Enhancing University Education Through Project-Based Learning: A Case Study on Full Stack MEAN Development for Web Application Design and Development

[1]Deepika Sirmoria [2]Dr M Trupthi [3]Dr G Vishnu Murthy
[1,2,3]Anurag University
[1]Deepikasirmoria9963@gmail.com [2]trupthijan@gmail.com [3]deancse@anurag.edu.in

Abstract— **The aim of this paper is to design and develop the web application to support project based learning activities in "Web Programming in MEAN" course at Artificial Intelligence(AI), Anurag University(AU). Project-based learning (PBL) can be an effective strategy for developing twenty-first-century learning and skills in future-oriented settings under-graduate education. This technique allows students to conduct in-depth research on worthy themes, allowing them to learn from their experiences and apply their newly acquired information, skills, and attitudes to real-life situations. By using cutting-edge tools to build web applications, the system hopes to help students understand web application designing and programming.**

Keywords— **Project-based learning; under-graduate; web àpplication; web programming; application bàsed system**

I. INTRODUCTION

The Project-based learning is an effective pedagogical approach that fosters deep understanding, critical thinking, and the development of essential 21st-century skills. It prepares students to tackle real-world challenges and encourages a lifelong love for learning[Markula et.al]. Project-based studies are detailed examinations of specific projects or initiatives undertaken by organizations or individuals.[Holmes et.all] These case studies provide a comprehensive analysis of the project's objectives, strategies, challenges, and outcomes. They are often used in business, academia, and other fields to gain insights into real-world scenarios and learn from both successful and unsuccessful projects.

 "This study aims to determine the impact of Project-Based Learning (PBL) on student engagement and learning outcomes in a MEAN web development course." given at AIML,AU. The developed system aims to enable students to design and program by creating their own web applications with cutting – edge tools like MongoDB, Express, NodeJS and Angular. These tools allow students to build their own web sites and same can be used as mobile applications. By providing an advanced web environment with these features, educational institutions can offer students a comprehensive and effective learning experience in website designing and programming, equipping them with valuable skills for the digital age.

The subsequent sections of the paper are organized in the following manner: The subsequent section provides an overview of the fundamental principles underlying the project-based learning methodology. Section 3 elucidates the utilization of features inside the application-based system designed for both teachers and students, as described in the present study. Section 4 delineates the survey that was undertaken subsequent to the course in order to ascertain students' perspectives on real-time systems and their impact on their academic performance. Section 5 is dedicated to presenting the conclusions derived from the study.

II. LITERATURE SURVEY

TABLE I
Literature Survey

Title & Year	Methodology	Limitations
Enhancing Web Programming Education through PBL, 2021[2]	Real-world web app development integrated into curriculum; project development based on feedback.	Small sample size; qualitative data from surveys & interviews, no control group.
Project-Based Learning for Software Engineering: Evaluation in Web Programming, 2022[1]	Team-based PBL with focus on web programming using GitHub	No control group for comparison; focus on perceptions, lacks quantitative performance metrics.
Effectiveness of Project-Based Learning in Enhancing Programming Skills,2022[3]	Pre- and post-tests to measure programming skill development through web app projects; focus on collaboration Learning	Short-term evaluation; didn't measure long-term retention of skills.
Student Perspectives on PBL in Web Development Courses, 2023[4]	Survey-based evaluation of student satisfaction and collaboration within PBL-driven web development projects.	Reliant on self-reported data; didn't assess if projects met industry expectations

III. PROJECT BASED LEARNING

Project-based learning (PBL) is an instructional approach that emphasizes learning through hands-on projects and real-world experiences. It encourages students to actively explore and

solve complex problems, collaborate with peers, and apply their knowledge and skills to authentic, meaningful tasks.

A. Key features and benefits of project-based learning

a. Prep Student-Centered: PBL shifts the focus from teacher-led instruction to student-centered learning. Students take ownership of developing and designing their own web application and have a say in the direction and outcomes of the project.

b. Authentic Tasks: Students are designed to mirror real-world challenges and scenarios, making learning relevant and practical. This helps students see the practical application of their knowledge.

c. Interdisciplinary: Web application often involves multiple courses or disciplines. Students can integrate knowledge and skills from various areas to solve complex problems, promoting a holistic understanding of a problem and provide a solution.

d. Collaboration: PBL encourages collaboration and teamwork. Students often work in groups 3-4 members per group), learning to communicate effectively, delegate tasks, and leverage each other's strengths.

e. Critical Thinking: Projects require students to think critically, analyze information, and make informed decisions. They develop problem-solving skills and learn to evaluate multiple solutions.

f. Time Management: Every web application has some dead line. This helps students improve their time management skills as they need to plan and organize their work to meet project deadlines.

g. Inquiry and Research: Students engage in inquiry-based learning, where they ask questions, conduct research, and seek answers. This fosters a natural curiosity and a love for learning.

h. Presentation and Communication Skills: Web applications often culminate in presentations or exhibitions, where students showcase their work to peers, teachers, or even the organisation. This hones their presentation and communication abilities.

i. Assessment: Assessment in PBL is often multidimensional, focusing on the process (e.g., teamwork, research, presentation) as well as the final product (e.g., the web application itself). It provides a more holistic view of student performance.

j. Motivation: Web application are typically engaging and interesting to students, increasing their motivation to learn. They see the value in what they are doing and are more likely to stay engaged.

IV. METHODOLOGY

- *Training:* Students are trained as part of curriculum content with hands on practical session for a period of 16 weeks

- *Specific Project Tasks:* Description of the project is explained along with the assessment criteria and individual tasks are assigned to a group of students and.
  For example:
  Task: Design a web application using the MEAN stack with user authentication and CRUD functionalities.

Assessment Criteria: Technical functionality (40%), code quality (30%), collaboration (20%), and documentation (10%).

- D*evelopment Process:*
  Planning: Initial requirement gathering and project scoping.
  Design: Database design, and user interface planning.
  Coding: Iterative development of back-end and front-end.
  Testing: Unit testing, user acceptance testing, and bug fixes.

V. APPLICATION BASED SYSTEM (ABS) FOR PROJECT-BASED LEARNING.

An Application based system was implemented in order to establish an optimal educational setting conducive to the implementation of project-based learning activities for "Web Programming with MEAN" course, hence facilitating seamless execution. The Google Classroom can be an excellent platform for implementing project-based learning (PBL) in your classroom. PBL is an instructional approach where students learn by actively engaging in real-world and personally meaningful projects. Google Classroom provides a set of tools and features that can support and enhance the PBL process. By leveraging Google Classroom for project-based learning; you can create an organized and collaborative digital environment that supports student engagement, communication, and the successful completion of meaningful projects.

The application offers two distinct activity modes that can be utilized by both professors and students. When you use activity modes, you can use some tools that teachers and students can use to do project-based learning tasks that are based on applications. The modes' interfaces were made to be similar so that everyone could find them easy to use. The login page for the app is where both teachers and students must go to get into activity modes and initiate their own activities on the system.

A. Teacher Activities

Google Classroom offers a "Teacher Mode" by default when you create a class as a teacher. However, there isn't a specific setting or option labeled as "Teacher Mode." Instead, Google Classroom is designed to provide teachers with various tools and features to effectively manage and organize their classes. Fig. 1. shows a screenshot of teacher interface of the application. After login in the application there are four panels. One of the panels is the classwork which is used to create the Assignment (PBL) for the students.
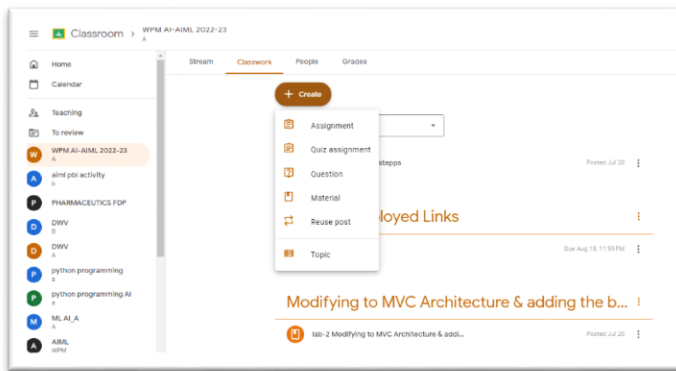
Fig. 1. Teacher Mode Interface for Assigning Project Based Learning

Fig. 2 shows the assigned PBL project with the instructions on the "PBL - Website Design, Development and Deployment" on the left-side and right-side the deadline due date, points and rubric and Fig. 3 shows the Google document shared where students can upload the details of the project attached to the PBL assignment. Fig. 4 Progress page of student work assigned for Project Based Learning.
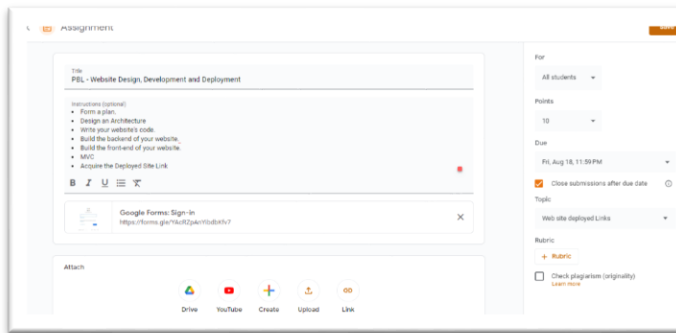

Fig. 2. Teacher Mode Interface for Assigning Project Based Learning

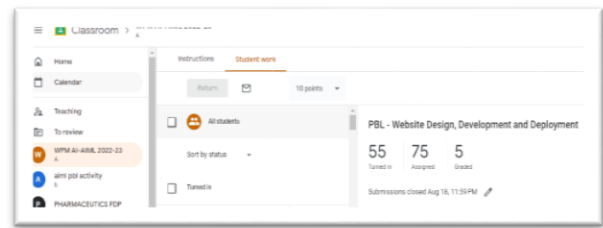Fig. 3. Google document shared assigned for Project Based Learning

Fig. 4. Progress page of student work assigned for Project Based Learning

B. Student activities

As previously stated, the interfaces of the teacher and student approaches were intentionally designed to be identical in order to provide a user-friendly experience for both educators and learners. Google Classroom has a student view that lets students interact with their classes and assignments, but no "student mode" setting. Learn how students can use Google Classroom:

- Joining Class: Students receive class codes or email invitations from their teachers to join Google Classroom classes. Students can also join a class on Google Classroom (classroom.google.com) by clicking on the "+" symbol in the top right corner and entering their teacher's class code.
- Dashboard: Students will see a dashboard with their classes when they log in to Google Classroom after enrolling. Each class will receive teacher updates, assignments, and announcements.
- Assignment Submission: Teachers submit assignments for students to complete. Upload files, type responses, or offer links for assignment submissions. Students can submit tasks when ready.
- Looking at Grades: Students can see their grades and teacher feedback in each class's "Grades" section.
- Communication: Students can post class-related comments and questions on the Stream to interact with the teacher and peers.

Students require a Google account (usually issued by their school) and teacher additions to utilize Google Classroom. They can then access their classes and assignments on Google Classroom. These tasks are done the same way by both teachers and students. Let's now pay more attention to the things that students do on the learning system to learn. The agile method was used for this study. This includes planning, design, coding, testing, and implementation.

C. Case Study

This paper examines the implementation of problem-based learning (PBL) in a student team project, using a specific example as a case study. "Loc8r –Web Application Development"

1) Planning: Loc8r-Web Application provides local Wi-Fi locations for work. It will offer facilities, opening times, ratings, and location maps for each location. Visitors can write ratings and reviews.

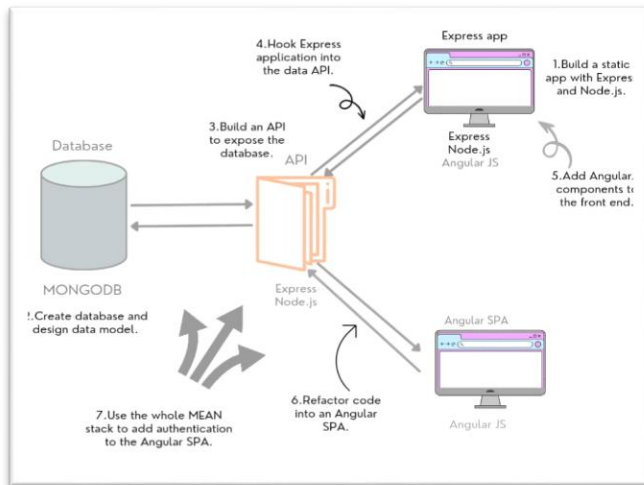2) Designing: Fig. 6: shows the architecture of the Loc8r stack application with Development stages.

Fig. 5. Architecture of the Loc8r stack application with Development stages

3) Coding: The installation of Node.JS and Express.JS played a crucial role in establishing the fundamental framework for the application. Once the development environment was established, the subsequent commands were executed on the command line interface (CLI) of V S Code in order to install Express.JS. As a part coding Fig.: 6 illustrates the configuration of the Loc8r directory application, which has been equipped with node modules and several packages. The App.js file serves as the start-up file for the application, Package.json, Routes handling, Implementing route path for user define middleware, Implementation of frontend view template engine, Implementation of public and model directories, Connection to MongoDB.
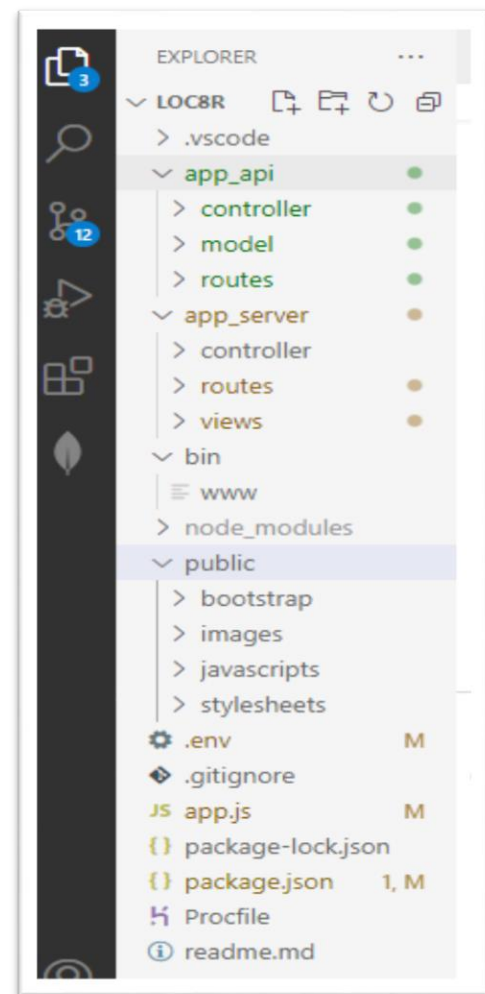

Fig. 6. Folder Structure of the Loc8r Web Application

4) Testing and Implementation: In order to make sure that the application meets the requirements set during the planning part, testing was done at different stages of the design and implementation process. The primary aim of this study is to implement the application on a platform that is both adaptable and user-friendly. The Cyclic platform as a service (PaaS) was selected for this purpose due to its ability to enable developers to concentrate on constructing, operating, and expanding application functionalities, as well as managing storage and network components. There are several advantages associated with the implementation of this solution, including cost reduction, improved accessibility to developer infrastructure, and enhanced support for Quality of Service (QoS). The deployment of Loc8r was executed using the cyclic website, resulting in the generation of the URL "https://loc8r.cyclic.app" as depicted in Fig. 7.
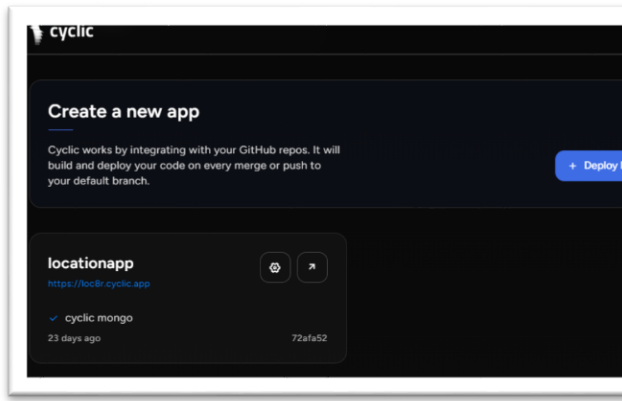
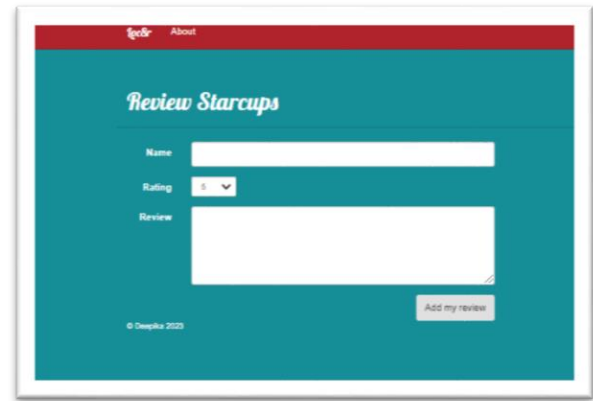Fig. 7. Loc8r –Deployed on Cyclic.sh website

5) User Interface Screen shots: The end product of the Loc8r application is shown as below Fig.8,9,10,11 are the screen shots are obtained from the home page, Info page, add review page and about page. It will look different on different devices, but it will always show a list of places with information about each one. People will be able to log in and give reviews.
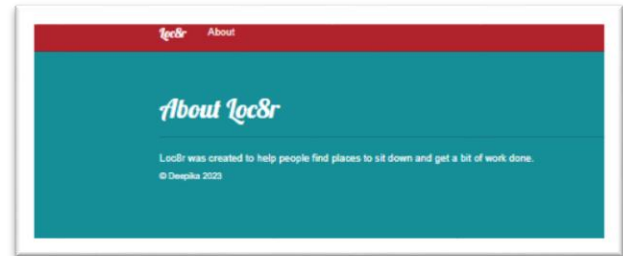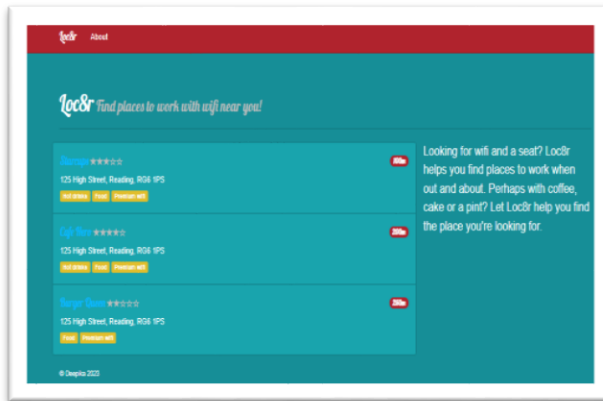

Fig. 8. Loc8r –Home Page

Fig. 9. Loc8r – Info Page

Fig. 10. Loc8r – Add Review Page

Fig. 11. Loc8r – Add Review Page

VI. EVALUATION

As can be seen in Fig. 2, the information regarding the deployed app is gathered through the use of a Google form. A poll was done at the end of the semester to assess student acceptance of the application-based system for project-based learning when compared to the other course EML which was executed in a traditional approach by other faculty. The survey's core comprised 20 statements. An anonymous poll was conducted with 140 students as respondents. This survey was completed by all course enrolled students. In the poll, students rated statements on a Likert scale: 1 for strongly disagreeing, 2 for disagreeing, 3 for somewhat disagreeing, 4 for agreeing, and 5 for strongly agreeing.
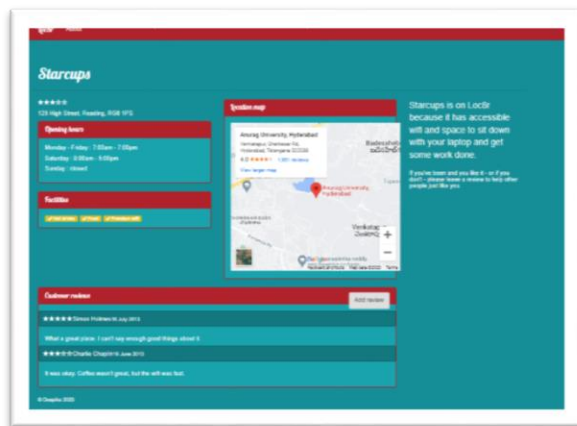
117

TABLE II
STUDENT RESPONSES SUPPORTING RUBRICS AND THEMATIC ANALYSIS

Criteria	Strongly Disagree(1)	Disagreeing(2)	Neutral (3)	Agree(4)	Strongly Agree(5)	Total Responses
My academic achievement enhanced with this system	6	5	23	24	82	140
PBL increased engagement in the classroom	2	3	24	35	76	140
The system helped in learning more compared to others	5	4	16	38	77	140
Technological tools aided retention of PBL concepts	2	4	20	29	85	140

A. Survey results

Given that the survey was conducted with all 140 students enrolled in the course, it is likely that the study used a **census sampling** method, where all individuals from the population (in this case, the students enrolled in the "Web Programming with MEAN" course) were included in the survey, rather than selecting a random or specific sample.but it suggests that the whole course group was surveyed.The survey findings indicate that the students expressed satisfaction with both the develòped system and the implemented appròach for pròject-based learning activities. Table 1 displays the assertions derived from the conducted survey, together with the corresponding responses provided.

TABLE III
FEW SURVEY ASSERTIONS AND RESPONSES

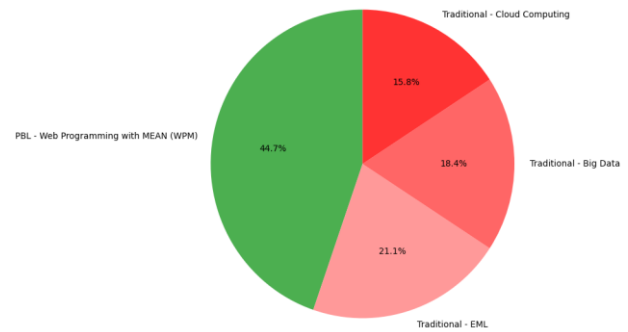| Statement No.	Statement	1	2	3	4	5	Total
1	My academic achievement enhanc this system	6	5	23	24	82	140
2	Did project based learning increase engagement in the class room	2	3	24	35	76	140
10	Comparing to other approaches did this system helped in learning more	5	4	16	38	77	140
12	Did the technological tools aid in the retention of the project based learning	2	4	20	29	85	140
15	PBL provides a student centric approach to teach the course web programming with MEAN	1	6	23	31	79	140

Fig. 9. Effectiveness Comparison: PBL (WPM) vs Traditional Subjects (EML, Big Data, Cloud Computing)

VII. CONCLUSION

The purpose of this document is to provide a description of how to use the features and capabilities of an application-based system that was built and developed to support project-based learning activities in the "Web Programming with MEAN" course that was offered at AIML, Anurag University. In this regard, the components of the course, the system that was designed, the online activities that were project oriented, and the study outcomes are explained. According to the findings, the application-based system and the functional approach for project-based learning activities were both to the students' satisfaction. "Students participating in PBL will perform better in terms of project completion and skill retention compared to students who follow traditional lecture-based learning.". The replies of students to the survey that was carried out and the academic results that were acquired demonstrate that the system provides an effective and sophisticated web environment for students to have meaningful learning experiences about web site creation and programming.

VIII. FUTURE SCOPE

PBL enhances student engagement, collaboration, and real-world skill development in web programming courses.
This approach can benefit the community by preparing industry-ready graduates and fostering more effective teaching methodologies. Key takeaways highlight the value of practical, hands-on learning, continuous feedback, and the development of essential soft skills.However, limitations like the absence of a control group, a small sample size, and technological dependencies need to be addressed to strengthen the findings and make them more applicable on a larger scale.

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