

AN AI-SUPPORTED PROJECT-BASED LEARNING APPROACH FOR ENHANCING WEB TECHNOLOGY COMPETENCE IN HIGHER EDUCATION

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Abstract

The rapid evolution of digital technologies has significantly transformed higher education, particularly in the domain of web technologies. However, traditional teaching approaches often fail to develop practical competencies required in real-world environments. This study proposes an AI-supported Project-Based Learning (PBL) approach implemented through a Learning Management System (LMS) to enhance students' web technology competence.

An experimental study was conducted involving undergraduate students divided into control and experimental groups. The experimental group was exposed to an AI-enhanced PBL environment, incorporating adaptive quizzes, automated feedback, and project-oriented tasks. The findings indicate a statistically significant improvement in students' competence levels compared to traditional methods. The results suggest that integrating artificial intelligence with PBL provides a more effective and personalized learning experience in higher education.

Keywords: Project-Based Learning, Artificial Intelligence, LMS, Web Competence, Higher Education.

Introduction

The increasing demand for skilled professionals in web technologies has placed new expectations on higher education institutions. While theoretical knowledge remains essential, the ability to apply this knowledge in practical contexts has become equally important. Nevertheless, conventional teaching methods often emphasize passive knowledge acquisition, which limits students' ability to develop real-world competencies.



In response to these challenges, Project-Based Learning has gained considerable attention as an effective instructional strategy. This approach encourages students to engage in real-world tasks and construct knowledge through active participation, aligning with the principles of Constructivism.

At the same time, the development of Artificial Intelligence in Education has introduced new opportunities for adaptive and personalized learning. AI-driven systems can analyze student performance, provide real-time feedback, and generate customized learning content.

Despite these advancements, limited research has explored the combined impact of AI and PBL in web technology education. Therefore, this study investigates how an AI-supported PBL approach can enhance students' competence in web technologies.

2. Literature Review (Revised)

Project-Based Learning (PBL) has been widely recognized as an effective pedagogical approach that promotes active learning and the development of higher-order thinking skills. According to John W. Thomas, PBL enhances student engagement by involving learners in meaningful and context-driven activities [1]. Similarly, Markham emphasizes that PBL enables students to connect theoretical knowledge with real-world applications, thereby improving long-term retention [2].

From a theoretical standpoint, PBL is grounded in constructivist learning theory. Jean Piaget proposed that knowledge is actively constructed through experience, while Lev Vygotsky highlighted the importance of social interaction in cognitive development. These perspectives provide a strong theoretical foundation for the application of PBL in higher education [3].

In recent years, the integration of artificial intelligence into education has gained significant attention. Research by Rose Luckin demonstrates that AI can support personalized learning by adapting content and providing real-time feedback [4]. Furthermore, studies by Zawacki-Richter et al. indicate that AI applications in higher education are particularly effective in assessment, feedback, and learning analytics [5].

Despite the growing body of literature on PBL and AI in education, most studies have examined these approaches independently. There remains a gap in understanding how their integration can influence competence development,

particularly in web technology education. This study addresses this gap by proposing an AI-supported PBL framework and evaluating its effectiveness in a higher education context.

3. Materials and Methods

This study employed a quasi-experimental research design conducted at Fergana State Technical University. A total of 60 undergraduate students participated in the study and were divided into control and experimental groups.

The control group followed a traditional lecture-based approach, while the experimental group was engaged in a Project-Based Learning environment supported by an AI-integrated LMS.

To clearly illustrate the research structure, Table 1 presents the comparison between the two groups.

Table 1. Research Design and Group Structure

Parameter	Control Group	Experimental Group
Number of students	30	30
Teaching method	Traditional lecture	PBL approach
Technology used	None	AI-supported LMS
Learning activities	Theoretical tasks	Real-world projects
Assessment method	Written exams	Projects + AI-based tests
Feedback type	Manual	Automated + adaptive

To evaluate students' competence in web technologies, a composite model was used, incorporating theoretical knowledge, practical skills, and project performance.

$$C = \alpha K + \beta S + \gamma P$$

Here, C represents overall competence, K refers to theoretical knowledge, S indicates practical skills, and P denotes project performance. The coefficients α , β , and γ represent weighting factors.

The components of competence and their assessment methods are summarized in Table 2.

Table 2. Components of Web Technology Competence

Component	Description	Assessment Method
Theoretical Knowledge (K)	Understanding of web concepts	Written tests
Practical Skills (S)	Ability to implement solutions	Coding tasks
Project Performance (P)	Real-world project development	Project evaluation

Pre-test and post-test assessments were conducted to measure learning outcomes. Statistical analysis was performed using an independent samples t-test.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Research Model

The conceptual model proposed in this study illustrates the relationship between artificial intelligence, the learning management system, and project-based learning activities in enhancing students' web technology competence.

The model is structured around three main components. First, artificial intelligence functions as an adaptive layer that analyzes student performance and generates personalized learning content, including automated quizzes and feedback. Second, the learning management system serves as the delivery platform that integrates instructional materials, project tasks, and monitoring tools. Third, Project-Based Learning acts as the pedagogical framework that engages students in real-world problem-solving activities.

These components interact to influence the development of web technology competence, which is measured through three dimensions: theoretical knowledge, practical skills, and project performance. The relationship between these variables can be interpreted as a structured learning process in which AI enhances personalization, LMS ensures system organization, and PBL drives active learning. The adaptive engine supports project-based learning activities by dynamically adjusting content and providing personalized feedback.

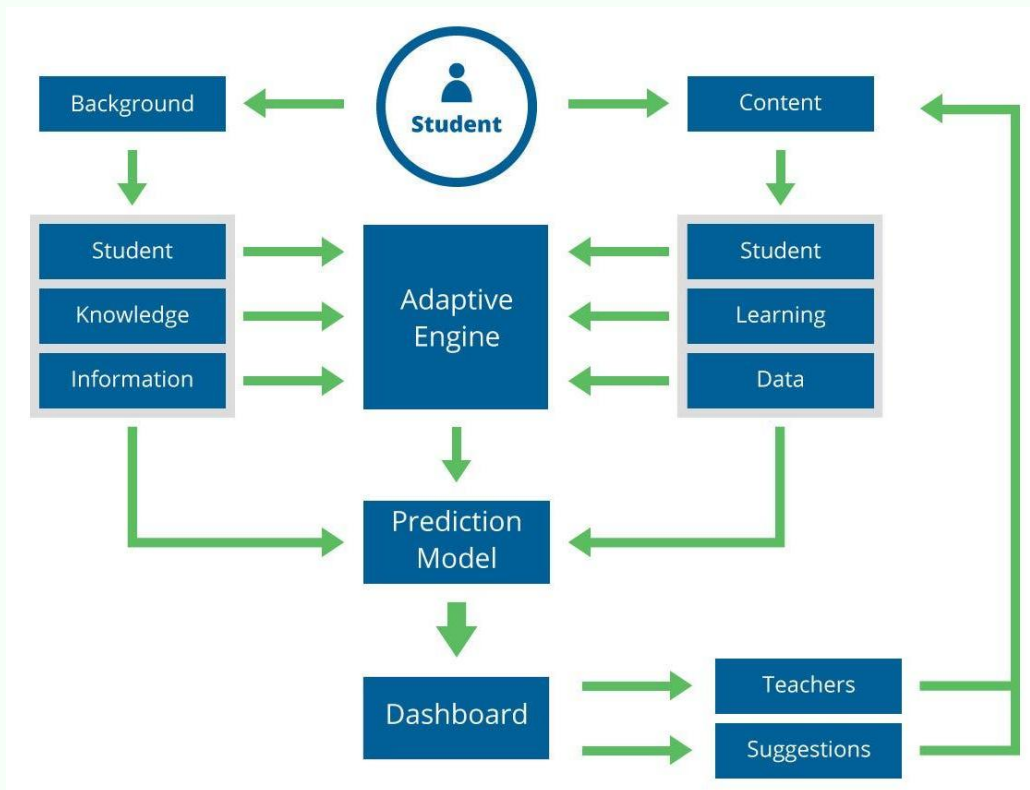


Figure 1. Architecture of the AI-based adaptive learning system integrated into the PBL environment

4. Results and Discussion

The results of the study indicate a significant improvement in students' performance within the experimental group compared to the control group. The architecture of the AI-based adaptive learning system used in this study is illustrated in Figure 1.

Table 3. Pre-test and Post-test Results

Group	Pre-test Mean	Post-test Mean	Improvement (%)
Control	62.3	70.1	+7.8%
Experimental	60.8	82.4	+21.6%

The experimental group demonstrated a substantially higher increase in competence levels, suggesting that the integration of AI and PBL creates a more effective learning environment.

To further validate the results, an independent samples t-test was conducted.

Table 4. Independent Samples t-test Results

Parameter	Value
t-value	3.87
p-value	0.001
Significance level	$p < 0.05$
Result	Significant difference

The statistical analysis confirms that the difference between the two groups is significant, indicating that the proposed approach has a measurable impact on learning outcomes.

These findings are consistent with previous studies indicating that AI-supported learning environments improve student performance and engagement [5], while project-based approaches enhance practical skill development and problem-solving abilities [1], [2].

5. Conclusion

This study demonstrates that an AI-supported Project-Based Learning approach significantly enhances students' web technology competence in higher education. The integration of artificial intelligence enables adaptive learning, while project-based activities foster practical skills and deeper understanding.

The results highlight the importance of combining technological innovation with pedagogical strategies to achieve optimal learning outcomes. Future research may focus on scaling this approach, exploring its applicability across different disciplines, and incorporating more advanced AI techniques.

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