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Development of Network Learning Management System (Net-LMS) to Support Effective Teaching and Learning of Network Devices

[1]Ifanyi Godspower Akawuku *[2]Charles Okechukwu Ugwunna, [3]Charles Ikenna Uchefuna
[1]Daniel Ugoh and [5]Joshua Oluwasegun Oluwaniyi

[1]Department of Computer Science, Nnamdi Azikiwe University Awka, Anambra State, Nigeria.
*[2]Department of Computer Science, Wigwe University Isiokpo, Rivers State, Nigeria.
[3]Department of Computer Science, Federal Polytechnic Oko, Anambra State, Nigeria
[5]Department of Computer Science, Federal University of Agriculture Abeokuta, Ogun State Nigeria.

*Corresponding authors' email: Charlesugwunna@wigweuniversity.edu.ng

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ABSTRACT
The current project was implemented in response to a challenge in network devices education which is characterized by the discrepancy between theoretical knowledge and practical skills. Traditionally, learners find it hard to apply the acquired knowledge to real networking tasks since teaching has always been focused more on theoretical rather than practical aspects. Net-LMS – an interactive learning platform integrating video tutorials, quizzes, practical tasks and performance analysis tools – was designed to solve this issue. Design Network Learning Management System (Net-LMS) has been developed using the WordPress website development platform, providing numerous advantages such as flexibility and the capability to integrate any required plugins for a better performance of the system. Development of Network Learning Management System involved several important stages aimed at creating a scalable learning platform with easy-to-navigate interfaces. First, web hosting and domain services were purchased to make it possible to develop the project on the Internet. Then, WordPress was installed to serve as the basis for further development. Additional protection of the website was ensured due to installation of SSL certificates, and Tutor LMS Plugin enabled the development of courses, management of users, delivering of assessments and learning performance tracking. Advantages Network Learning Management System possesses several major advantages including the opportunity for repeated network configuration practice without the need for physical networking devices. Such an advantage contributes to improved engagement among the learners, enhances practical skills, and provides chances for building confidence through constant practice. Finally, all test cases concerning the project performance have been successfully completed. Conclusion Overall, the development of Network Learning Management System resulted in creation of a valuable tool for network education which combines theoretical and practical approaches.

Keywords: Network Simulation, Learning Management System (LMS), E-learning, Virtual Labs, Network Device Training

INTRODUCTION

The rapid integration of digital technologies has transformed teaching and learning, particularly in computer networking education (Zuo et al., 2025). Further, the recent COVID-19 pandemic has increased the use of online learning tools, thus highlighting the drawbacks in traditional learning due to lack of interactions and practical involvement (Ugwunna et al., 2023). As such, the Net-LMS will help in making the process of teaching and learning of network devices more interactive and technology-based. The students need to have practical skills when configuring and managing network devices such as routers, switches, and firewalls. The availability of the required networking equipment makes it difficult for the students to develop the necessary skills (Cisco, 2021; Kurose & Ross, 2021). Additionally, research studies show that technology-based learning can help in increasing practical skills in learners due to the availability of practical learning environments through interactive platforms (Al-Fuqaha et al., 2015). In this way, the development of Network Learning Management System (Net-LMS) will be a better way to promote practical learning of network devices.

The commonly used teaching approach relies mostly on lectures and textbooks. Because of this, students tend to focus more on reading and memorizing information rather than gaining practical experience. Although theoretical knowledge is necessary for understanding networking concepts in the curriculum, it does not fully prepare students for real-world tasks such as configuring a router for an organization or troubleshooting network problems. While it is one thing to have an idea of how a router works in general, Rashid et al., (2019) explain that students often memorize networking concepts but more often struggle to apply them in practice without simulation tools. Moreover, it is common that students do not get that practical experience because the cost and organizational arrangements of installing real network equipment in schools and other institutions are on the high side. Unfortunately, current day learners may leave school with serious inadequate practical competencies. Net-LMS allows students to practice all acquired knowledge and skills in real life with the aid of technology by performing a practical application of the acquired knowledge between students in virtual environments. This addresses the persistent issue of students memorizing concepts but can never

implement them due to resource constraints (Mwansa et al., 2024).

These challenges called for the development of Net-LMS, an LMS based on WordPress, one of the most flexible solutions out there. The research by Richards (2020) points towards WordPress being chosen for several major reasons such as speed for development and affordable, flexible, and easily accessible. WordPress is useful when it comes to teaching since it allows for new features to be included in the future without having to build a costly system from scratch.

As network technologies continue to evolve, learning platforms need to adapt without relying on frequent hardware upgrades. The WordPress-based Net-LMS addresses this by allowing new tools, configurations, and features to be added as requirements change (Al-Fuqaha et al., 2015). This ensures that students can engage with up-to-date networking practices even when physical equipment is limited. The platform also supports self-paced learning, giving students the chance to track their progress through assessments and feedback, which helps them build stronger technical skills (Almarashdeh, 2016). Additionally, collaborative features encourage students to share knowledge and solve problems together, fostering practical abilities that are directly applicable to real-world networking environments (Dabbagh & KITSANTAS, 2012; Cisco, 2021).

Even more, the platform also represents certain network issues such as traffic flow, security connections, and problem solving that the student will likely face in their future job placement. A network engineer and administrator need these skills, and at Net-LMS, students get to master and build on those skills in a safe environment. Most importantly, Net-LMS can accommodate an unlimited number of users due to the ability of WordPress to scale hence suitable for contemporary organizations. The platform may expand to accommodate more users or with the addition of new features which makes the solution indefinite for the education of network devices (Richards, 2020).

This paper aims to create Net-LMS, an online learning environment designed to help students understand and use network devices. It aims to provide students with practical, real-world lessons through a WordPress-based Learning Management System (LMS) to enhance learning quality. The objectives are to develop an accessible online platform with interactive resources, ensure efficient performance on desktop browsers, and support students in gaining practical knowledge of configuring network devices such as routers, access point. Repeaters etc.

Summary of Related Works

Table 1: Summary of Related Works

S/N	Author	Methodology	Strength	Limitation
1	Smith, R. (2020)	Used an LMS-based case study for networking courses	Helped to arrange lessons well and manage course materials	Focused more on theory, not enough hands-on practice
2	Alves et al. (2021)	Used virtual labs for teaching	Helped students understand better and stay engaged	No LMS to track students or give quick feedback
3	Dicheva, D. et al. (2015)	Used gamification in learning systems	Increased student interest and participation	Not well connected to LMS for tracking progress
4	Makransky, G. et al. (2016)	Used virtual simulations for teaching	Helped students improve in practical work	No LMS tracking or real-time feedback
5	Potkonjak, V. et al. (2016)	Developed virtual lab systems	Allowed students practice without real labs	Not connected to LMS
6	Dillenbourg, P. (2015)	Created orchestration graphs for learning	Helped link teaching methods with theory	Not focused on practical networking tools
7	Kirkwood, A. & Price, L. (2014)	Studied use of technology in teaching	Showed benefits for theory and practice	No focus on networking or LMS
8	Coutinho et al. (2023)	Developed virtual lab framework	Supports hands-on learning	No LMS integration
9	Brinson, J. R. (2015)	Used virtual labs in teaching	Flexible and cost-effective	No LMS integration
10	Jeong, H. et al. (2019)	Built collaborative simulations	Encouraged teamwork	No LMS tracking
11	Means, B. et al. (2010)	Studied online collaborative learning	Improved engagement	No real-time LMS feedback
12	García-Peñalvo et al. (2021)	Integrated multiple learning tools	Improved organization of learning	No strong link to networking tools
13	Sáiz-Manzanares, M. et al. (2020)	Evaluated IT training tools	Gave useful insights	Weak LMS integration
14	Makransky, G. &	Studied immersive virtual labs	Increased student interest	Not fully linked to LMS

S/N	Author	Methodology	Strength	Limitation
	Petersen, G. B. (2019)			
15	Al-Samarraie, H. et al. (2018)	Designed cloud-based learning system	Affordable and easy to access	Limited LMS interaction
16	Radianti, J. et al. (2020)	Reviewed virtual labs in education	Useful for IT learning	No LMS tracking
17	Zawacki-Richter, O. et al. (2019)	Reviewed AI in education	Supports personalized learning	Not fully used with LMS
18	Bdiwi, R. et al. (2019)	Compared virtual learning platforms	Showed platform benefits	Weak assessment tracking
19	Mwansa et al. (2024)	Used case study with Cisco Packet Tracer	Real classroom experience	No LMS integration
20	Heradio, R. et al. (2016)	Designed virtual lab framework	Supports real-life simulations	No LMS integration
21	Kebande, V. R. (2024)	Used virtual labs in cybersecurity training	Improved engagement and understanding	Limited LMS and feedback support
22	Navarro, C. et al. (2024)	Used virtual simulations in lab teaching	Helped students understand concepts better	Limited LMS integration and tracking

Knowledge Gap: Lapses and Shortcomings

The studies depicted in table 1 has provided insightful information about network device education, however they all have similar flaws in their methodology. The absence of LMS integration is a major problem in most of the research. (Kebande, 2024; Navarro et al., 2024)., showed how effective virtual labs can be, but they lacked LMS capabilities, which made it harder for educators to keep track of their students' progress or provide them immediate feedback. These platforms only work as stand-alone solutions without LMS integration, which lowers their overall efficacy in offering a comprehensive learning experience. Without a cohesive system to integrate their learning experiences, students may thrive in one area but struggle in another due to the lack of seamless integration between practical tools and LMS capabilities.

MATERIALS AND METHODS

Net-LMS is a cloud-based platform built with the help of WordPress and LMS plugins, the platform makes user interaction and course administration simple. The Object-Oriented Analysis and Design Methodology (OOADM) was chosen for its ease of use. It was decided that a complex system should be divided into smaller modules and then put back together to create a coherent whole (Object Management Group, 2017). As depicted in figure 1, the Net-LMS platform architecture implements a design that integrates all components jointly to deliver smooth learning operations. The platform uses various interconnected levels that streamline database operations and interface management with content organization. The platform provides a simple user interface available to three main user types which include students and educators alongside administrators. Through the platform interface users gain access to materials and videos as well as quizzes and tracking their educational progress.

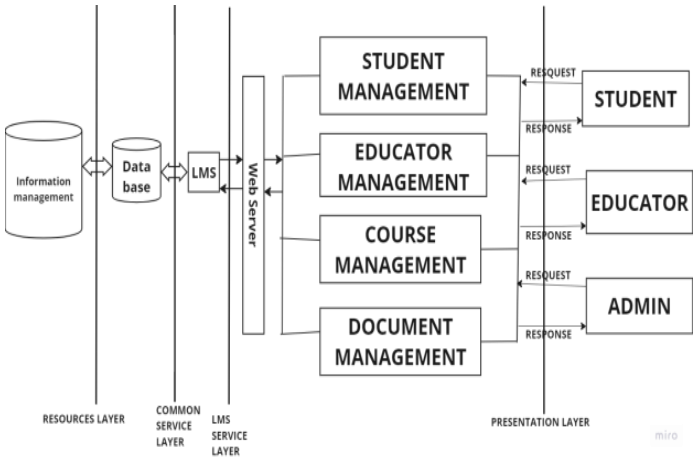

Figure 1: Architecture of Net-LMS

Functional Requirements

Table 2: Functional Requirements

No	Module	Functional Requirement
1	User Authentication Module	Allows users (students, educators, and admins) to register, log in, and manage profiles.
2	Course Management Module	Enables instructors to create, edit, and organize courses with video lessons, assignments, and quizzes.
3	Video Learning Module	Provides students with access to instructional videos for practical learning.
4	Assessment Module	Supports quizzes and automated grading, allowing students to test their understanding.
5	Progress Tracking Module	Tracks students' progress and performance throughout their courses.
6	Discussion Forum Module	Facilitates communication between students and instructors for collaborative learning.
7	Analytics and Reporting Module	Generates reports on student engagement, quiz performance, and course completion.

As shown in table 2, the fundamental operating features of the Net-LMS platform stand established as functional requirements. The essential functionalities of Net-LMS include features for user authentication while also managing courses through videos and assessments in addition to progress logging and discussion groups and analytics capabilities. Each module operates to create a systematic program that keeps students along with educators fully engaged in their learning process.

Non-functional Requirements

Table 3: Non-Functional Requirements

No	Requirement	Explanation
1	Performance	The system should load in 15 seconds and allow seamless video playback without buffering.
2	Scalability	The platform must support an increasing number of users and courses as demand grows.
3	Compatibility	Net-LMS should work across various devices, including desktops, tablets, and mobile phones.
4	Security	User data, course materials, and video content must be protected from unauthorized access.

The non-functional requirements presented in Table 3 aim to guarantee efficient performance of the Net-LMS platform (Saleh & ElShahrani, 2023; Rahman, Nayem, & Siddik, 2023). Users receive protection from all data types combined with device compatibility through security systems that support growing student counts and classes alongside optimal video playback performance. Both functional requirements and non-functional requirements complement each other by defining how well Net-LMS functions while ensuring its reliability to serve students and educators effectively.

Pseudo Code of the System

A pseudo code is a step-by-step procedure or set of rules used to perform tasks or solve problems. For Net-LMS, we'll be able to create an algorithm for one of the core processes such as how the platform grades a quiz and helps to track progress.

Quiz Grading and Tracking the Progress Algorithm

Step 1: Start

Step 2: The Net-LMS platform is accessed by a user (a student) to log in.

Step 3: The user selects a course and then completes a quiz.

Step 4: The system then compares the user answers to the answers kept in the database.

Step 5: Calculate the score.

(If it's right, the system adds a point. No points are added for every incorrect answer.)

Step 6: Save the score into the Progress Object key for the user ID of the student.

Step 7: Update progress.

Step 8: Display feedback.

Step 9: It gives analytics to the educator.

Step 10: End

As illustrated in Figure 2, the algorithm evaluates the student's marks (M) as follows:

i. If $M \geq 50\%$, the system displays Pass.
ii. If $M < 50\%$, the system displays Fail/Retake.

This grading system offers a transparent and structured approach to assessing student performance and -delivering actionable feedback.

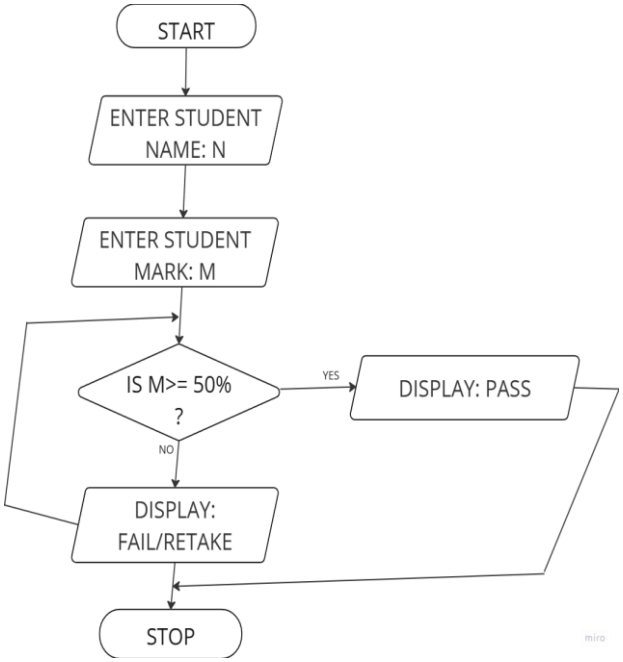

Figure 2. Student Grading

System Design

The process flow of the system illustrated in Figure 3 starts from user login and authorization, followed by access depending on the assigned role that will allow entry into course tools, evaluation functions, and progress tracking.

Figure 4 illustrates the system structure via a class diagram, presenting such crucial elements as users, courses, quizzes, video materials, and analytics modules, including their relationship with one another. In addition, a use case diagram (Figure 5) will elaborate on the interaction between students, instructors, and administrators when using the system's functions, indicating duties of all the parties involved and their permissions.

Interactions between the objects are presented in Figure 6, showing the sequence of interactions with the middleware in the learning management system, then with the e-learning registry, and, finally, with the content database from the side of the student request (Object Management Group, 2017). Moreover, an object diagram provided in Figure 7 will provide additional information regarding the interaction of enrollment, role assignment, and course entities at a certain moment of time. At last, an activity diagram presented in Figure 8 gives a description of the process flow of course selection and enrollment, starting with course choice and finishing with providing course submission of registration details. Together, these diagrams offer a coherent analytical representation of how academic activities are executed within Net-LMS.

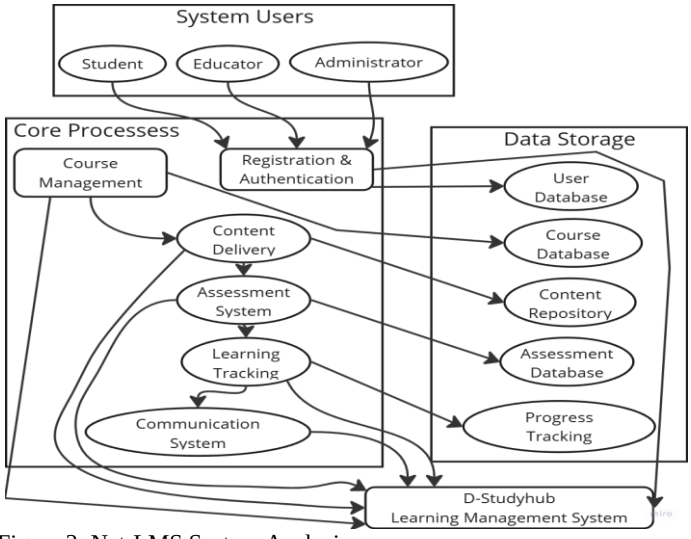

Figure 3: Net-LMS System Analysis

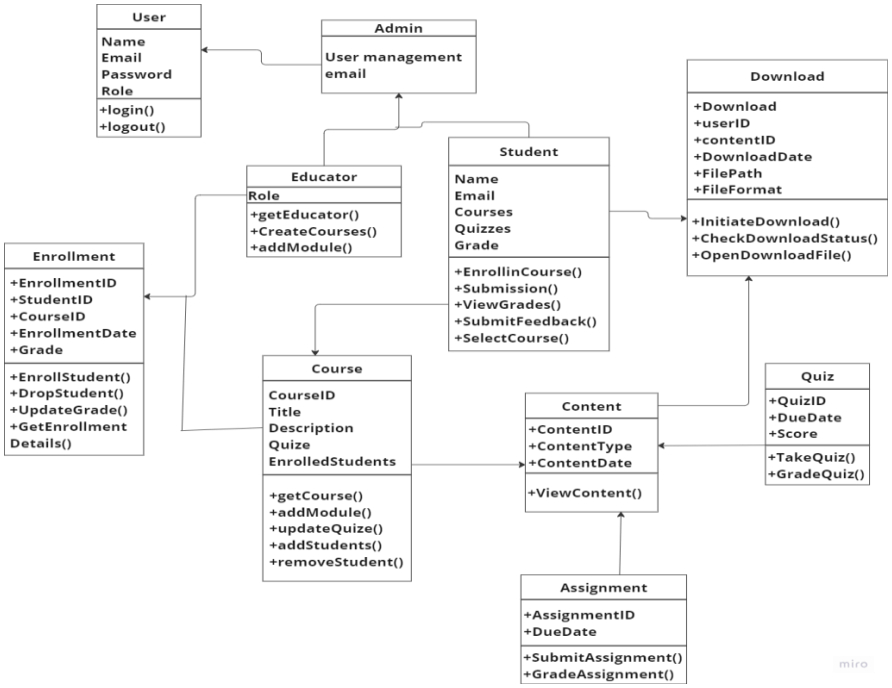

Figure 4: Class Diagram of Net-LMS

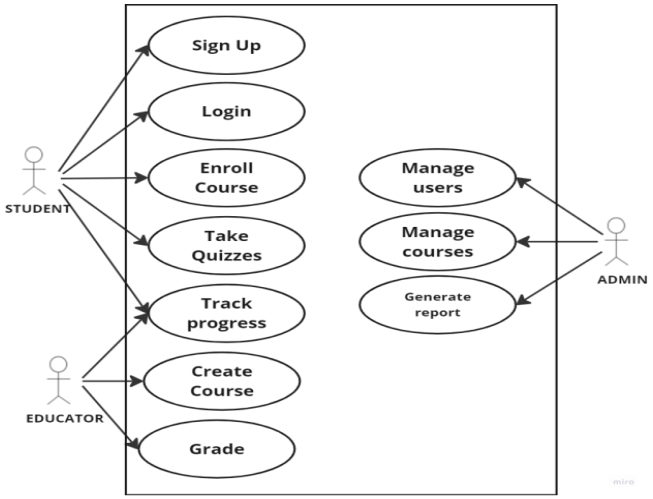

Figure 5: Use Case Diagram of Net-LMS

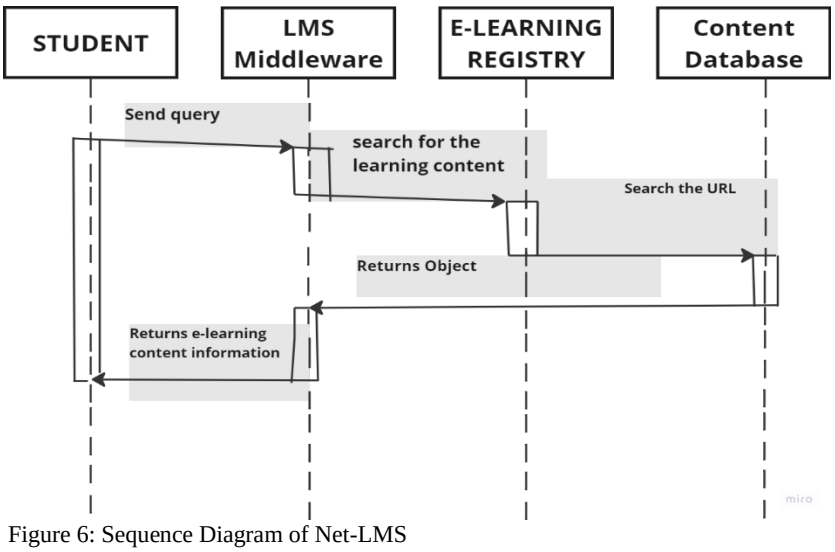

Figure 6: Sequence Diagram of Net-LMS

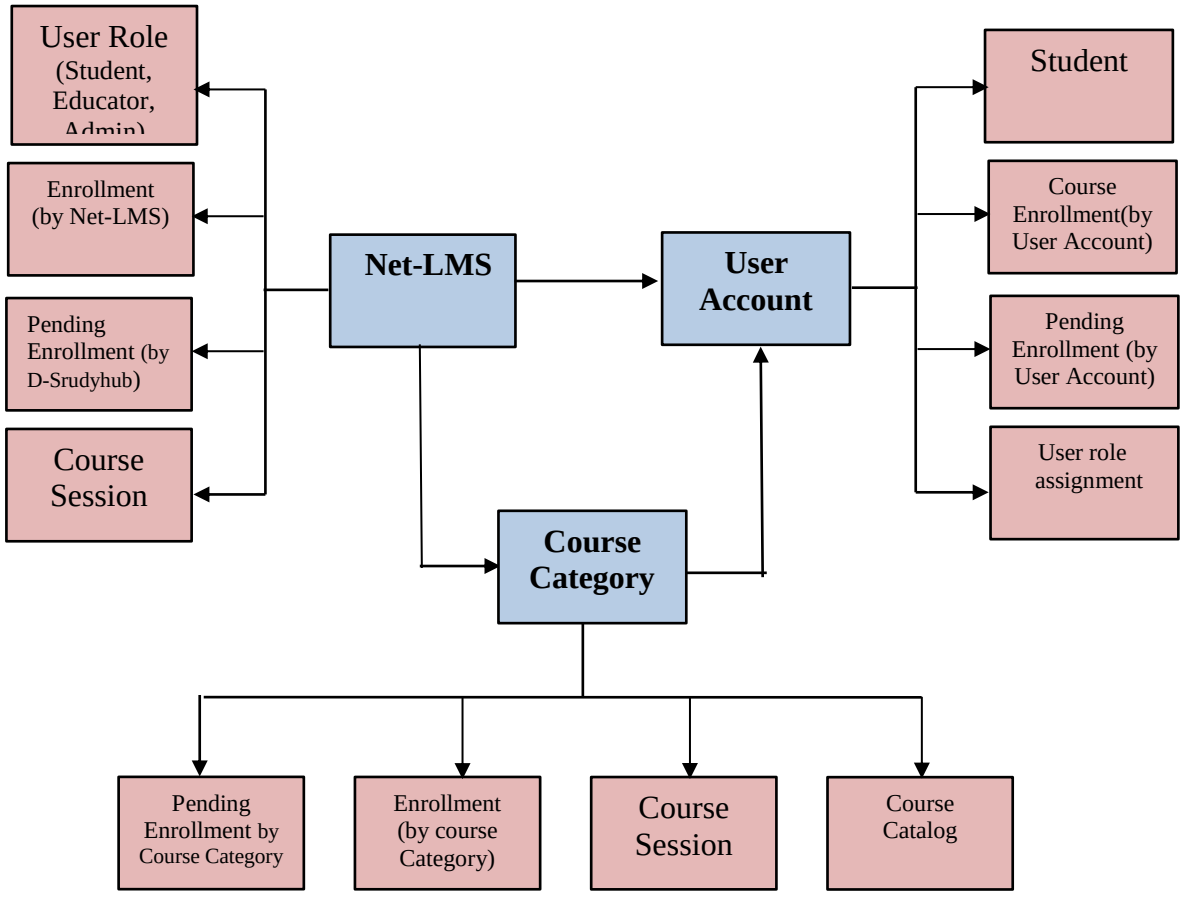

Figure 7. Object Diagram of Net-LMS

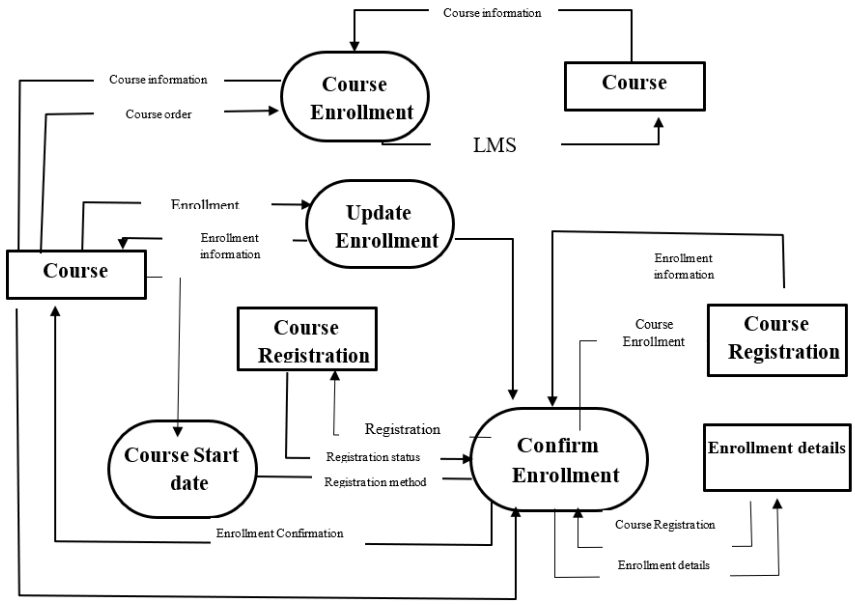

Figure 8: Activity Diagram of Net-LMS

Test Case Plan

This section assesses the level of functionality and efficiency of the Net-LMS platform with the help of a carefully developed scheme of a test case plan as shown in table 4.0. It defines the features to be assessed, the expected outcome and the observed outcome. The test plan proves that the platform is suitable to carry out the intended goals and objectives of the paper.

Table 4: Test Case Plan for Net-LMS

S/N	Test Cases	Description	Result	Expected Result
TEST_100				
1	TEST_100_001	Students should be able to log in to their accounts securely.	Pass	Users can successfully log in to their accounts.
2	TEST_100_002	Educators should be able to create and upload course materials successfully.	Pass	Educators can create and upload courses without issues.
3	TEST_100_003	Students should access video tutorials seamlessly.	Pass	Students can access videos without interruptions.
4	TEST_100_004	Users should navigate between lessons without lags.	Pass	Navigation between lessons is smooth.
TEST_200				
5	TEST_200_001	Students should attempt quizzes and receive instant results.	Pass	Quiz attempts are successful, and results are immediate.
6	TEST_200_002	Educators should be able to monitor students' progress.	Pass	Students' progresses were monitored by educator.
7	TEST_200_003	The system should store quiz results for progress tracking.	Pass	Quiz results are stored securely for progress monitoring.
TEST_300				
8	TEST_300_001	The platform should load efficiently on desktop browsers.	Pass	The platform loads within few seconds on desktops.
9	TEST_300_002	The platform should load efficiently on mobile devices.	Pass	The platform loads within few seconds on mobile devices.
10	TEST_300_003	Students should view high-quality videos without buffering.	Pass	Video playback is smooth across devices.
11	TEST_300_004	User profiles should update instantly when changes are made.	Pass	Profile updates are reflected immediately.
TEST_400				
12	TEST_400_001	Students should receive E-mail confirmation after registration.	Pass	Registration confirmation E-mail were delivered.
13	TEST_400_002	Students should receive notification when new course is been uploaded	Pass	Notification alert was delivered promptly.
14	TEST_400_003	Educators should communicate with students via chat	Pass	Chat communication is functional.

Out of 14 test cases used to evaluate Net-LMS platform, the Net-LMS platform successfully surpassed all the tested cases, thus reaching a success rate of 100%, as shown in Table 6.0 above.

Table 5: Overall Test Results for Net-LMS

ID	Total Test Cases	Total Passed Cases
TEST_100	4	4
TEST_200	3	3
TEST_300	4	4
TEST_400	3	3
Overall Total	**14**	**14**

From table 7, the results from these tests show that Net-LMS performs as expected and meets the design requirements as per its objectives. From test ID TEST_100, there are no issues with user functionalities such as login and navigating through the content in the platform. Test ID TEST_200 shows the successful evaluation of assessments and grading functions showing that both quiz and assignment functionalities are effective and efficient for educators and students.

Test ID TEST_300 evaluated the responsive capabilities and ability to handle media such as videos on both the desktop and mobile platforms, and it was observed that videos play well and profile updating works perfectly on the site. Finally, from TEST_400, email notification and chat functionalities were evaluated successfully. Overall, Net-LMS proved to be a functional, reliable, work-oriented and friendly online learning environment.

RESULTS AND DISCUSSION

The main output of this project was the Net-LMS as shown in figures 9 to 12. The Landing page shown in Figure 9 serves as the entry point to the system. It presents users with a clear and engaging interface that includes the platform logo, a brief overview of its purpose, available courses, and options for registration or login. By providing direct access to essential sections of the site, the page ensures that users can conveniently access the platform at any time and from any location.

The Dashboard (Figure 10) is the first view displayed after login and is customized according to user roles. Students can access lessons, review enrolled courses, and track their academic progress. Instructors manage course materials, grade submissions, and monitor class activities, while administrators oversee system configurations and user accounts. The layout is simple and structured, with accessible menus, activity updates, and relevant tools designed to support effective interaction with the system.

Figure 11 highlights the Instructor's Page, a dedicated environment for educators to create and manage their courses. It provides tools and resources that enable instructors to design structured learning experiences and extend their reach to a broader audience. Through this interface, educators can organize content efficiently while contributing to both student development and their own professional growth.

Finally, the Course Page (Figure 12) is where students actively engage with learning materials. They can stream videos, download resources, and complete assessments. Instructors structure content into organized sections to improve clarity and ensure that learning materials are presented in diverse and engaging formats.

Figure 9: Landing Page of Net-LMS

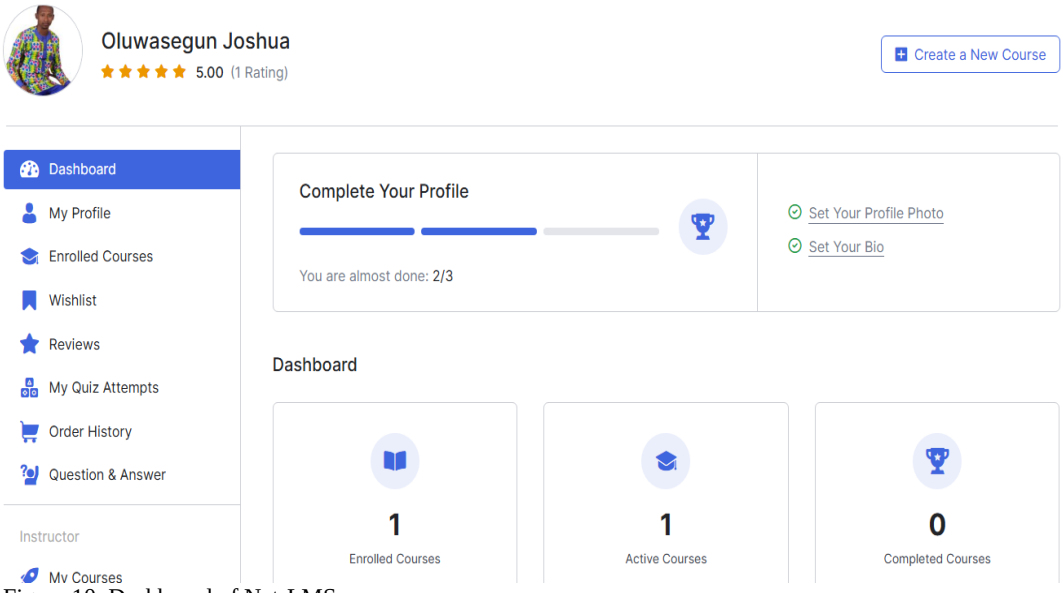

Figure 10: Dashboard of Net-LMS

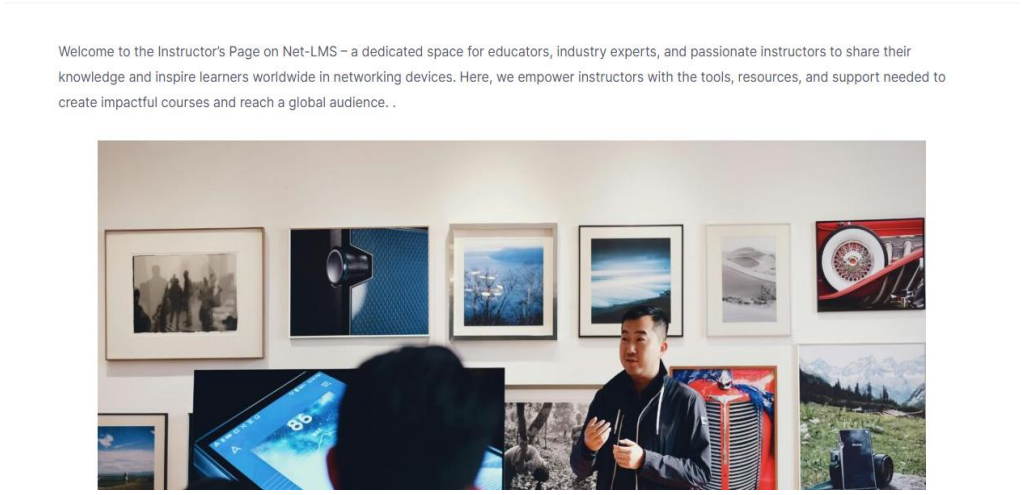

Figure 11: Net-LMS Instructure's Page

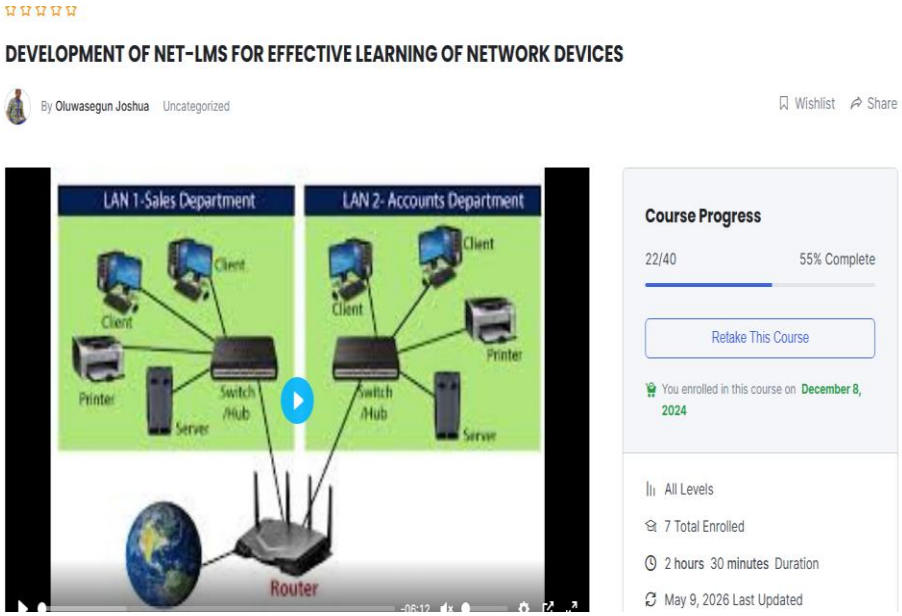

Figure 11: Course Page of Net-LMS

CONCLUSION

This paper created Net-LMS, which is a learning platform that would facilitate and realistically make studying of network devices easier. Standard approaches to the teaching of networking have their drawbacks because very often they rely solely on theory and do not allow the student to try themselves in practice. Network learning management system (Net-LMS) addresses this issue by integrating video demonstration, question tests, and progress check under one package. Lack of availability of study material and inadequate online tutoring make the learning of network devices complex; therefore, the creation of Net-LMS enhances the capability of teaching network devices immensely. All in all, Net-LMS successfully transfers the gap that exists between the learning theory and their practical real-life application; thus, the tool is beneficial for students and educators. This paper provides an affordable and accessible solution for network device training. It bridges the gap between theory and practice.

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