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DEVELOPMENT AND EVALUATION OF AN AI-POWERED EDUCATIONAL APPLICATION FOR INTELLIGENT LEARNING MATERIAL ANALYSIS IN HIGHER EDUCATION

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ABSTRACT

The rapid advancement of Artificial Intelligence (AI), particularly Generative AI and Large Language Models, is transforming higher education by providing innovative tools that enhance teaching, learning, and student engagement. This study presents the development and evaluation of AI Lesson Visualizer & Quiz, a web-based educational application designed to support students in processing learning materials through AI-powered content analysis. The application enables users to upload PDF documents or enter textual content and automatically generates concise summaries, key concepts, visual representations, and self-assessment quizzes using the Google Gemini API. The system was developed using React, Vite, Tailwind CSS, Node.js, and Express, following a client-server architecture that ensures efficient document processing and seamless interaction between the frontend, backend, and AI services. To evaluate the effectiveness and usability of the proposed application, an empirical study was conducted involving 250 university students from the Faculty of Technical and Natural Sciences at the University of Vlora "Ismael Qemali". Participants represented both Bachelor's and Master's study programs in Computer Science, Mechanical Engineering, and Electrical Engineering. Following practical use of the application, students completed a structured questionnaire based on a five-point Likert scale.

The results indicate a high level of user satisfaction and acceptance of the proposed system. Students

positively evaluated the application's usability, interface design, AI-generated summaries, concept extraction, visual learning support, and self-assessment quizzes. Furthermore, participants reported that the application improved their understanding of educational materials, reduced study time, and increased engagement in the learning process. A substantial majority also expressed support for the broader integration of AI-powered educational applications into higher education. The findings suggest that integrating Generative AI into educational applications may enhance students' perceived learning experience, facilitate comprehension, and promote active engagement. The proposed application represents a practical example of how modern AI technologies can be successfully integrated into higher education to support intelligent, personalized, and student-centered learning environments.

Keywords: Artificial Intelligence, Generative Artificial Intelligence, Higher Education, Educational Technology, AI-Assisted Learning

1. INTRODUCTION

The rapid advancement of digital technologies has significantly transformed higher education, reshaping the ways in which knowledge is created, delivered, and acquired. Universities are increasingly integrating intelligent digital solutions into teaching and learning processes to improve educational quality, enhance student engagement, and provide more personalized learning experiences. Among these emerging technologies, Artificial Intelligence (AI) has become one of the most influential innovations, offering new opportunities to support both students and educators through intelligent content generation, adaptive learning environments, and automated educational services.

Recent developments in generative AI have accelerated the adoption of AI-powered educational applications capable of analyzing learning materials, generating summaries, identifying key concepts, creating self-assessment quizzes, and providing personalized feedback. These capabilities enable students to organize information more efficiently, reduce study time, and improve their understanding of complex topics. At the same time, AI assists educators by automating routine tasks, preparing instructional materials, and supporting data-driven decision-making within the educational process.

Despite the growing interest in AI-supported learning, many existing studies primarily focus on the theoretical potential of Artificial Intelligence or evaluate commercially available AI tools. Comparatively fewer studies present the design, implementation, and empirical evaluation of dedicated AI-based educational applications developed specifically for higher education environments. Moreover, limited research combines the technical development of an educational application with a comprehensive evaluation of students' perceptions regarding its usability, usefulness, and impact on learning outcomes.

To address this gap, this study presents the design, development, and evaluation of AI Lesson Visualizer & Quiz, an intelligent web-based educational application that assists students in processing learning materials. Developed using React, Vite, Tailwind CSS, Node.js, and Express, and powered by the Google Gemini API, the application enables users to upload PDF or text-based learning materials and

automatically generate concise summaries, key concepts, visual representations, and self-assessment quizzes. These functionalities are intended to facilitate independent learning and improve students' comprehension of academic content.

The effectiveness of the proposed application was evaluated through a quantitative study involving 250 students from the Faculty of Technical and Natural Sciences, representing both Bachelor's and Master's study programs. Following practical use of the application, participants completed a structured questionnaire designed to evaluate usability, functionality, AI-generated content quality, learning support, and overall satisfaction. The collected data provide valuable insights into students' acceptance of AI-supported learning technologies and their perceived educational benefits.

The main contribution of this study is twofold. First, it presents the implementation of a practical AI-powered educational application that integrates modern web technologies with large language models to support university learning. Second, it provides empirical evidence, based on feedback from 250 students, regarding the usability and educational effectiveness of the proposed system. The findings contribute to the growing body of research on Artificial Intelligence in higher education and demonstrate how AI can enhance student-centered learning environments.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature on Artificial Intelligence and innovative learning environments. Section 3 describes the research methodology and the developed application. Section 4 presents the experimental results and statistical analysis. Section 5 discusses the findings in relation to previous studies, while the final section summarizes the conclusions, limitations, and future research directions.

The main contributions of this study are as follows:

- Development of an AI-powered educational web application for intelligent learning material analysis.
- Integration of the Google Gemini API to generate summaries, key concepts, visual representations, and self-assessment quizzes.
- Empirical evaluation involving 250 university students from three academic disciplines.
- Quantitative analysis of students' perceptions regarding usability, functionality, and educational effectiveness.
- Practical evidence supporting the integration of Generative AI into higher education.

2. LITERATURE REVIEW

2.1 Artificial Intelligence in Higher Education

Artificial Intelligence (AI) has become one of the most transformative technologies in higher education, fundamentally changing how knowledge is delivered, accessed, and assessed. Recent advances in machine learning, deep learning, and natural language processing have enabled universities to integrate intelligent systems into teaching, learning, assessment, and academic administration. Rather than serving solely as

automation tools, AI-based applications increasingly function as learning assistants capable of adapting educational content to students' needs, providing personalized recommendations, and supporting decision-making throughout the learning process.

Several studies have shown that AI can improve learning efficiency by providing immediate feedback, automating repetitive educational tasks, and facilitating personalized instruction. According to Zawacki-Richter et al. [1], Artificial Intelligence has considerable potential to enhance higher education through adaptive learning systems, intelligent tutoring, automated assessment, and learning analytics. Their systematic review also emphasizes that AI should complement, rather than replace, educators by supporting evidence-based teaching practices.

The emergence of Generative Artificial Intelligence has significantly expanded these capabilities. Unlike conventional AI systems that primarily classify or predict information, generative models are capable of producing coherent text, explanations, summaries, visual content, programming code, and educational resources in real time. Large Language Models (LLMs), including Google's Gemini, OpenAI's GPT models, and Anthropic's Claude, have introduced new possibilities for creating interactive learning environments that actively assist students during independent study.

2.2 Generative AI for Teaching and Learning

The rapid adoption of generative AI has attracted considerable attention from researchers investigating its educational impact. Kasneci et al. [2] argue that Large Language Models have the potential to transform education by providing personalized explanations, generating instructional materials, supporting formative assessment, and facilitating student engagement. At the same time, they emphasize the importance of maintaining human supervision to ensure the accuracy and pedagogical quality of AI-generated content.

Similarly, UNESCO [3] highlights that generative AI should be implemented according to principles of transparency, fairness, privacy protection, and responsible use. Educational institutions are encouraged to establish ethical guidelines that maximize educational benefits while minimizing risks related to misinformation, bias, and academic integrity.

Generative AI has demonstrated particular value in assisting students during self-directed learning. AI-generated summaries reduce cognitive load by condensing lengthy educational materials into concise representations, while automatically generated quizzes enable students to evaluate their understanding immediately after studying. These functionalities promote active learning strategies and encourage continuous self-assessment.

2.3 AI-Based Educational Applications

Recent years have witnessed a growing number of AI-supported educational platforms designed to improve student learning experiences. Intelligent educational systems increasingly integrate document

analysis, adaptive recommendations, automated feedback, conversational interfaces, and learning analytics within a single environment.

Several commercial solutions, including intelligent tutoring systems and AI-powered learning assistants, provide automatic summarization, question generation, and personalized recommendations [5]. However, many existing platforms function as general-purpose AI assistants rather than educational systems specifically designed to support structured university learning.

Unlike many existing solutions, the application proposed in this study combines multiple educational functionalities within a unified web platform. Using the Google Gemini API, uploaded PDF documents are automatically analyzed to generate structured summaries, identify key concepts, create visual representations of learning content, and produce self-assessment quizzes [6]. The integration of these functions within a single application aims to simplify students' study processes while encouraging active engagement with learning materials.

2.4 Challenges and Ethical Considerations

Despite its significant educational potential, the adoption of Artificial Intelligence presents several challenges. The accuracy of AI-generated content depends on the quality of the input data and the underlying language model. Incorrect or incomplete information may negatively affect students' understanding if AI-generated responses are accepted without critical evaluation.

Researchers also emphasize concerns regarding data privacy, algorithmic bias, transparency, explainability, and academic integrity. The increasing use of generative AI has raised questions about plagiarism, overreliance on automated systems, and the development of students' critical thinking skills. Consequently, AI should be viewed as an educational support tool that complements traditional teaching rather than replacing educators or independent learning.

Responsible implementation therefore requires clear institutional policies, ethical guidelines, and continuous human supervision to ensure that AI technologies contribute positively to higher education.

2.5 Research Gap

Although existing studies demonstrate the educational potential of Artificial Intelligence, relatively few combine the development of a dedicated AI-powered educational application with a large-scale empirical evaluation of student perceptions in authentic university settings. Most published research either focuses on theoretical discussions, evaluates commercial AI tools, or investigates isolated AI functionalities without integrating multiple learning support features into a single platform.

Furthermore, limited empirical evidence is available regarding students' perceptions of applications that simultaneously provide automated summaries, concept extraction, visual knowledge organization, and AI-generated self-assessment quizzes using modern Large Language Models.

To address these limitations, the present study develops and evaluates an AI-supported educational application specifically designed for higher education. The application integrates contemporary web technologies with the Google Gemini API and is empirically evaluated through a survey involving 250 university students. By combining software implementation with quantitative evaluation, this research contributes both technically and pedagogically to the growing field of Artificial Intelligence in higher education.

3. METHODOLOGY

3.1 Research Design

This study employed a quantitative research design supported by the development and evaluation of an Artificial Intelligence-based educational application. The research combined software implementation with empirical evaluation to investigate the effectiveness of AI technologies in supporting higher education learning.

The study consisted of three main phases. First, an AI-powered web application, named AI Lesson Visualizer & Quiz Fig.1, was designed and implemented using modern web technologies. Second, the application was tested by university students under real learning conditions. Finally, students' perceptions regarding the usability, functionality, and educational effectiveness of the application were collected through a structured questionnaire and statistically analyzed.

This mixed implementation-and-evaluation approach allowed both the technical performance of the application and its educational value to be assessed within an authentic academic environment.



Figure 1: Web application, AI Lesson Visualizer & Quiz

Figure 2 presents the overall workflow of the AI Lesson Visualizer & Quiz Application, illustrating how learning materials are processed by AI to generate summaries, key concepts, visual learning support, and self-assessment quizzes. It also highlights the main student evaluation dimensions—usability, learning support, and student satisfaction—and their relationship with the acceptance of AI-powered tools in higher education.

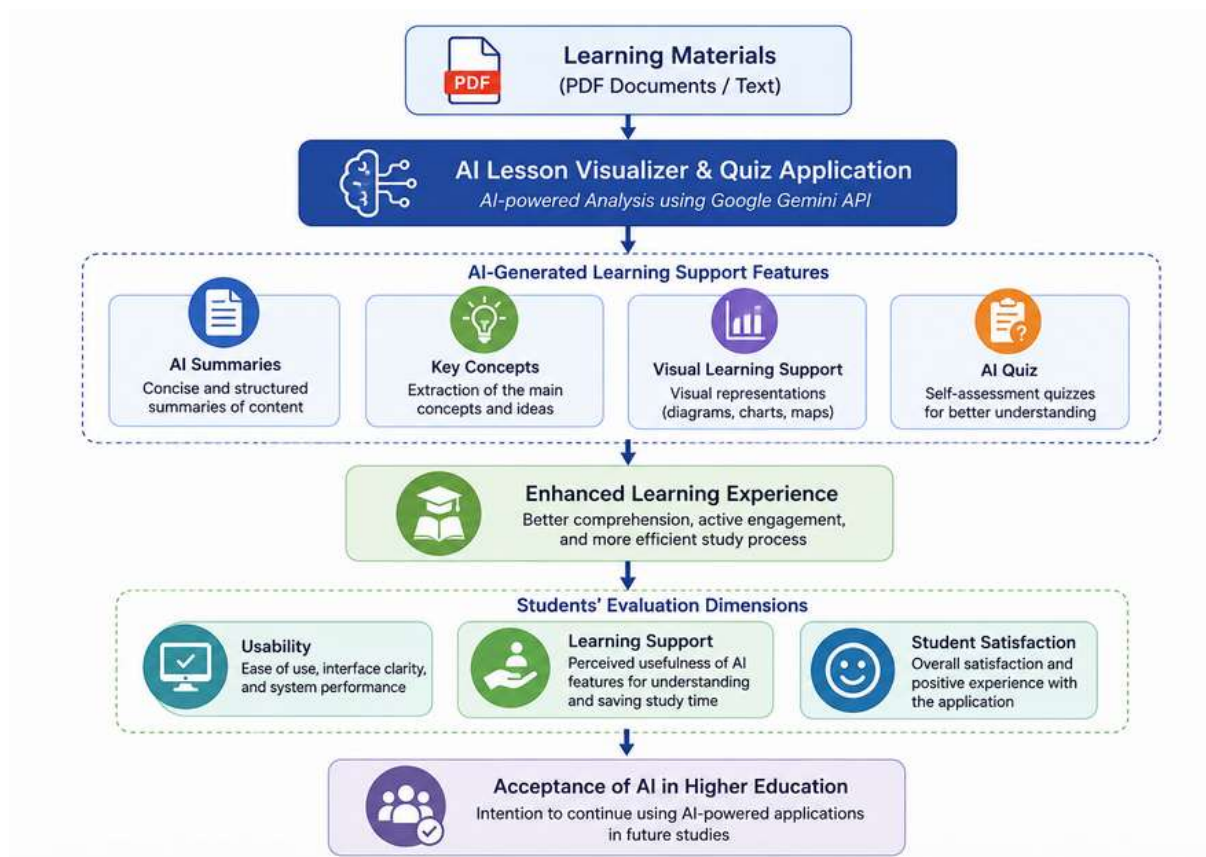


Figure 2: AI-Powered Learning Support and Student Evaluation Framework

3.2 Participants

The study involved 250 students from the Faculty of Technical and Natural Sciences at the University of Vlora "Ismail Qemali", Albania.

Participants ranged in age from 18 to 28 years and represented both undergraduate and graduate study programs.

The sample included students enrolled in:

- Bachelor's Degree
 - First Year
 - Second Year

- Third Year
- Master's Degree
 - First Year
 - Second Year

Students were selected from three academic disciplines:

- Computer Science
- Mechanical Engineering
- Electrical Engineering

The gender distribution included 110 male students (44%) and 140 female students (56%). Participants were selected using a convenience sampling strategy based on their availability and willingness to participate. Participation was voluntary, and all students were informed about the objectives of the study before completing the evaluation.

3.3 AI Application Development

To investigate the educational potential of Artificial Intelligence, a web-based educational application called AI Lesson Visualizer & Quiz was developed. The application was designed following a client–server architecture and integrates modern frontend, backend, and AI technologies. The frontend was implemented using React, Vite, and Tailwind CSS, providing a responsive and intuitive user interface. The backend was developed using Node.js and Express.js, which manage application logic, document processing, and communication with external AI services. Artificial Intelligence functionalities were implemented using the Google Gemini API, enabling automatic content analysis and educational content generation [7]. Uploaded PDF documents were processed using the Multer library for file management and pdf-parse for text extraction. Figure 3 presents the overall research methodology, including research design, participant selection, application implementation, learning material processing, AI-generated learning resources, questionnaire-based evaluation, statistical analysis, and interpretation of the results [8].

After uploading learning materials, the system automatically:

- extracts textual content;
- generates concise summaries;
- identifies key concepts;
- creates visual representations of the content;
- generates multiple-choice quizzes for self-assessment.

This workflow provides students with an integrated learning environment that supports independent study and improves comprehension of academic materials.

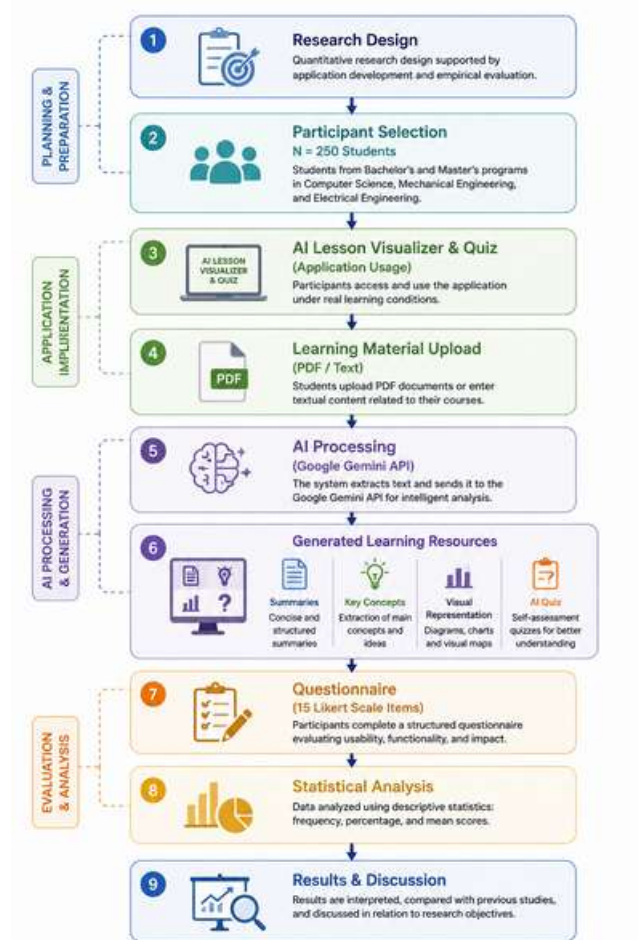


Figure 3: Research Methodology and AI-Based Application Evaluation Workflow

3.4 System Architecture

The developed application follows a client–server architecture, separating the user interface from the processing layer.

The workflow consists of the following stages:

1. Students upload a PDF document or enter educational text.
2. The frontend sends the request to the backend server.
3. The backend extracts the textual content.
4. The processed text is submitted to the Google Gemini API.
5. The AI model generates summaries, key concepts, visual diagrams, and quizzes.
6. The generated results are returned to the frontend and displayed to the user.

This modular architecture facilitates scalability, maintainability, and future integration with additional AI services.

3.5 Data Collection Instrument

Students evaluated the application using a structured questionnaire consisting of 15 statements measured on a five-point Likert scale:

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

The questionnaire evaluated the following dimensions:

- usability;
- interface clarity;
- document upload functionality;
- usefulness of AI-generated summaries;
- effectiveness of concept extraction;
- usefulness of visual representations;
- quality of AI-generated quizzes;
- learning efficiency;
- student engagement;
- learning support;
- accuracy of AI-generated results;
- application performance;
- future intention to use the application;
- acceptance of AI in higher education;
- overall satisfaction.

3.6 Experimental Procedure

The evaluation was conducted during regular university learning activities.

Each participant was asked to:

1. access the AI Lesson Visualizer & Quiz application;
2. upload one or more learning materials in PDF format;
3. review the generated summaries, concepts, diagrams, and quizzes;
4. complete the generated self-assessment quiz;
5. complete the evaluation questionnaire.

This procedure ensured that all participants evaluated the application after practical use rather than based solely on theoretical impressions.

3.7 Data Analysis

The collected questionnaire responses were analyzed using descriptive statistical methods.

Frequency distributions and percentages were calculated for each questionnaire item to summarize students' perceptions regarding the usability and effectiveness of the proposed application. The findings are presented through tables and graphical representations that illustrate the distribution of responses for each evaluation criterion. The demographic characteristics of the participants, categorized by gender, age, level of study, and academic program, are presented in Table 1.

Table 1: Demographic Characteristics of the Participants (N = 250)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	110	44.0%
	Female	140	56.0%
Age	18–20 years	150	60.0%
	21–23 years	60	24.0%
	24–28 years	40	16.0%
Study Level	Bachelor's	200	80.0%
	Master's	50	20.0%
Academic Year	First Year Bachelor	95	38.0%
	Second Year Bachelor	60	24.0%
	Third Year Bachelor	45	18.0%
	First Year Master	30	12.0%
	Second Year Master	20	8.0%
Department	Computer Science	205	82.0%
	Mechanical Engineering	25	10.0%
	Electrical Engineering	20	8.0%

Table 2. Students' Evaluation of the AI Lesson Visualizer & Quiz Application

No.	Statement	Mean	Positive Responses
Q1	The application was easy to use.	4.28	86%
Q2	The interface was clear and understandable.	4.32	86%
Q3	PDF upload worked smoothly.	4.32	86%
Q4	AI-generated summaries were useful.	4.32	86%
Q5	Generated key concepts improved understanding.	4.28	86%
Q6	Visual representation improved understanding.	4.24	84%
Q7	Generated quizzes were useful.	4.14	82%
Q8	The application saved study time.	4.24	84%
Q9	AI made learning more interesting.	4.36	88%
Q10	The application improved understanding.	4.30	86%
Q11	Generated results were accurate.	4.24	84%

Q12	Application speed was satisfactory.	4.24	84%
Q13	I would use this application again.	4.42	88%
Q14	AI applications should be used more in higher education.	4.50	92%
Q15	Overall satisfaction.	4.36	88%

4. EXPERIMENTAL RESULTS AND STATISTICAL ANALYSIS

The highest-rated statement was *"AI applications should be used more widely in higher education"* (Mean = 4.50), with 92% of participants selecting either *Agree* or *Strongly Agree*. This finding suggests that students recognize the educational value of Artificial Intelligence and support its broader integration into university teaching and learning.

Table 3. Ranking of Questionnaire Items

Questionnaire Item		Mean
Rank		
1	Q14 – AI applications should be used more in higher education	4.50
2	Q13 – I would use this application again	4.42
3	Q15 – Overall satisfaction	4.36
4	Q9 – AI made learning more interesting	4.36
5	Q2 – The interface was clear and understandable	4.32
6	Q3 – PDF upload worked smoothly	4.32
7	Q4 – AI-generated summaries were useful	4.32
8	Q10 – The application improved understanding	4.30
9	Q1 – The application was easy to use	4.28
10	Q5 – Generated key concepts improved understanding	4.28
11	Q6 – Visual representation improved understanding	4.24
12	Q8 – The application saved study time	4.24
13	Q11 – Generated results were accurate	4.24
14	Q12 – Application speed was satisfactory	4.24
15	Q7 – Generated quizzes were useful	4.14

The graphs in Fig. 4 show the age distribution and academic program distribution of the 250 participants. Regarding age, the majority of participants were 18–20 years old (60%), followed by those aged 21–23 years (24%) and 24–28 years (16%). In terms of academic program, most participants were from Computer Science (82%), while Mechanical Engineering accounted for 10% and Electrical Engineering for 8% of the sample.

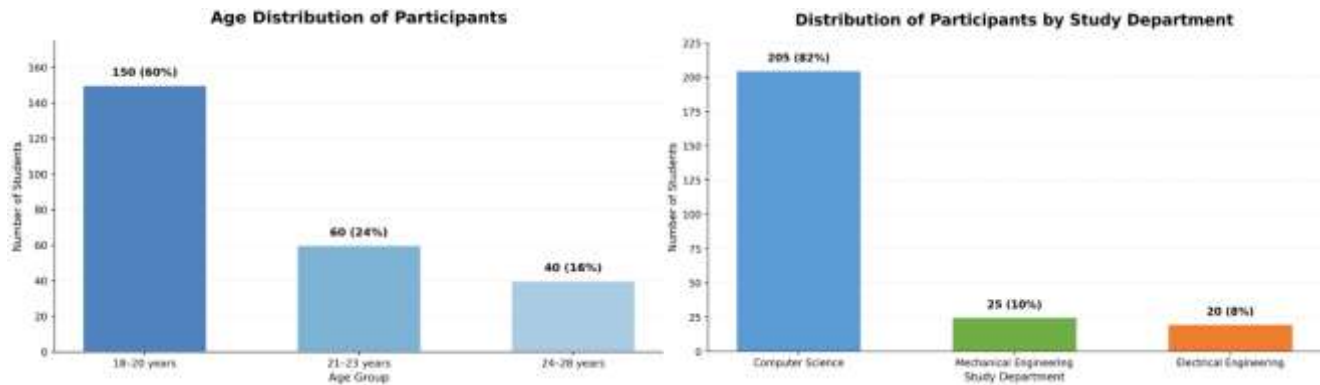


Figure 4. Age and Academic Program Distribution of Participants

Fig. 5 presents the mean scores and positive response rates for the 15 questionnaire items based on a 5-point Likert scale. Overall, the results indicate a highly positive evaluation of the application, with mean scores ranging from 4.14 to 4.50 and positive responses ranging from 82% to 92%. The highest-rated item was the perceived need to use AI applications more extensively in higher education, while the lowest positive response was related to the usefulness of the generated quizzes.

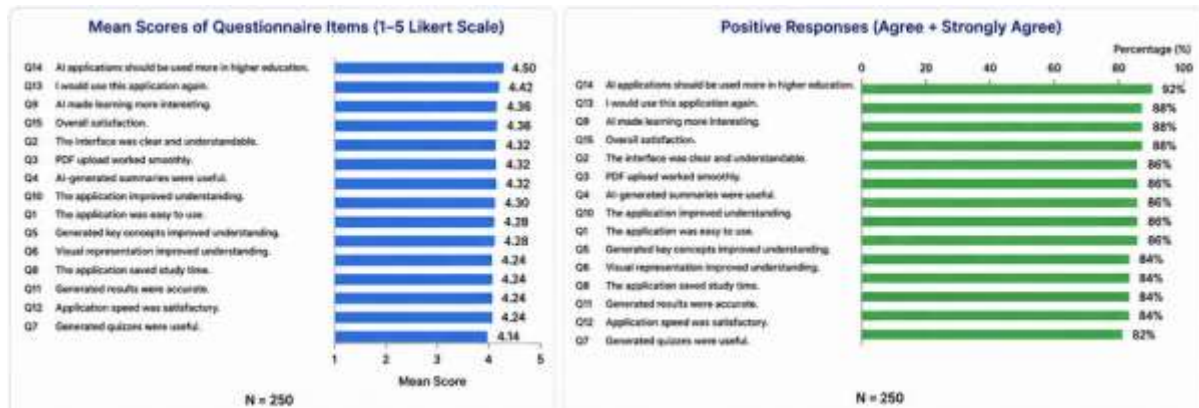


Figure 5. Mean Scores and Positive Responses to the Questionnaire Items

5. DISCUSSION

The findings of this study demonstrate that the proposed AI Lesson Visualizer & Quiz application was positively received by university students and effectively supported their learning process. Overall, the questionnaire results indicate a high level of satisfaction with both the usability and educational value of the developed system. All evaluation items achieved mean scores above 4.0 on a five-point Likert scale, suggesting strong user acceptance.

One of the most important findings is students' positive perception of Artificial Intelligence as a learning support tool. More than 90% of participants agreed that AI-based educational applications should be more widely integrated into higher education. This result reflects the increasing acceptance of AI technologies among university students and confirms the growing demand for intelligent learning environments.

The usability results also indicate that students considered the application intuitive and easy to use. High

ratings for interface clarity and PDF upload functionality suggest that the system provides a user-friendly learning experience. Ease of use is a critical factor influencing technology acceptance and supports previous research indicating that simple and well-designed educational interfaces increase student engagement and willingness to adopt new technologies.

Another important outcome concerns the educational value of AI-generated learning materials. Students highly evaluated the automatically generated summaries, key concepts, and visual representations, indicating that these features improved their understanding of course content. These findings are consistent with previous studies reporting that generative AI can reduce cognitive load by organizing complex information into concise and meaningful learning resources.

The AI-generated quizzes also received positive evaluations. Although this feature obtained a slightly lower mean score than the other functionalities, more than four out of five students considered it useful for self-assessment. This suggests that automated quizzes effectively support formative assessment by enabling students to evaluate their understanding immediately after studying.

Students also reported that the application helped them save study time while making the learning process more engaging. These findings support the idea that AI can increase learning efficiency by automating routine learning activities such as summarization, concept extraction, and question generation. Consequently, students can dedicate more time to understanding concepts rather than manually organizing learning materials.

Overall satisfaction with the application was particularly high, and most participants expressed their intention to continue using the system in future studies. This indicates strong acceptance of AI-supported educational technologies and suggests that similar applications could become valuable components of digital learning environments in higher education.

The findings of this research are consistent with previous studies. Kasneci et al. [2] emphasized that generative AI can enhance student engagement, provide personalized learning support, and improve access to educational resources. Similarly, Zawacki-Richter et al. [1] identified intelligent tutoring systems, adaptive learning, and learning analytics as promising AI applications in higher education. Furthermore, the UNESCO [3] guidance recognizes generative AI as a technology capable of supporting innovative teaching and learning when implemented responsibly. The results of the present study complement these findings by providing empirical evidence from a practical AI application evaluated by 250 university students.

Although the results are encouraging, several limitations should be acknowledged. The study was conducted at a single higher education institution, which may limit the generalizability of the findings. In addition, the evaluation relied on students' self-reported perceptions rather than objective measures of academic performance. Future research should therefore investigate the long-term impact of AI-supported

learning environments across multiple universities and academic disciplines while incorporating objective indicators such as learning outcomes, examination performance, and knowledge retention.

6. CONCLUSION

This study presented the design, development, and evaluation of AI Lesson Visualizer & Quiz, an Artificial Intelligence-powered web application developed to support students in processing educational materials through automated summaries, key concept extraction, visual knowledge representation, and AI-generated self-assessment quizzes.

The application integrates modern web technologies, including React, Node.js, Express, and the Google Gemini API, to provide an interactive learning environment that enhances students' independent study experience. The proposed architecture enables efficient document processing while offering multiple AI-assisted learning functionalities within a single platform.

The empirical evaluation, conducted with 250 university students, demonstrated a high level of acceptance and satisfaction with the proposed system. The results showed that students considered the application easy to use, appreciated the clarity of the user interface, and found the AI-generated summaries, concepts, visual representations, and quizzes valuable for improving their understanding of educational materials. Furthermore, participants reported that the application helped them save study time, increased their engagement in the learning process, and supported more effective self-directed learning.

One of the most significant findings of the study is the strong acceptance of Artificial Intelligence in higher education. Most participants expressed their willingness to continue using the application in future studies and agreed that AI-based educational tools should be more widely integrated into university teaching and learning. These findings highlight the growing role of generative AI as a practical educational assistant capable of complementing traditional teaching methods rather than replacing them. The main contribution of this research lies in combining the technical implementation of an AI-powered educational application with its empirical evaluation in a real university environment. Unlike many studies that focus primarily on theoretical discussions of Artificial Intelligence in education, this work demonstrates how modern Large Language Models can be effectively integrated into a practical learning platform and provides quantitative evidence of students' perceptions regarding its usability and educational value. Although the obtained results are encouraging, several limitations should be acknowledged. The study was conducted at a single higher education institution, and the evaluation relied primarily on students' perceptions rather than objective academic performance indicators. Therefore, the findings should be interpreted within the context of the selected participant group. Future research will focus on expanding the application by incorporating adaptive learning mechanisms, personalized learning recommendations, multilingual support, voice interaction, learning analytics dashboards, and integration with Learning Management Systems (LMS) such as Moodle. In addition, future studies should evaluate the long-term impact of AI-supported educational applications on students' academic achievement, knowledge retention, and learning motivation across multiple universities and academic disciplines. Overall, the findings confirm that

Artificial Intelligence has considerable potential to enhance higher education by providing intelligent, interactive, and personalized learning support. The proposed application represents a practical example of how generative AI can improve students' learning experiences while contributing to the ongoing digital transformation of higher education.

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