Learning Management System Built Using the MERN Stack

H. P. A. H. Piyumantha[1], D. V. S. Prabhash[2], T. K. Weerasinghe[3], R. T. K. Weerasiri[4], D. I. De Silva[5] and S. M. D. T. H. Dias[6]
[1]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA
[2]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA
[3]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA
[4]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA
[5]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA
[6]Faculty of Computing, Sri Lanka Institute of Information Technology, New Kandy RD, Malabe, SRI LANKA

[1]Corresponding Author: dvsprabhash99@gmail.com

ABSTRACT

Web based applications play a main role in our day-to-day life and therefore, it is important to ensure the quality and reliability of web applications. With the sudden increase in use of web based applications for online and distant learning, it is important to address existing issues in current Learning Management Systems (LMS), so that users can benefit from a better, uninterrupted learning experience. This work mainly contributes to understanding how the MERN stack can be efficiently used in building a reliable and secure LMS that will provide its services free of charge so that students are provided with a free and uninterrupted learning experience. An LMS that is equipped with user handling functionality, managing courses and course materials, and maintaining a library, has been the focus of the study that resulted in producing this paper. The work also includes reasoning as to why the MERN stack was selected for developing the proposed system.

Keywords-- ExpressJS, MERN, MongoDB, NodeJS, ReactJS

I. INTRODUCTION

In the recent years, mostly due to COVID-19 pandemic, the impact of web development has on almost every aspect of our life has increased. With the increase of people using web based applications for work and work related tasks, learning, shopping, seeking medical consultation, etc., it can be said that closely studying the subject of web development, novel solutions and issues it is presenting, and finding ways for improving the performance, user experience, security, and reliability of systems that use web based applications for interacting with stakeholders of such systems, is a must. Our focus on the subject of web based applications is aligned with those interests with special regard to e-Learning systems that provide services free of charge. According to UNESCO, a considerable amount of students have experienced interruptions in engaging educational activities as a dire consequence of universities and schools switching to a more practical online teaching-learning experience [1]. A solution for such interruptions would be to use a Learning Management System as Ülker and Yılmaz have discussed in their work [2], for conducting and managing e-Learning activities. It is the objective of the researchers to find out whether it is possible to build a simple web based application for providing free educational services, by using a popular technology stack used in web development.

The proposed system provides functionalities for its users as well as its administrators, completely free of charge. It provides with the functionality of generating reports for its users on relevant topics, and thereby allows users to better understand the interactions of their own as well as other users. The system is a fully fledged web based application that allows instructors to create courses and upload course materials for the courses created, and students to view all courses available, enroll to courses, download course materials and extra reading material, and give feedback on courses they have enrolled to. Moreover, administrator of the system can upload books to the library so that students can access extra reading material suggested by courses they are following, which will result in ensuring that the system aims at providing free online education. Designing a basic learning management system to minimize the impact of issues caused by network connectivity, has been a given top priority.

An introduction to the technology stack which was chosen for the development of the proposed system is discussed in the "Methodology" section of this paper, with reasoning as to why it was chosen. Following the introduction to the technology stack, the Methodology section also explains backend processes related to the main functions of the system with the use of relevant flow charts. Purpose of each of the main functions of the system are explained in the "Proposed System" section using relevant images to help the reader get a better idea of each function. Expected results and key findings of the research are discussed in the "Discussion" section of this paper, and the main points of this literature are summarized in the "Conclusion" section, reminding the reader the main objectives of the research.

II. LITERATURE REVIEW

Many researches have been conducted to study the challenges and benefits of using e-learning platforms, how learning management systems can be improved, and what qualities of e-learning have made it an attractive alternative to the conventional teaching-learning process. Throughout the entirety of this literature, authors refer to the work of other researchers and the concepts grasped from their work are reflected. Since it is the aim of the authors to identify how the MERN stack can be efficiently used to develop a web based learning management system and gain insight on the types of possible interactions, previous work devoted to studying the use of MERN stack in developing web based applications and performance optimization of web applications built using the MERN stack, have been referred.

Several studies conducted in different regions of the world to identify why e-learning has attracted students, have produced different results. Chang, Hajiyev and Su have identified through their research that, in Azerbaijan, the overall experience of using e-learning systems attracts students [3]. In another research conducted in Malaysia, Almaiah and Man discovered that factors such as advantages relative to the conventional learning systems, perceived enjoyment, and extended compatibility mainly contribute to students in Malaysia using e-learning systems [4]. Information produced by the findings of these two researches have been important for the research as it helped in understanding the requirements for designing the learning management system in such a way that students will be tempted use it.

Since the proposed learning management system was to be built using the MERN stack, studies that focused on developing web based applications using the MERN stack and researches conducted on developing learning management systems were referred to understand how the MERN stack would affect the proposed system's performance. The work of Patil et al. demonstrates the design of a web based application developed for a college using MERN stack, and justifies that it was possible to successfully develop a learning management system with a variety of functionalities. Through their work they have been able to justify that the features of the system are easily accessible [5]. Studying their work has been important for structuring the proposed system as developing an easily accessible and scalable learning management system has been a top priority.

In order to develop an adaptive and scalable e-learning system, it is vitally important to understand how the system should be modeled to reach maximum efficiency. Studies that suggested such design models were referred by the researchers to make a decision on how the system should be modeled to increase performance and thereby increase the user experience. Ahmed, Sangi, and Mahmood proposes that an adaptive e-learning model should consist of four main components: adaptive model, content model, learner model, and communication interface [6]. The adaptive model which is also known as "adaptation model", refers to a model that is used to describe methods used for adaptation in the system. The content model focuses on learning objectives and the resource formats used. The learner model is responsible for holding characterizing data of the learner and it is used in the context of lifelong learning. The communication interface is for allowing communication between students and the e-learning system. Shareable Content Object Reference Model or otherwise known as SCORM, is used for modeling the content model [7].

III. METHODOLOGY

The proposed system was developed using the MERN stack after considering a number of alternative technology stacks. The MERN stack is made up of four main technologies. It uses MongoDB which is a document based database technology for persisting data, ExpressJS which is NodeJS web framework, ReactJS which is a frontend JavaScript library, and NodeJS which is a JavaScript web server [8]. The name "MERN" comprises the first letter of the name of each of the four technologies. The MERN stack allows for building web based applications with a 3-tier architecture using JavaScript and JSON [8]. The database technology MongoDB is a NoSQL database that allows creation of schemas, collections, databases, etc. and stores records in documents consisting of objects holding key-value pairs similar to JavaScript Object Notation (JSON) objects. The backend technology comprises NodeJS and ExpressJS. NodeJS is a cross-platform JavaScript runtime environment that allows executing JavaScript code outside a browser thereby providing the functionality to build scalable servers. Moreover, NodeJS extends its functionality by allowing developers to install packages through packaging services such as yarn and npm. ExpressJS is a server-side web framework that is built for NodeJS which claims to be a "fast, reliable, minimalist" web framework for NodeJS. Supporting middleware is one of the main reasons why writing server side code using ExpressJS is considered to be easy [8]. Middleware not only speeds up the process of building a server, but also eases the task of debugging the code. Moreover, ExpressJS allows connecting to and manipulating the data in the database considerably easier than many other server-side web frameworks, by using XML HTTP Requests (XHR), GET or POST requests, or matching the URL in the incoming request with the relevant API method [9]. The frontend technology used in the MERN stack is JavaScript based similar to the backend

technology. Unlike its counterpart in the MEAN stack, ReactJS is a JavaScript User Interface (UI) library; not a framework. According to some researchers, ReactJS (most commonly referred to as React), is considered to be the main component of the MERN stack as it is capable of supporting the creation of data-driven interfaces with minimum number of lines of code [9]. The component based approach used for creating single page applications reduces development time as it allows reusability of code, and in turn eases the maintenance of the code as well. Since React can act accordingly for changing data by efficiently rendering updated components, performance of web based applications developed using React are most likely to be higher. Testing the backend and frontend of a MERN web application can be done separately using JavaScript testing framework of choice for each side of the application.

Node.js is used to develop the backend. MongoDB is used as database. Mongoose is used to create the connection between Node.js and MongoDB. First name, last name, gender, date of birth, contact no, email address, address, qualifications, password, and profile picture are taken as inputs and stored in the database when registering a new teacher. First name, last name, gender, date of birth, contact no, email address, address, password, and profile picture are taken as inputs and stored in the system when registering a new student. Bcrypt is used to hash passwords. Multer is used to upload profile pictures. System only accepts strong passwords. Passwords must contain at least one number and one uppercase and lowercase letter, and at least 8 or more characters. Course details such as course name, category, and course materials are stored in the database. When a student registers for a course, a record of which courses the student is registered for is stored in MongoDB. Title. ISBN number, author, published date, publisher, category, description cover page image and e-book is stored in the system. Multer is used to upload cover page image and e-book. ISBN number is validated before store the details.
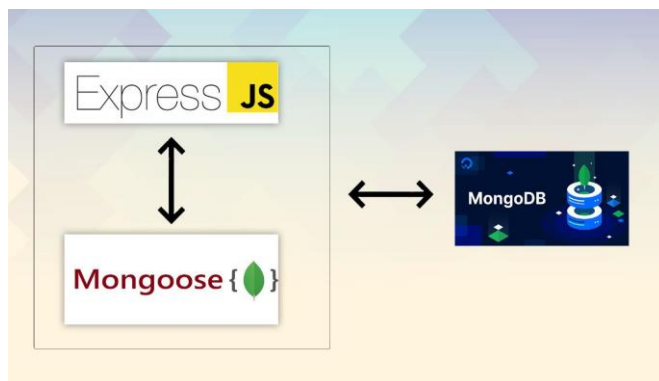

Figure 1: Technologies used for developing the backend of the system, and how they interact with each other to form a reliable and scalable backend

IV. PROPOSED SYSTEM

The proposed system is a Learning Management System (LMS) which aims to build a community for people interested in the concept of free education. Students who are willing to benefit from being able to access study materials free of charge, and instructors who are willing to design courses in such a way that knowledge on selected topic(s) is accessible by anyone who is keen on gaining knowledge on those topics for free are identified to be the two main types of users of the proposed system. Additionally, administrator who handles the administrative tasks is also considered to be a user as he/she is also registered to the system and given a separate login. Generally, all users of the system are facilitated with CRUD operations, a search function, and a report generation function. When it is required to make changes to existing data maintained by the system, user will be prompted to confirm their choice for making such changes. Moreover, all core functionalities are equipped with the capability of uploading files of at least one file type. Individual descriptions for each function are provided as follows:

A. User Management

User Management function is mainly responsible for providing the functionality of registering users to the system, maintaining registered users' information, and allowing users to modify information maintained by the system. Additionally, administrator of the system is capable of generating reports that give him/her summarized information about users. Since guest users are granted strictly limited interactions with the system, both teachers and students who wish to get the most out of the system, are required to be registered with the system. User registration is different from one another for teachers and students, and administrator of the system is considered to be initially registered to the system. Administrator registers teachers to the system after gathering required information and validating the information received, whereas guest students who are impressed by the guest view of the system and motivated to register to the system, are allowed to register themselves by providing required information.
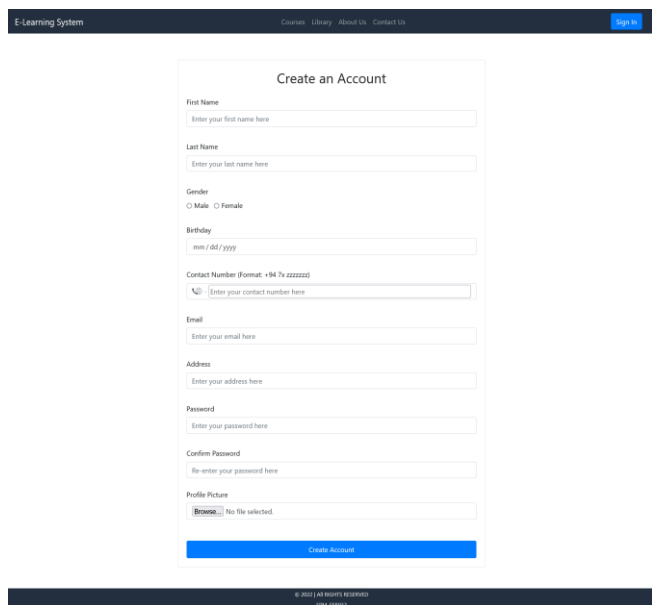
Figure 2: User registers to the system by providing required information

Registered users of the system then can log into the system to access as many functions as they are allowed. It is worth making note that teachers and students do not have access to the same functionalities within the system and therefore capabilities of each party are different from one another. Once registered, teachers and students are allowed to make changes to their profile or change the password to their profile.

The administrator of the system is provided with the functionality to view list of teachers and view list of students. In addition, the administrator can search for a particular user in each of those lists, and generate a report on the list of teachers as well as a report on the list of students.
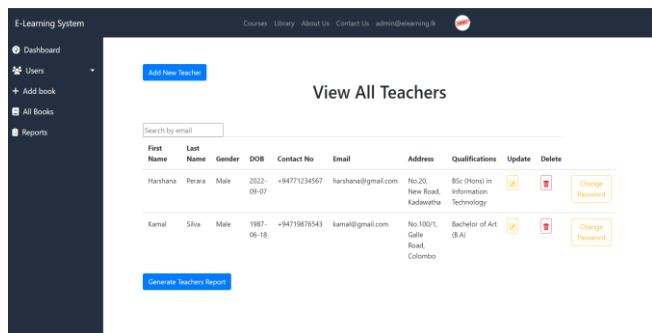
Figure 3: Administrator views list of all teachers. Administrator can search for a teacher by email, update information of a teacher, delete a teacher, or change the password of a teacher login as requested by the respective teacher.

B. Course Management

Course Management function allows students to view courses added by various teachers and enroll to a selection of courses. Since guest students also should be able to view the overview of courses, list of courses will be the main landing page of the system. Guest students who are impressed by the course overviews are redirected to register themselves with the system prior to enrolling themselves to a course.

Students can view the list of courses they have enrolled themselves into after they have enrolled to courses. They can access the features that allow them to search for a course they have enrolled to by its name, un-enroll from a course, or get a report of all the courses they have enrolled themselves to, from the view for list of enrolled courses.
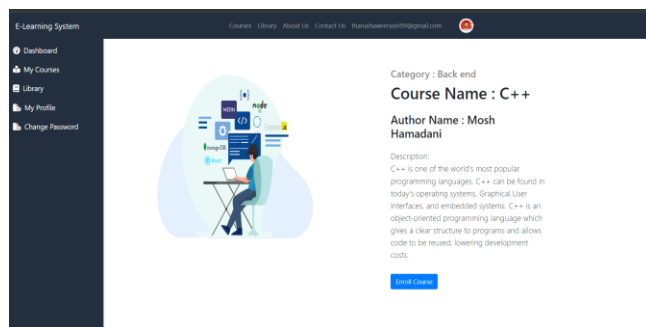

Figure 4: Student views single course. Student can click on the "Enroll Course" button to enroll themselves in the course

Students can view the courses they have enrolled themselves into and use the feature for giving feedback, to share their experiences and thoughts about a certain course. Feedback given by students can be updated or deleted later so that students are given the ability to make changes to course feedback so that their current thoughts on the course are reflected through feedback.
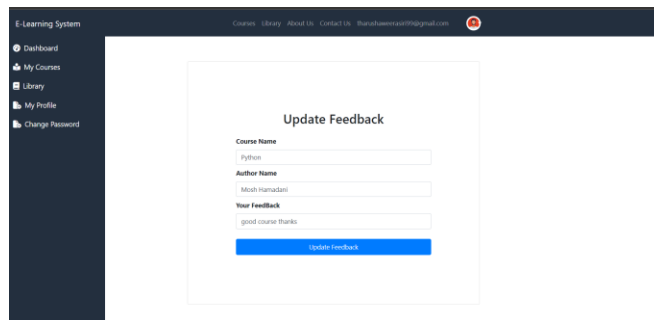

Figure 5: Student is shown current details of the feedback and student can make necessary changes and update the feedback

C. Course Material Management

The Course Material Management function handles the creation of new courses and uploading course material to created courses. It also handles the function that allows users to download course material from enrolled courses. Teachers who are interested in creating a new course have to use the "Add New Course" feature to create a new course and provide relevant information so that a new course can be created.

Once a new course is created, teacher can then upload relevant course material to be listed with reference to the relevant course. When uploading course material, relevant information will be gathered from the teacher.
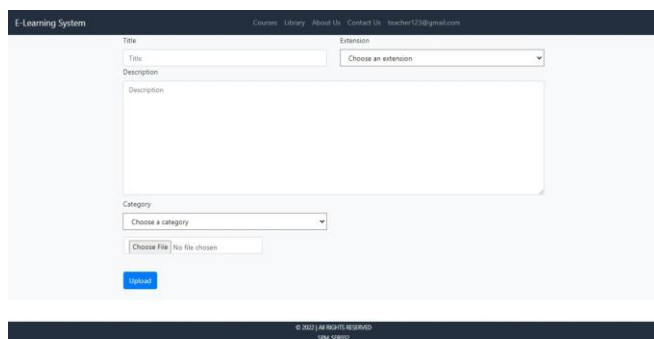
Figure 6: Teacher can upload course material for a selected course.

Teachers can also view the list of course material uploaded by them, allowing them to make changes to or remove course material updated should they suspect any irrelevances. In this listed view of course materials uploaded by them, teachers can search for course material by its title, which allows them to filter the list of course materials and focus on the selected course material. Through the listed view teachers can click on the edit button which will get them redirected to the page where information regarding the course material will be gathered. Alternatively, they can click on the delete button which will result in removing course material updated to a certain course. Teachers who view the list of course material uploaded by themselves can also generate a report of the course materials they have uploaded.
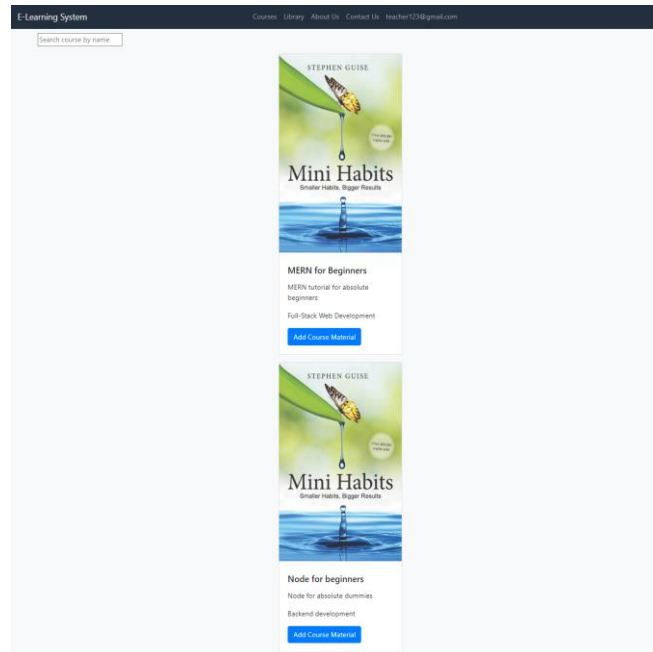
Figure 7: Teacher views all courses added by them. Teacher can search for a certain course by name

Students who have enrolled themselves for courses are also provided some functionalities by the Course Material Function as well. They could view the course materials uploaded for the courses they have enrolled to, in listed view. This list of course material then can be filtered by accessing the search function to filter course material by name. Once they have found the course material they are interested in, they can download the course material by simply clicking on the button with a download icon on it.

D. Library Management

Library Management function is used by the administrator of the system to add additional reading material to the library maintained by the system itself so that, students will not have to worry about having to pay for getting access to such reading material. Administrator will have to provide required information related to the book that is to be uploaded to the library. Books uploaded to the library will be accessible by all types of users and will be shown a list of all books. However, the listed view will be different for administrator from the listed view for students and teachers.

Administrator can choose the update option made available in the listed view, to update details of a specific book. Alternatively, the administrator can remove the book from the listed should he/she fail to see the relevance of keeping the book listed in the library. Administrator can also generate a report of all the books that exist in the library, and search for a book by the ISBN number of the specific book.
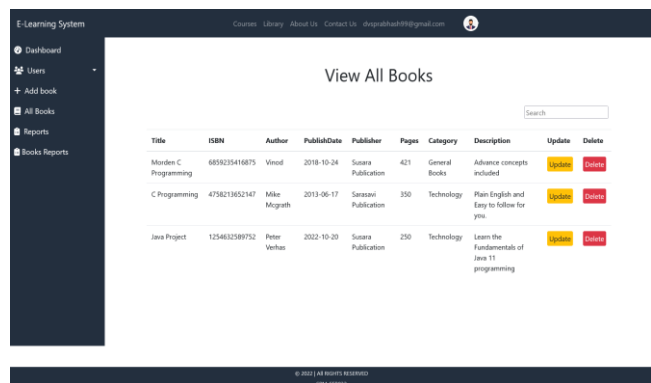
Figure 8: Administrator views list of all books in the library. Administrator can search for a book by ISBN, update information of a book, or delete a book from the list

Users of the system can use their listed view of all the books that exist in the library, to view details of the book and download the book if they feel the book contains information they require. Moreover, they will also be provided with a search functionality that will allow them to search for a book by its title.
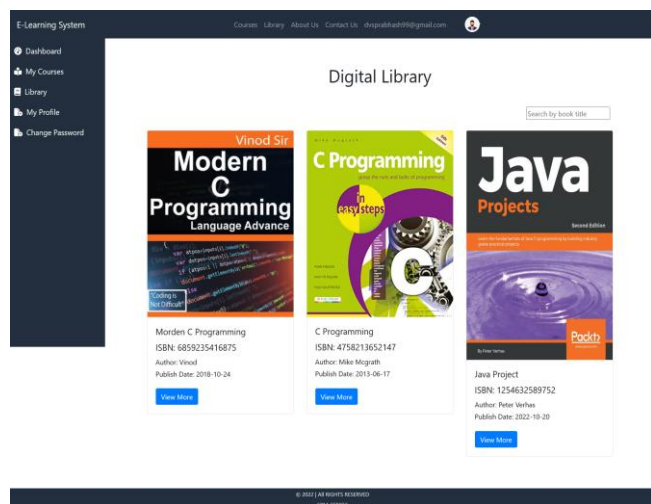

Figure 9: User views list of all books in the library. User can search for a book by title

V. DISCUSSION

It is highly expected that the number of students engaging in learning activities through learning management systems which are mainly focused on providing free education such as this one, will increase due to the fact that students are highly attracted to reliable and highly available learning management systems that provide free educational services. Current trend of educational organizations promoting the concept of online education is also expected to result in increasing the number of students using this type of educational platforms.

The number of teachers involved in free learning management systems such as this one is also expected grow as the teachers are highly likely to appreciate promoting the concept of free education.

Since allowing users to access extra reading materials for completely free of charge is immensely useful, it is expected that being able to access a library that is maintained internally would keep on taking in many users.

Out of various automated testing tools, Selenium is used to test our software solution [10]. It is the aim of the authors to check whether the software solution meets the required specifications and identify variances between actual and expected results.
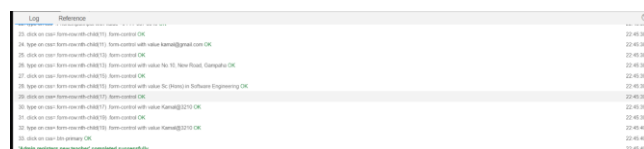

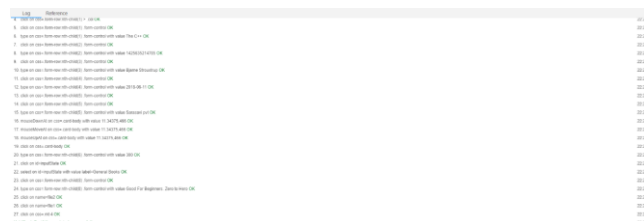**Figure 10:** Selenium test result for Register New Teacher interface

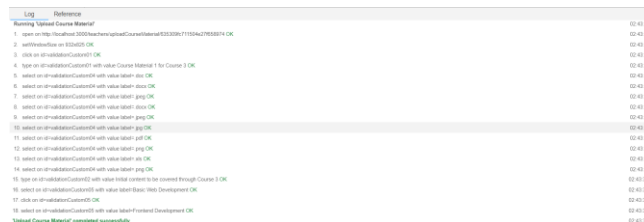**Figure 11:** Selenium test result for Add Book to Library interface

Figure 12: Selenium test result for Upload Course Material interface
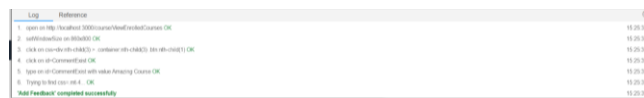

Figure 13: Selenium test result for Give Feedback to Library interface

VI. CONCLUSION

It has been the main objective of the research to assess the possibility of building a reliable web based

application that serves as a learning management service providing educational services.

The authors of this literature have chosen the MERN stack as the preferred technology stack because it is a technology stack proven to be reliable. The authors would like to recommend looking into using other possible technology stacks for development.

Throughout this literature authors have shared proof of the functionality of the system and discussed the main functions of the system.

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