educational resources and opportunities (educational democratization), however, these platforms often focus on specific niches or cater to a more individual learner journey.

Kim, Lee & Yoon came up with a model to guide the design and development of an e-learning platform so it would be successful. They suggest five factors that contribute to the success of an e-learning platform.These are;

1. system quality - this is the functionality, reliability and usability of the e-learning platform
2. lecture content - referring to the quality, relevance and accessibility of learning materials on the platform.
3. teaching quality - which is the effectiveness on the lecturer's part in delivering educational content.
4. online interaction - refers to the level of engagement and interaction among students, instructors and course materials.
5. achievements - which are the tangible outcomes attained by students and instructors in relation to predefined learning objectives and performance standards that have been set.

By focusing on these core principles, we aim to create an integrated teaching and learning environment using GCTU as a case study. The internet is the perfect tool for learning, as it offers flexibility and expediency to learners at the same time offering endless opportunities for innovative teaching.

**1.2 Problem Statement**

This project proposes the development of a comprehensive, integrated e-learning platform to enhance teaching and learning in Africa. It will address the challenges of student location and accessibility while remaining cost-effective in the long term. Universities in Ghana, especially, GCTU face challenges in with growing student population. There is also the limited accommodation on campus as well as around campus that create a bottleneck, hindering access to education for many qualified students. Furthermore, the need for providing quality education to individuals in remote regions and also expanding the university’s reputation or reach beyond the Ghana geographical borders is also there.

ELearning provides a very promising solution to this challenges by reducing the reliance on physical classrooms, thereby enhancing access to education for students in remote areas and also expand the universities global reach. It will solve the problem of accommodation constraints by offering courses online, eliminating the need for everybody to come to campus at once. Also students in remote areas can access the quality education by using the e-learning platform, regardless of their location. This bridges the geographical gap and allows for fair and equal access to quality education. Finally, the university would be able to extend its wings and offer access to education to students worldwide. Harvard University’s extension school, for instance, offers a variety of online courses and even full degree programs to learners worldwide. This move by Harvard, shows that they recognized the limitations of traditional educational models in meeting the demands. This would increase the university’s international recognition and would contribute in creating a global learning community, whereby students from different countries worldwide can collaborate and learn together.

**1.2.1 Limited Accommodation and Accessibility Challenges at GCTU**

This university faces a significant challenge in providing adequate on-campus housing for its student population and the ones available around campus are costly. This results in a large portion of the students body residing far from campus, often at least 10 kilometers away. This geographical distance creates a barrier to traditional in-person learning, giving that lectures start at 8 am, it forces students to make long and potentially expensive and exhausting daily commutes to attend lectures.

**1.2.2 The High Cost of Existing Solutions**

While third-party video conferencing platforms like Zoom or TeamViewer provide an option for remote learning, the ongoing costs associated with these services could result in a substantial financial challenge for GCTU. For a technical institution like GCTU, which encourages innovation and seeks to capitalize on its own experience, this is particularly concerning.

**1.2.3 The Need for a Custom, Cost-Effective E-Learning Platform**

A comprehensive e-learning platform that is specifically built to cater for GCTU's particular circumstances is important. This platform would be required to provide top priority to features like:

Video-conferencing: This feature would aim to facilitate real-time interaction and collaboration between instructors and students regardless of location.

Flexibility and Accessibility: This feature would aim to cater to the different learning needs of students by offering asynchronous learning opportunities alongside live lectures.

Cost-Effectiveness: This approach would aim to eliminate ongoing licensing fees for external video conferencing platforms, saving GCTU valuable resources.

**1.3 Research Aim and Objectives**

**1.3.1 Research Aim**

The main objective is to develop an interactive e-learning platform.

**1.3.2 Specific Objectives**

1. Since the platform allows students to access university resources, we need to create an index of all these resources, including recorded lecture sessions, per course, per year.

b. We also want to make sure all students, you'd be able to access the platform and all of its features.

**1.4 Significance of study**

The COVID-19 pandemic accelerated the shift towards digital learning, as highlighted by research conducted by Jakhar et al. (2020). Even though many schools are trying to transition back to face-to-face or in-person teaching and learning, the need for having a flexible and accessible learning solution still remains a priority. In a similar research conducted by the students of GCTU last year (2023), Adagobo et al, proposed that successfully developing a platform that serves in the context of e-learning would serve the university in improving learning procedures on campus. Implementing a hybrid approach to learning, combining the positives of asynchronous learning and synchronous learning would greatly improve teaching and learning in the school. Students residing far from campus or juggling work and studies can access course materials and complete assignments on time, and since some students grasps concepts quickly, while others benefit from revisiting materials and practicing at their own pace, the features incorporated on this platform would allow them to focus on understanding before moving on. Some students also prefer visual learning through recordings, while others benefit from interactive activities. This hybrid approach would cater to these different learning styles.

**1.5 Scope and Limitation**

**1.5.1 The scope of this research**

The project will focus on providing a solution for a comprehensive online learning module for Ghana Communication Technology University.

**1.5.2 The limitations of this research**

1. The initial development phase will focus on core functionalities and will need further iterations to incorporate more advanced features.

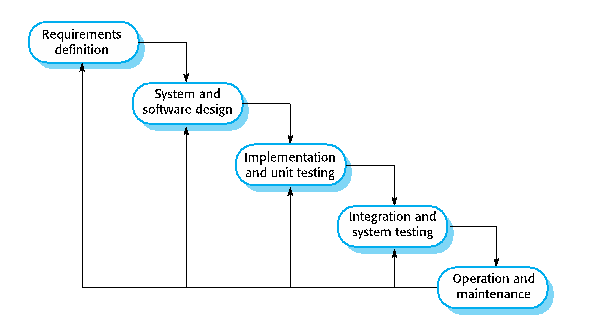
2. It will also be piloted with courses for the Faculty of Engineering, as scaling it up for university-wide adoption would require further planning and resource allocation.

3. Also external factors such as lack of reliable internet connectivity and lack of reliable power supply / electricity could impact its effectiveness.

**1.6 Brief Methodology**

**1.6.1 Design Concept**

The project would employ the Waterfall Software Development model, which would allow for a linear sequential development. The module would guide us through requirement analysis, design, development, testing, deployment then maintenance, inn that order. The benefits of this approach allows for the project to flow smoothly from start to finish, avoid bottlenecks, and would help us meet deadlines. Manzor Ahmad et al, (2015) concluded that this module is recommended for strict deadlines and projects with a good design process.



*Figure 1.1 The Waterfall Software Development Life Cycle*

**1.6.2 Software required**

1. Ubuntu 20.04LTS Operating system on Windows Subsystem for Linux
2. Microsoft Windows 11 pro
3. Visual Studio Code for Windows as a text-editor for developing both client-side and server side
4. Docker as a containerization platform that will allow us to package our application and its dependencies into self-contained units for easy deployment.
5. Chrome, Firefox Web Browsers

**1.6.3 Frameworks and Libraries**

1. Web Real Time Communication (WebRTC) technology
2. NodeJS to serve as the runtime environment for our server
3. ExpressJS as our web Framework
4. Socket.io for real-time bidirectional communication

**1.6.4 Hardware Requirements**

1. Processor (CPU):

Minimum: Intel Core i5-8th Gen or AMD Ryzen 5 3rd Gen (or equivalent)

Recommended: Intel Core i7-10th Gen or AMD Ryzen 7 3rd Gen (or equivalent)

1. RAM:

Minimum: 8GB DDR4 RAM

Recommended: 16GB DDR4 RAM - This would allow us to run multiple development tools smoothly

1. Storage:

Minimum: 256GB SSD for faster loading times and overall performance

**1.7 Organization of Project**

The project is organized as follows: Chapter 1 covers the introduction, study background, issue description, major and secondary objectives, significance of the study, scope and limitations, process, and project organization. In Chapter 2, the literature review is discussed in order to offer an analysis of relevant and current research studies. The project's methodology is thoroughly discussed in Chapter 3. This is an extended version of the brief method from chapter 1. Chapter 4 covers outcomes and analysis, or the evaluation and analysis of results. Chapter 5 is meant to be the conclusion.

**CHAPTER TWO**

**LITERATURE REVIEW**

**2.1 Overview**

This chapter conducts a comprehensive review of the existing literature relevant to the field of study. It lays the foundation for the proposed project by by providing a detail analysis of each of the projects parts. This chapter explores the theoretical frameworks and methodological approaches used in earlier studies. It offers an evaluation of of relevant projects pertaining to WebRTC (Web Real Time Communication), SSR (Server Side Rendering), Scalable Database management Systems and the use of ODM (Object Data Modelling) libraries, Containerization, System architecture design to avoid SPOF (Single Point of Failure) as well as Web Sockets. Reviews in this chapter are drawn from online resources and journal publications.

**2.2 Current Issues of Concern**

The university system in Ghana is having a hard time keeping up with the increasing number of students enrolled. The restricted housing options on and around campus leads to bottlenecks, and students in remote locations frequently do not have access to high-quality educational programs. Universities also find it difficult to have a solid worldwide reputation and reach outside of Ghana. These problems undermine both the overall influence of Ghanaian institutions and educational equity.

Furthermore, the increasing demand for flexible and accessible learning options adds another layer of complexity. Students are looking for educational options that work with their hectic schedules and geographic constraints. This increasing demand for flexibility may not be met by traditional classroom environments.

**2.3 Definition of Related Areas**

This section reviews detailed definitions that are closely related to the project topic and scope, aiming to make things clearer and further understanding of the project.

**2.3.1 WebRTC (Web Real Time Communication)**

WebRTC, which stands for Web Real-Time Communication, empowers peer-to-peer associations without the required for third-party servers. Information sharing over WebRTC is straightforward, supported by WebRTC APIs, and accessible at many stages thanks to its simplicity. At first, servers are required for clients to set up associations. After the initial setup, clients can talk directly to each other, without the server involved. When a client sends data to the signaling server, the server transfers this data to the other client. After accepting this information, the client stores it locally. In this way, this client sends its claim information to the server, which transfers it to the other client. This trade guarantees both clients are mindful of each other, encouraging an association foundation. Signaling servers, utilized for this information trade, are standard servers with the sole reason of encouraging client information trade. The method of exchanging information from one client to another in WebRTC is called signaling. In WebRTC session establishment, the initial step is offer generation. A client initiating communication creates an offer, typically a JavaScript object encapsulating Session Description Protocol (SDP) data. The Session Description Protocol (SDP) embedded within the offer specifies media capabilities, such as video and audio codecs supported. The client sends this offer to the signaling server, which forwards it to the other client. Upon receiving the offer, the other client stores it locally and constructs an answer containing its own SDP information.. This answer, also transmitted via the signaling server, details the recipient's media capabilities. While both parties now possess a mutual understanding of each other's media offerings, an additional exchange of data, termed ICE (Interactivity Connection Establishment) candidates, is necessary to establish the peer-to-peer connection. Clients give URLs of these servers to the WebRTC API to get ICE candidates. As the client makes an offer, ICE candidates are recovered from the servers. These candidates are at that point sent to the other client by means of the signaling server. The same handle happens when creating answers. Once both clients have each other's SDP information and ICE candidates, they can build up a coordinate peer-to-peer association. Information transmission through WebRTC APIs from that point happens straightforward between the clients, empowering efficient and secure real-time communication.

**2.3.2 Web Sockets**

Web Sockets allow for two way communication, between a client like a web browser and a server through a persistent, full-duplex connection. Unlike HTTP requests where the client typically initiates communication and the connection closes after each response, WebSockets remain open, allowing both the client and server to exchange messages at any time. This back and forth communication is ideal for applications requiring low latency real time updates, such as chat platforms, online games or collaborative editing tools. By using a handshake process (“HTTP upgrade request” and “WebSocket Handshake”) to establish connections, Web Sockets can efficiently receive data in both directions without the need for repeated setup. This efficiency makes Web Sockets more effective for real time communication compared to methods like polling or long polling. In summary Web Sockets offer a solution, for creating web applications that demand immediate responsiveness and minimal delays.

**2.3.3 Server Side Rendering**

Server-side rendering (SSR) is a procedure that renders a web page on the server instead of within the browser. When a website is rendered on the server, a completely rendered page is sent to the client and the client's JavaScript bundle locks in and empowers the Single Page Application system to function.  Server side rendering (SSR) is a method employed in web development where the server dynamically creates the HTML content of a web-page and sends it to the clients browser. This differs from client side rendering, where the browser uses JavaScript to generate the HTML content after receiving HTML from the server.In SSR, when a user asks for a web page, the server handles the request, collects the data from a database or external APIs, and then generates the HTML content incorporating this data. The entire HTML page is then transmitted to the client's browser for display without any processing. This approach can lead to quicker initial page loading times. Improved search engine optimization (SEO) since search engines can easily scan and index the HTML content. SSR is frequently utilized in web applications developed with server side technologies like Node.js, Django, Ruby on Rails and PHP. It proves advantageous for websites with content or dynamically generated content where SEO and performance play vital roles. Nonetheless implementing SSR may add complexity to development and up keep efforts as it necessitates handling of server side and client side logic to ensure consistency and optimal performance, across platforms and devices.

**2.3.4 Success of e-learning platforms**

The rise of online learning platforms can be explained by several key factors. First, their on-demand access model grants learners anytime, anywhere learning, enabling them to progress at their own pace. Second, eLearning platforms offer a varied content library, catering to various learning preferences through multimedia elements like quizzes, interactive videos, and simulations. These elements promote increased learner engagement and improve knowledge retention. Finally, the inherent scalability and adaptability of eLearning platforms allow them to effectively serve a wide range of learners with diverse learning needs. Research conduction by S.Kim et al(2015) suggests that five core principles significantly contribute to the success of an eLearning platform:

1. System Quality: This encompasses the platform's technical functionality, reliability, and user-friendliness. Here, factors like intuitive interface design, responsiveness, and seamless content delivery are crucial.
2. Content Quality: This refers to the quality, relevance, and accessibility of learning materials hosted on the platform. Content should be well-organized, current, and aligned with established learning objectives.
3. Instructional Design: This focuses on the effectiveness of the instructional methods employed in delivering the learning content. This includes factors like clear learning objectives, well-structured content delivery, and the use of appropriate pedagogical approaches.
4. Online Interaction: This emphasizes the level of engagement and interaction within the platform. This includes fostering communication and collaboration among learners, instructors, and the learning materials themselves through discussion forums, group activities, and interactive assessments.
5. Learning Outcomes Assessment: This refers to the process of measuring and evaluating the knowledge and skills acquired by learners against predefined learning objectives and performance standards. Effective assessment strategies should be integrated within the platform to track learner progress and provide feedback for continuous improvement.

By focusing on these core principles, eLearning platforms can create an integrated and learner-centric teaching and learning environment.

**2.3.5 Scalable No-SQL Database Management Systems**

MongoDB stands out as a liked No-SQL database recognized for its ability to scale effectively. Its distributed architecture is the key, to this scalability allowing it to manage data volumes and heavy traffic loads efficiently. MongoDB utilizes sharing to distribute data among servers facilitating scaling. This implies that as data and traffic increase you can expand the number of servers in the MongoDB cluster to accommodate the growing demand. The adaptability of MongoDB schema also plays a role in its scalability. Unlike databases MongoDB does not mandate a predefined schema making it simple to introduce new fields or modify existing ones without any downtime. This adaptability proves beneficial in environments where requirements are subject to frequent changes. Apart from scaling MongoDB also supports scaling by enabling you to enhance individual server resources (such as CPU and RAM) within the cluster to manage higher workloads. The combination of vertical scaling capabilities makes MongoDB a scalable database solution suitable for various applications ranging from small startups, to large enterprises.

**2.3.6 Containerization (with Docker)**

Docker, an example of containerization transforms the landscape of software development and deployment by packaging applications and their requirements, into self contained units known as containers. These containers operate reliably across settings spanning from development, to production guaranteeing behavior of applications regardless of their deployment location. Containerization offers application segregation, flexibility and optimized resource usage simplifying the development and deployment workflow while enhancing resource efficiency compared to machines.

**2.3.7 System Architecture Design (avoiding Single Point of Failure)**

A critical aspect of system architecture design is the elimination or mitigation of Single Points of Failure (SPOFs). An SPOF is a single component whose failure can cause the entire system to become inoperable. It's really important to make sure that a our system doesn't rely on one part that could cause the whole thing to fail. When a single point of failure occurs it means that if one component breaks the entire system will stop working. To prevent this, methods like having backups and being able to handle faults are used to keep the system running even if something goes wrong with one or more parts. This is particularly crucial, in systems where any downtime could lead to losses or affect how users interact with it. Ultimately avoiding points of failure helps boost the reliability, availability and resilience of a system.

**2.4 REVIEW OF RELATED AREAS**

This section provides an overview of other studies done by other authors that are relevant to this work. It briefly outlines the working of the systems examined in these related works, along with the methodologies used by the respective authors. Furthermore, it evaluates the strengths and weaknesses in these related works.

**2.4.1 Reviewed Work One**

**The Design and Implementation of an E-Learning System By; (Muhammad Hajara Hussaini. 2022)**

In this paper, the author discusses that the surge in admission requests to educational institutions globally has increased the strain on limited school resources across various regions. This strain can be seen in the limited number of human and material resources that is required to adequately cater for the needs of growing enormous populations. He argues that a new learning environment must be built that provides autonomy and flexibility, establishes contacts and facilitates smooth communication between cultural knowledge centers, and allows all members of a knowledge-based society easy access. He proposed that one approach to accomplishing this is through the use of virtual classrooms.The virtual classroom would supplement the traditional classroom method of teaching and learning, and it can be implemented using a variety of technology including teleconferencing or videoconferencing.

**Methodology used**

The author aimed to develop a web application for the eLearning platform. He set the system up into two parts; a client-side (front-end) which was developed using HTML5, CSS3 and JavaScript; and a server-side (back-end) which was developed using PHP and MySQL.

The application served three fundamental user interfaces, an administrator’s interface, an instructor’s interface and a learner’s interface. The administrator would be responsible for managing user details, course materials and user access rights and permissions. The instructor would be able to upload materials that were relevant to the course, as well as interact with students on the platform. The student would be able to register for courses, join virtual classrooms for lectures and have access to a centralized repository of course materials.

**Authentication**

The author set up authentication on the back-end of and makes use of the database which stores user accounts, and authentication credentials. The client-side interface was set up in a way that, the login page was universal and learners and instructors and admins would have to select their user type before entering their username and passwords.

**Virtual Classroom**

The author setup the virtual classroom without a videoconferencing feature. The virtual classroom served as a platform for access to learning materials, quizzes, assignment materials as well as class schedules, among others.

**Strengths of the study.**

The research provided insights into the following:

1. The study highlights the issue of pressure on education resources globally, setting a relevant context for the proposed solution
2. The author proposes good comprehensive solution in proposing for the development of a new learning environment. This solves the problem of pressure on limited resources available in universities.
3. The author recognized the need for a supplement for teaching and learning through the implementation of a virtual classroom. This is in line with the trend in higher education to accommodate growing student population.
4. Despite the absence of videoconferencing features in the virtual classroom, the platform offers practical utilities such as access to learning materials, quizzes, and class schedules. This pragmatic approach prioritizes functionality and usability, aligning with the study's objectives.

**Limitations of the study**

1. The virtual classroom setup described in the study lacks videoconferencing capabilities. This limitation could restrict the interactive and engaging quality of online lectures, thereby hindering effective communication between instructors and students.
2. While the study describes functionalities for administrators, instructors, and students, it does not include ways for encouraging active involvement and participation in the virtual classroom setting. Without proper methods to encourage learner involvement and collaboration, the usefulness of the eLearning platform may be jeopardized.

**2.4.2 Reviewed work two**

**The Process of Designing the Functionalities of an Online Learning Platform- A Case Study By; (Robert Oliwa, 2021)**

In this study, the author is looking into the process of designing the functionalities of an online learning platform as proposed by three distinct user groups: students, academics, and administrative staff. Furthermore, the study aims to acquire insight into how these participants' opinions influence the platform construction process. Using a case study design, the author investigates whether users of the online learning platform can help define its functionalities, specifically remote class creation and sharing, test administration, and enhanced student activity reporting. Within the context of Ghana Communications Technology University, by involving students, instructors, and administrative staff in platform development, the proposed e-learning platform for GCTU can address diverse needs and preferences, ensuring accessibility, flexibility, and cost-effectiveness.

**Methodology**

The study used a mixed-methods approach to assess the design and functionality of an online learning platform through the eyes of students, professors, and administrative staff.

**Qualitative Data Collection**

Individual interviews were held with randomly selected individuals from each user group (students, teachers, and administrative personnel). These interviews provided detailed insights into participants' preferences, experiences, and needs for the online learning platform. Questions that were open-ended allowed participants to freely express their ideas and suggestions, leading to an even more specific understanding of their perspectives.

**Quantitative Data Collection**

A detailed online survey was distributed to a handful of students and teachers to get quantitative data on their thoughts and experiences with the online learning platform's functions or what said functions should be. The survey used structured questions and Likert scales to quantitatively assess participants' attitudes and preferences. This enabled a systematic examination of replies and the discovery of trends and patterns across various user groups. This study has established grounds for the development of a successful e-learning platform by employing a mixed-methods approach.

**Strengths of study**

1. By combining qualitative feedback from individual interviews with quantitative data from surveys, the study gathered a wide spectrum of viewpoints from students, teachers, and administrative personnel.
2. The integration of qualitative and quantitative data enabled a comprehensive synthesis of findings, resulting in useful suggestions for improving the design and effectiveness of an online educational platform.

**Limitations of the study**

1. The study sample size which was used might have been limited which would mean that the conclusions drawn from the study cannot be applicable in a more generalized setting or outside the context of the research.

**2.4.3 Reviewed Work 3**

**Design And Implementation Of A Desktop Based System To Enhance Teaching Using Screen Sharing Technology Through Wlan Using GCTU As A Case Study(Adabogo Emmanuel, Gertrude Fafali, 2022)**

This study aims to address several key challenges and to improve the overall learning experience for both lecturers and students. Their approach aimed to allow for seamless sharing of educational materials, presentations to eliminate the need for costly subscription-based virtual classrooms. Using real-time video and audio sharing mechanisms with WebRTC, they aimed to optimize the platform to allow for interactive discussions and collaborations between lecturers.

**Methodology**

The methodology that the authors employed encompasses several key components aimed at designing and implementing a screen-sharing software for e-learning purposes.

1. **Technology Selection:** The study begins by carefully identifying appropriate technologies for designing and implementing the screen-sharing system. This phase considers factors like efficiency, tolerance for errors, scalability, and cost efficiency.
2. **WebRTC Implementation:** They utilize WebRTC to facilitate real-time communication and data transfer between lecturers and students. This technology provides a framework for audio and video peer to peer streaming over the web without the need for a third party, making it ideal for this application.
3. **Backend Development:** The utilized JavaScript runtime, NodeJS for the back-end development, which is responsible for the server-side operations.
4. **User interface design:** They used HTML and CSS from the front-end or user interface, which is the part of the application that users interact with.
5. **Scalability Assessment**: The system's scalability is assessed, taking into account elements such as the number of concurrent users it can support and its ability to handle increasing workload demands.

**Strengths**

1. By utilizing WebRTC technology and implementing real-time screen sharing capabilities, the study offers an innovative solution to address the challenges faced in traditional e-learning environments.
2. The research's focus on building a desktop-based system with open-source technologies such as JavaScript, HTML, and CSS shows its focus on cost-effectiveness. The study offers universities a more financially sustainable alternative to pricey subscription-based virtual classroom applications.
3. Along with basic screen-sharing capabilities, the system supports chat, file-sharing, and audio streaming. These extra features improve the e-learning experience by encouraging interaction and collaboration between lecturers and students in virtual classroom environments.
4. The system's design prioritizes scalability, with up to 26 individuals using a single 4G WIFI interface. This scalability means that the system can effectively serve different class sizes while also adapting to the changing needs of educational institutions throughout time.

**Limitations**

1. The study focuses primarily on the development and testing of a screen-sharing system that employs WebRTC technology. It may not include all aspects of e-learning, including assessment methodologies, curriculum design, and learner engagement strategies.
2. While the system has effective screen-sharing features, it may have technical restrictions such as bandwidth, latency, and device compatibility. Users with slower internet connections or older technology may have performance issues, which limit the system's accessibility and usability.
3. The findings of the study may be specific to the context in which it was conducted, such as the particular technological infrastructure and user preferences within the university campus; drawing the results to other educational settings or cultural contexts might require additional change.

**2.4.4 Reviewed Work 4**

**Design and Implementation of Online-Learning platform with a large class size: Case study at University of Energy and Natural Resources-Ghana By; ( Peter Appiahene, Christopher Ninfaakang, 2017)**

This research explores the experimental use of a web-based platform to supplement and improve the teaching and learning of the Computer Literacy and Information Technology course at Ghana's University of Energy and Natural Resources (UENR103). The study was conducted over two academic years with a combined class of over 300 students each year. The document discusses the methodology used in developing the online-learning platform, the results of implementing the platform, student engagement through activities like group discussions and self-assessment tests, and the overall response from students and instructors to the technology-supported learning environment. The study aims to showcase the application of online learning for large classes and how it was implemented at the University of Energy and Natural Resources, providing insights into the benefits and challenges of using technology in education.

**Methodology**

The first phase of the study focused on developing a web-based platform tailored to supplement the teaching and learning of the Computer Literacy and Information Technology course at the University of Energy and Natural Resources (UENR). This involved collaboration between instructional designers, web developers, and subject matter experts to create a platform that aligns with course objectives and student needs. The developed online-learning platform was implemented over two academic years, accommodating a combined class of over 300 students each year. This phase involved integrating the platform into the course curriculum, providing access to students, and facilitating instructor training on platform usage and management. Throughout the study, student engagement was promoted through a variety of activities supported by the online learning platform. These activities included group discussions, self-evaluation assessments, interactive quizzes, multimedia information delivery, and collaborative projects. The goal was to encourage active learning, involvement, and knowledge retention among students.

**Strengths**

1. Providing the option for students to read materials or watch videos caters to diverse learning styles and preferences, accommodating different ways in which students may absorb information effectively.
2. The ability for students to submit assignments online and download materials from the platform streamlines the process of academic tasks, making it more convenient and efficient for both students and faculty.
3. The implementation and testing phase of the project highlight the main features of the e-learning system, such as authentication mechanisms, database utilization, user account management, and error handling, indicating a comprehensive and well-thought-out development process.

**Limitations**

1. The authors faced challenges in gathering information and data from users for an objective assessment of the proposed e-learning products was challenging. Expected users were unwilling to provide input or gave vague information, leading to uncertain results.

**2.4.5 Review work 5**

**Web-Based E-Learning System for Sinda Day Secondary School (Patrick Nyirenda 2019)**

This paper explores the design and development of a web-based e-learning system specifically implemented for Sinda Day Secondary School in Zambia. The primary objective of this system is to address the educational needs of rural secondary schools by enhancing accessibility to educational materials for students. The document details the functionalities incorporated within the e-learning system, the testing methodologies employed to ensure its efficacy, and the potential benefits it offers in contributing to the advancement of Zambia's educational landscape.

**Methodology**

This study adopted an incremental software development process model. This iterative approach involves the breakdown of overall system requirements into discrete, independently functional modules. Each module progresses through a well-defined development cycle encompassing requirements gathering, design, implementation, and rigorous testing phases. Subsequent iterations result in the delivery of enhanced functionalities, building upon the previous version until the complete e-learning system is realized.

**Strengths**

The e-learning system boasts several strengths that contribute to its effectiveness and user experience.

1. **User-Centered Interface:** A user-friendly front-end interface fosters intuitive interaction between the system and its users. This design characteristic plays a critical role in promoting user adoption and engagement.
2. **Assessment Management for Instructors:** The system empowers instructors with the ability to store assessment questions, administer assessments to students, and generate comprehensive results and reports. This functionality streamlines the assessment process and facilitates effective learning evaluation.
3. **Robust Administrative Features:** The e-learning system provides administrators with a comprehensive set of tools for user management. These capabilities encompass question creation and deletion, user account management, assessment and ranking oversight, and user feedback collection. This level of administrative control ensures the system’s functionality and facilitates informed decision-making.
4. **Modular Design for Enhanced Functionality:** The system incorporates a modular design, featuring integrated modules like User Dashboard, Attend Lessons, Download Notes, Assessments, and Alternative options. This modular architecture promotes a holistic learning experience by providing a comprehensive range of functionalities that cater to diverse learning needs.
5. **Data Visualization for Improved Understanding:** The implementation of a Data Flow Diagram offers a visual representation of the overall application data flow and the underlying processes within the e-learning system. This data visualization technique enhances understanding of the system's functionality for stakeholders and facilitates informed decision-making.
6. **Systematic Development Approach:** The e-learning system's development adhered to established software development life cycle phases, including a dedicated Requirements Phase. This systematic approach ensures the effective identification and validation of user needs, resulting in a system that is well-aligned with its target audience.

**Limitations**

The limitations of the e-learning system design and development include

1. Possible challenges in ensuring consistent access to the system.

**2.4.6 Review 6.**

**Design and Implementation of an E-learning Platform Using N-Tier Architecture. (Nawar S. Alseelawi, Enas K. Adnan, Hussein T. Hazim, Haider TH. Salim ALRikabi, and Khalid Waleed Nasser, 2022).**

This paper presents the development of an e-learning platform specifically designed for Iraqi universities. The platform leverages a multi-layered architectural approach, known as N-Tier architecture, to facilitate an interactive learning environment that fosters communication and engagement between instructors and students. This initiative aims to address the limitations inherent in traditional educational methodologies and promote a more dynamic learning experience. The authors delve into the development methodology employed, outlining the utilization of the ADDIE model. This iterative instructional design model provides a structured framework for the platform's creation. Additionally, the paper meticulously details the distinct layers comprising the N-Tier architecture, explicating the specific functionalities of each layer within the overall system. The concluding section of the paper discusses the successful implementation of the e-learning platform within Iraqi universities. The authors present the results obtained through an assessment questionnaire, potentially evaluating user satisfaction, platform effectiveness, or learning outcomes.

**Methodology**

The document adopts the ADDIE model, a widely recognized instructional design framework, to guide the development and improvement of e-learning platforms. This iterative model encompasses five distinct phases: Analysis, Design, Development, Implementation, and Evaluation.

1. Analysis Phase: During this initial phase, a thorough needs assessment is conducted to identify discrepancies between the desired learning outcomes and the current capabilities of the target audience. This analysis involves constructing a comprehensive picture of these knowledge and skill gaps, informing the subsequent development stages.
2. Design Phase: The design phase focuses on meticulously crafting a blueprint for the e-learning platform. This stage entails the articulation of specific learning objectives, the development of appropriate assessment tools, the selection of engaging learning activities, and the creation of high-quality content.
3. Development Phase: Following the established design plan, the development phase involves the production of the actual learning materials. This stage translates the conceptual framework into tangible components, such as interactive modules, multimedia elements, and learning assessments.
4. Implementation Phase: Once the learning materials are developed, they are deployed and made accessible to the target student group. During this implementation stage, the effectiveness of the preparatory materials is evaluated to ensure they meet the needs of the learners.
5. Evaluation Phase: The final phase of the ADDIE model emphasizes the ongoing assessment of the e-learning platform's effectiveness. This stage involves collecting feedback from learners and instructors, analyzing performance data, and utilizing these insights to make continuous improvements to the platform's content, delivery methods, and overall learning experience.

**Strengths**

The paper identifies several key strengths associated with the N-Tier architecture employed in the e-learning platform's development. These strengths contribute significantly to the platform's effectiveness and user experience.

1. Enhanced Usability: The platform prioritizes user-friendliness, ensuring intuitive navigation for both instructors and students. This characteristic is crucial for fostering widespread adoption and engagement within the educational environment.
2. Content Accuracy and Quality: The platform demonstrably offers accurate and high-quality educational materials. Content is meticulously reviewed to ensure it is free from linguistic and grammatical errors, promoting effective knowledge transfer and skill development.
3. Streamlined Content Management: The platform facilitates efficient management of educational materials through user-friendly upload and download functionalities. This streamlines the process of adding, updating, and sharing learning resources.
4. Interactive Learning Environment: The N-Tier architecture fosters an interactive learning environment that encourages communication and collaboration between instructors and students. This interactive approach promotes a more engaging and dynamic learning experience.
5. Catering to Diverse Needs: The platform exhibits versatility by offering educational content suitable for a variety of learning needs and preferences. This adaptability ensures the platform can cater to a wider student population with diverse educational backgrounds and learning styles.
6. Intuitive Navigation: The platform prioritizes user-centric design principles, resulting in an intuitive navigation system. This feature allows users to easily locate desired information and learning resources, enhancing the overall user experience.

**Limitation.**

The study acknowledges certain limitations within the described virtual classroom environment.

1. Lack of Videoconferencing: The current virtual classroom setup lacks integrated videoconferencing functionalities. This omission has the potential to restrict interactivity and engagement during online lectures. The absence of visual communication channels could hinder the establishment of rapport and effective communication between instructors and students, potentially diminishing the overall learning experience.
2. Limited Strategies for Active Participation: The study identifies a gap in the current approach, as it does not explicitly discuss strategies for fostering active student involvement and participation within the virtual classroom environment. Without the implementation of these strategies, there is a risk of diminished learner engagement and collaboration. This could negatively impact the platform's effectiveness in achieving its intended learning outcomes.

**2.4.7 Review 7**

**Developing E-Learning Platform for Teaching and Learning Construction Technology (by W. L. Chu and C. L. Christopher Kwan**. **2019)**

This article presents the development and implementation of an e-learning platform specifically designed to facilitate the instruction of construction technology for undergraduate students. The authors acknowledge the inherent challenges associated with mastering construction technology concepts for students lacking practical internship experience. They posit that e-learning can serve as a valuable tool to enhance the learning experience in this domain.The article details the design and implementation phases of the e-learning modules. These modules incorporate a diverse range of instructional materials, including online study guides, comprehensive course readings, engaging video lectures, informative animations, and interactive quizzes. To assess the effectiveness of the e-learning modules, an end-of-module survey was administered to student participants. The analysis of the survey results revealed a positive consensus among students, indicating that the blended learning approach significantly improved their overall learning experience. Based on these findings, the article concludes that e-learning presents a practical and effective methodology for delivering construction technology education to undergraduate students.

**Methodology**

This document outlines the development of an e-learning platform for construction technology education, employing a mixed-method research approach. The methodology involved a user experience evaluation component, where 30 participants engaged with the online learning course to provide valuable data for analysis. The focus of the study was to tailor construction technology content specifically for civil engineering students in Hong Kong. The course content was meticulously developed by drawing upon established reference literature in the field. To assess the effectiveness of the e-learning materials, the study utilized end-of-module surveys to gather student feedback. Additionally, the document incorporated insights gleaned from existing research on cognitive load theory and quiz design principles. This integration of theoretical frameworks aimed to optimize the learning experience for students by minimizing cognitive overload and promoting effective knowledge retention.

**Strength**

The strengths identified in the document include positive feedback from participants regarding the well-structured course materials, ease of accessing online learning materials, and the effectiveness of the animations in describing the construction process. Participants also found the e-learning method to be user-friendly, efficient in terms of time management, and effective in helping them learn the topic independently. Overall, the document suggests that the e-learning platform was considered an effective means of delivering construction technology content, with high ratings for learning effectiveness and user satisfaction.

**Limitations**

Limitation related to the quiz design of the course.

**2.5 Summary of all Seven Related Reviews**

The related works clearly demonstrate the significance of e-learning systems and the different methods and approaches used in the development of e-learning systems.

The first work proposes a virtual classroom solution to alleviate pressure on limited educational resources. Despite lacking videoconferencing, the platform offers practical utilities like access to learning materials, quizzes, and schedules. The second work investigates the process of designing an online learning platform with input from students, academics, and administrative staff. The mixed-methods approach gathers qualitative and quantitative data, offering insights into diverse user preferences. The third work focuses on improving the learning experience through screen-sharing technology. By utilizing WebRTC, the system enables real-time interaction and collaboration between lecturers and students. The fifth related work explore the implementation of a web-based platform to supplement teaching for large classes. The platform facilitates activities like group discussions and self-assessment tests, aiming to enhance student engagement. Nyirenda discusses the design and development of a web-based e-learning system for a rural secondary school. The Incremental Model is used, providing a user-friendly interface and administrative capabilities. The sixth work focuses on developing an e-learning platform for Iraqi universities using N-Tier architecture. The ADDIE model guides the development process, resulting in an interactive and versatile platform. Chu and Kwan develop an e-learning platform for teaching construction technology. The platform includes study guides, videos, and quizzes, with positive feedback from participants regarding its effectiveness. Overall, these studies emphasize the significance of specialized e-learning systems that take into account user preferences, technological infrastructure, and educational objectives. While each platform offers advantages, typical constraints include the lack of videoconferencing capabilities and the difficulty in getting extensive user feedback. Nonetheless, these efforts contribute to the continued evolution of e-learning by proposing novel techniques to meet the different demands of both learners and educators.

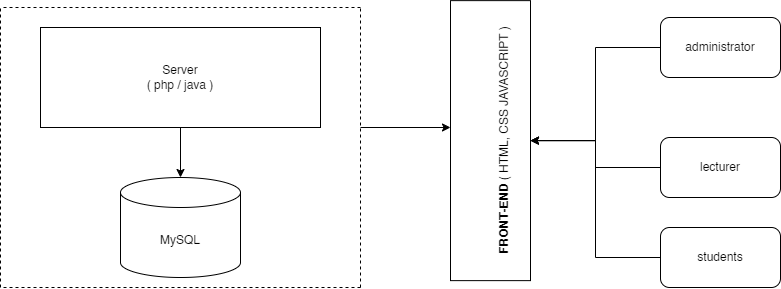
**2.6 Identified gaps from the seven related works**

From the weaknesses of all seven related works, the following gaps were identified

1. **Absence of Video Conferencing Features:** The majority of the reviewed platforms lack video conferencing capabilities, which may hinder interactive and engaging online lectures. To bridge this gap, we are going to prioritize the integration of comprehensive video conferencing features into our e-learning platform. This feature will enable real-time interaction and collaboration between instructors and students, resulting in a more immersive and dynamic learning experience. We will look into using reliable video conferencing APIs or platforms to enable easy integration and excellent performance.
2. **Lack of Comprehensive User Involvement:** Most of the reviewed papers mention problems in getting comprehensive user feedback or participation. To close this gap, we will require active input from potential users (instructors and students) throughout the development process. We will perform user interviews, surveys, and focus groups to better understand their individual requirements, preferences, and challenges. We will also incorporate their suggestions into the platform's design and functionality, such as the addition of video conferencing and online IDE capabilities. By actively engaging consumers, we can modify the platform to better match their needs and increase user satisfaction..
3. **Limited Assessment and Evaluation Methods:** While several of the reviewed papers address the use of quizzes and assessments, there is a gap in the discussion of overall evaluation methods. To close this gap, we will make sure that our e-learning platform includes a variety of customizable evaluation tools that can be tailored to different learning objectives and styles. We intend to include features like auto-graded quizzes, peer evaluations, coding exercises within the online IDE, and performance analytics to help students track their progress and find areas for growth.

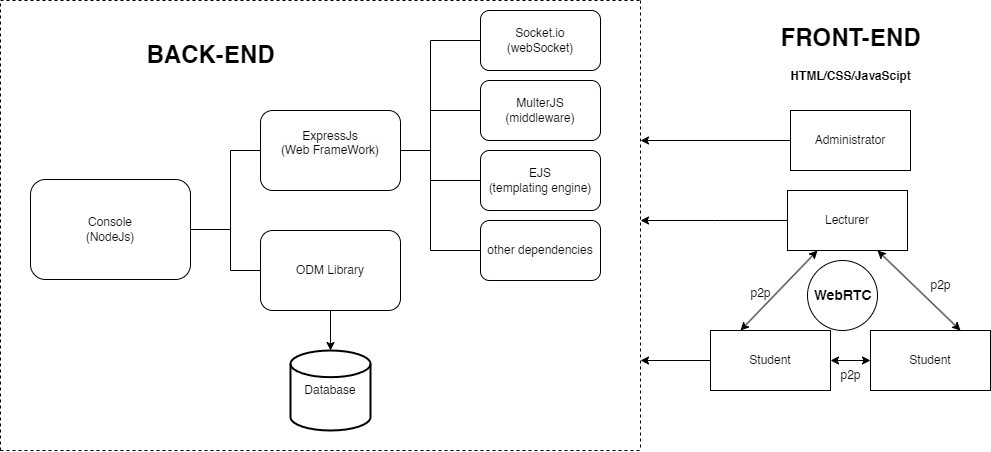
**2.7 Setup of Current E-learning Systems from the reviewed works**

The current designs primarily use web-based platforms with user-friendly interfaces, which frequently include different user interfaces for administrators, teachers, and students. Access to learning materials, quizzes, assignments, and administrative chores are commonly provided, albeit most lack video conferencing capabilities and may have scalability and user engagement limits. Front-end technologies generally comprise HTML, CSS, and JavaScript, but back-end development frequently uses PHP, Node.js, or Java, as well as databases like MySQL or MongoDB. Some platforms may additionally include other technologies, such as WebRTC enabling real-time communication and screen sharing.



**2.8 Proposed Design of the E-learning platform**

In terms of design, the proposed platform intend to offer a unified and user-centric experience. This includes creating a unified user interface that incorporates functionality for administrators, teachers, and learners, as well as providing straightforward navigation for features like as video conferencing, an online IDE, quizzes, assessments, and a centralized repository. In addition, the platform will have a responsive design, making it accessible across a wide range of devices and screen sizes to satisfy a variety of user preferences. In terms of technology, the platform will employ NodeJS with the Express framework on the back end and server-side rendering to dynamically render views to the client. Data management will be handled by the relational database MongoDB.Integration of reliable video conferencing systems such as WebRTC to encourage real-time communication, while an online IDE based on CodeMirror will allow students to code right within the platform. Course materials will be organized in a centralized repository using Google Cloud Storage or GitHub, with customizable quiz and assessment features and automatic grading capabilities provided using libraries such as Quizizz or Google Forms API.



**2.9 Conclusion**

Finally, whether developing software or hardware projects, it is critical to choose the suitable technology. The choice of technology can have a considerable impact on whether a system implementation succeeds or fails. This is obvious in the potential for systems to be loaded with flaws and errors caused by the use of incorrect languages or frameworks, as well as full programme failures caused by inadequate technological choices. The conclusions gathered from the related studies presented here provide valuable guidance for reaching our goals by providing empirical data on the best technologies, and algorithms for efficient system design and performance. In line with this, our research project will use WebRTC technology to assure device compatibility and low latency. This option will allow for smooth connectivity between devices running diverse platforms, increasing the system's overall efficiency and effectiveness. By carefully researching and implementing the appropriate technology, we hope to create a robust and efficient e-learning platform that satisfies the needs and expectations of its users.