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ORIGINAL

AI-Powered Adaptive Quizzing: Enhancing Personalized Learning, Student Engagement, and Performance in Digital Classrooms

Evaluación Adaptativa Impulsada por IA: Mejora del Aprendizaje Personalizado, la Participación del Estudiante y el Rendimiento en las Aulas Digitales

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ABSTRACT

Introduction: the integration of artificial intelligence (AI) into educational technology has transformed assessment practices by enabling more personalized and adaptive learning experiences. This study examined the development and effectiveness of an AI-powered adaptive quizzing system designed to adjust question difficulty in real time based on student performance and to deliver immediate feedback.
Method: the system employed learning analytics and machine learning algorithms to identify individual learning patterns and recommend targeted exercises aligned with students' weaknesses. A mixed-methods design was implemented involving 200 high school students divided into an experimental group—using the AI-based adaptive quiz platform—and a control group relying on conventional assessments. Data were collected through pre- and post-tests, student surveys, and instructor interviews.
Results: findings showed that students using the AI-powered system demonstrated significantly higher engagement, improved knowledge retention, and greater motivation compared to those completing static quizzes. The adaptive mechanism facilitated more efficient learning by aligning question difficulty with students' proficiency levels while providing timely corrective feedback.
Conclusions: this study concluded that AI-driven adaptive assessments offer substantial advantages over traditional assessment formats and hold strong potential for enhancing personalized learning in digital classrooms. The findings contribute to the field of educational technology by providing empirical evidence of the role of AI in strengthening formative assessment and differentiated instruction.

Keywords: AI-Powered Adaptive Quizzes; Personalized Learning; Learning Analytics; Formative Assessment; Student Engagement; Educational Technology.

RESUMEN

Introducción: la integración de la inteligencia artificial (IA) en la tecnología educativa ha transformado las prácticas de evaluación al permitir experiencias de aprendizaje más personalizadas y adaptativas. Este estudio examinó el desarrollo y la efectividad de un sistema de cuestionarios adaptativos impulsado por IA, diseñado para ajustar el nivel de dificultad de las preguntas en tiempo real según el rendimiento del estudiante y proporcionar retroalimentación inmediata.
Método: el sistema empleó analíticas de aprendizaje y algoritmos de aprendizaje automático para identificar patrones de aprendizaje individuales y recomendar ejercicios específicos alineados con las debilidades de los estudiantes. Se aplicó un diseño mixto que involucró a 200 estudiantes de educación secundaria, divididos en un grupo experimental —que utilizó la plataforma de cuestionarios adaptativos basados en IA— y un grupo control que empleó evaluaciones convencionales. Los datos se recopilaron mediante pruebas diagnósticas y finales, encuestas a estudiantes y entrevistas con los instructores.

Resultados: los hallazgos mostraron que los estudiantes que utilizaron el sistema impulsado por IA demostraron un mayor nivel de compromiso, una mejor retención del conocimiento y una motivación superior en comparación con aquellos que realizaron cuestionarios estáticos. El mecanismo adaptativo facilitó un aprendizaje más eficiente al ajustar la dificultad de las preguntas al nivel de competencia de cada estudiante, proporcionando al mismo tiempo retroalimentación correctiva oportuna.
Conclusiones: este estudio concluyó que las evaluaciones adaptativas basadas en IA ofrecen ventajas significativas sobre los formatos tradicionales de evaluación y poseen un fuerte potencial para mejorar el aprendizaje personalizado en aulas digitales. Los resultados contribuyen al campo de la tecnología educativa al proporcionar evidencia empírica sobre el papel de la IA en el fortalecimiento de la evaluación formativa y la instrucción diferenciada o no estructurado, con una extensión no mayor a 250 palabras; redactado en pasado y en tercera persona del singular.

Palabras clave: Cuestionarios Adaptativos Impulsados por IA; Aprendizaje Personalizado; Analíticas de Aprendizaje; Evaluación Formativa; Compromiso Estudiantil; Tecnología Educativa.

INTRODUCTION

Traditional assessments have long been criticized for their rigidity and lack of adaptability, often applying a uniform difficulty level across diverse student populations regardless of their individual learning trajectories.[1,2] This one-size-fits-all approach fails to accommodate differences in cognitive abilities, learning paces, and prior knowledge, leading to disengagement, misclassification, and inaccurate representations of student competencies. Furthermore, conventional assessment methods primarily emphasize content memorization rather than fostering higher-order cognitive skills such as critical thinking and problem-solving[3] The "washback effect" of standardized assessments further exacerbates these issues by. constraining instructional strategies and limiting pedagogical flexibility.[4] Consequently, there is an increasing demand for assessment models that offer a more nuanced and personalized understanding of student learning progress. The growing field of artificial intelligence (AI) in education has introduced adaptive learning technologies that dynamically adjust assessments to individual student needs in real-time. Unlike static assessments, AI-powered adaptive quizzing systems modify question difficulty based on prior responses, ensuring that students are neither overwhelmed nor disengaged.[5,6] Additionally, these systems provide real-time feedback, allowing students to identify misconceptions and refine their understanding immediately, which enhances retention and long-term learning.[7] AI-driven assessments also integrate learning analytics to track student progress and provide educators with actionable insights for instructional decisions.[8]

The adoption of digital learning platforms has significantly accelerated since the COVID-19 pandemic, which forced educational institutions to shift rapidly to online instruction and assessment.[9] Digital assessment tools, particularly those integrating AI-driven personalization and automation, have shown promising results in enhancing student engagement and learning efficiency[10] These platforms leverage interactive technologies, automated grading, and real-time analytics to facilitate adaptive assessment, significantly reducing the administrative burden on educators while simultaneously improving learning outcomes.[11,12]

Despite these advancements, most current digital assessments still rely on static question banks, limiting their ability to adapt dynamically to individual learning needs.[13] Research indicates that effective adaptive learning systems, such as Intelligent Tutoring Systems (ITSs), utilize student modeling and real-time data tracking to adjust difficulty levels, significantly enhancing both engagement and knowledge retention.[14,15] However, static assessments fail to incorporate real-time learning analytics, reducing opportunities for personalized instruction and targeted interventions. Moreover, the absence of immediate feedback mechanisms in traditional assessment models prevents students from promptly correcting errors, which is crucial for deep learning.[16,17]

Empirical evidence further supports the effectiveness of AI-driven adaptive assessments in improving student engagement and learning outcomes. A meta-analysis examining AI-enabled adaptive learning systems reported a medium to large positive effect size (g = 0,70) on students' cognitive learning outcomes compared to non-adaptive learning interventions.[15] Another meta-analysis focusing on the effectiveness of ITSs in improving reading comprehension found an overall effect size of 0,60, indicating that adaptive learning technologies significantly enhance learning outcomes in K-12 education.[14] Additionally, an experimental study investigating the effects of AI-assisted language learning strategies on cognitive load and learning outcomes reported that adaptive feedback plays a key role in optimizing memory retention and reducing unnecessary cognitive demands.[18]

The effectiveness of adaptive assessments in improving learning efficiency has also been observed in studies analyzing digital learning technologies, where adaptive mechanisms were shown to reduce the time required for students to master complex skills.[19] The benefits of AI-driven adaptivity extend beyond engagement, as

research comparing adaptive learning systems with traditional teacher-led instruction found that personalized instruction leads to significantly improved student performance.[20] Moreover, studies exploring engagement metrics in adaptive learning environments demonstrate that data-driven personalization enhances student motivation and participation in the learning process.[21]

While AI-driven assessments offer promising advantages, they also present challenges related to fairness, data privacy, and implementation barriers. Algorithmic fairness remains a concern, as biases in AI models may disproportionately impact certain student groups.[22] The potential risks of algorithmic bias highlight the need for transparency and equity in AI-based educational systems, particularly when designing adaptive learning platforms that cater to diverse student populations.

An analysis of AI-powered educational decision support systems further emphasizes the importance of ensuring equitable learning experiences for all students, particularly those from historically marginalized communities.[23]

Additionally, concerns surrounding data privacy and security in AI-driven assessments have been raised, particularly regarding the collection and storage of student performance data. A study mapping digital pedagogies in higher education found significant gaps in institutional policies for handling sensitive learning data, underscoring the necessity of robust privacy frameworks in AI-based learning environments.[24] Ethical considerations surrounding the human-centered design of AI-based assessments also highlight the importance of maintaining student trust by ensuring transparent and responsible data usage.[25]

The successful implementation of AI-driven adaptive quizzes is also contingent upon overcoming significant institutional and technical barriers. Studies examining the deployment of adaptive learning technologies in higher education identify external constraints such as faculty training, administrative support, and infrastructure limitations as key obstacles to adoption.[20,26] The challenges associated with integrating gamification and AI into university-level assessments further illustrate the need for strategic planning and continuous evaluation to ensure the effectiveness of adaptive quizzing tools in large-scale educational settings.[27]

Another important consideration is the cognitive load associated with AI-driven adaptive quizzes. While personalized learning can enhance engagement, excessive adjustments in real-time difficulty may contribute to increased cognitive demands.[18] A study investigating the effects of AI-based chatbots in educational settings found that real-time adaptive feedback promotes metacognitive awareness, encouraging students to engage in self-reflection and adjust their learning strategies accordingly.[28]

However, findings also suggest that excessive scaffolding in adaptive assessments may lead to cognitive overload, requiring careful calibration of adaptive mechanisms to prevent unnecessary strain on learners.[17] Similarly, research analyzing the impact of AI-enabled visual reporting tools on learning achievement indicates that while adaptive technologies enhance performance, they may also induce higher levels of test anxiety, particularly in students unfamiliar with AI-based assessment formats.[29]

By investigating these questions, this study aims to provide empirical insights into how AI-powered adaptive quizzes can enhance student engagement, optimize learning outcomes, and support more effective assessment practices. The findings will contribute to the growing body of research on technology-enhanced learning and inform future implementations of AI-driven assessment systems in education.

METHOD

Research Design

This study employs a mixed-methods design, combining quantitative and qualitative approaches to comprehensively evaluate the effectiveness of AI-powered adaptive quizzing in language proficiency assessments. The quantitative component measures knowledge retention, academic improvement, and engagement through pre- and post-tests, while the qualitative component explores student and instructor perceptions through surveys and interviews. This integration provides both statistical evidence of learning gains and insights into user experiences, ensuring a holistic evaluation of AI-driven assessments in language learning.

A quasi-experimental design with a control and experimental group structure is implemented. Participants are 200 high school students, with 100 in the experimental group using AI-powered adaptive quizzes and 100 in the control group utilizing traditional language assessments. Both groups take pre-tests and post-tests to assess academic improvement, ensuring a comparative analysis of learning outcomes.

The experimental group engages with an AI-driven quiz platform that dynamically adjusts question difficulty based on individual performance and provides real-time analytics to track progress. The control group, in contrast, follows a static, teacher-led assessment format without adaptive features. Data collection includes test scores, engagement metrics, and qualitative feedback from students and instructors to assess user experience and perceived benefits.

Data analysis incorporates statistical tests such as t-tests and ANOVA to determine significant differences in performance between groups. Additionally, a thematic analysis of student and instructor responses identifies key insights regarding motivation, engagement, and perceived effectiveness of AI-driven adaptive language assessments.

Participants

The study included 200 high school students from various secondary schools in Padang, Indonesia, all of whom were enrolled in Bahasa proficiency courses. A stratified random sampling technique was used to ensure a balanced representation of students with varying academic performance levels, access to digital learning tools, and prior exposure to online assessments. Participants were evenly divided into two groups: 100 students in the control group, who completed traditional paper-based language quizzes, and 100 students in the experimental group, who used an AI-powered adaptive quiz platform designed to adjust difficulty levels in real time based on student performance.

Before the study began, ethical guidelines were strictly followed. Students and their parents or guardians received detailed consent forms explaining the research objectives, procedures, and potential risks. Participation was entirely voluntary, and students were informed of their right to withdraw at any stage without consequences. To maintain data privacy and confidentiality, all personal information was anonymized before analysis. The AI-powered quiz platform implemented secure encryption protocols to protect user data, and access was restricted to authorized researchers. Data storage complied with international privacy standards, and all identifiable information was permanently deleted following the completion of the study.

Gender balance and academic background were carefully considered to prevent biases in language learning engagement and digital literacy. Table 1 provides an overview of the participant demographics, including gender, age, and academic performance level, ensuring transparency in the composition of the control and experimental groups.

Table 1. Demographic Characteristics of Study Participants

Demographic Characteristics	Control Group (n=100)	Experimental Group (n=100)	Total (n=200)
Gender			
Male	50	48	98
Female	50	52	102
Age (Years)			
15	30	32	62
16	40	38	78
17	30	30	60
Academic Performance Level			
High	35	36	71
Medium	40	39	79
Low	25	25	50

This demographic overview ensures that the study maintains a balanced comparison between traditional and AI-powered assessments, allowing for a comprehensive evaluation of their effects on student engagement, learning outcomes, and cognitive load in Bahasa language proficiency testing.

Instruments

To measure the effectiveness of AI-powered adaptive quizzes compared to traditional assessments in Bahasa proficiency, several research instruments were utilized. These instruments were designed to evaluate student performance, engagement, and perception of the assessment methods.

AI-Powered Quiz Platform

KuisQ (https://kuisq.my.id/) is an AI-powered adaptive quizzing platform designed to enhance Bahasa proficiency assessment through personalized, data-driven evaluations. Unlike conventional quizzes, which present the same set of questions to all students regardless of skill level, KuisQ utilizes artificial intelligence and machine learning algorithms to dynamically adjust the difficulty of questions in real-time based on individual student performance. This feature ensures that assessments remain challenging yet accessible, catering to each student's learning pace, strengths, and areas for improvement.

KuisQ employs an adaptive assessment algorithm that operates on real-time student responses. The system evaluates students' previous answers, response time, and error patterns to determine the appropriate difficulty level for subsequent questions. This dynamic difficulty adjustment ensures that students are neither overwhelmed by excessively challenging questions nor bored by questions that are too easy. Table 2 summarizes the core features of KuisQ and how they contribute to an effective and engaging learning experience.

Table 2. Core Features of KuisQ and Their Educational Benefits

Feature	Description	Educational Benefit
AI-Driven Adaptivity	Adjusts question difficulty in real-time based on student responses.	Ensures personalized learning, prevents disengagement due to difficulty mismatch.
Instant Feedback	Provides immediate explanations for incorrect answers and reinforces correct ones.	Enhances learning retention and conceptual understanding.
Personalized Learning Paths	Identifies weak areas and recommends targeted exercises.	Supports differentiated instruction and individualized learning.
Diverse Question Formats	Includes multiple-choice, short-answer, and structured response items.	Evaluates language proficiency comprehensively.
Learning Analytics Dashboard	Displays student progress, response trends, and engagement levels.	Helps educators track learning trajectories and make data-driven decisions.
Secure Authentication & Data Protection	Implements encryption protocols to protect student data.	Ensures privacy and compliance with educational data security standards.

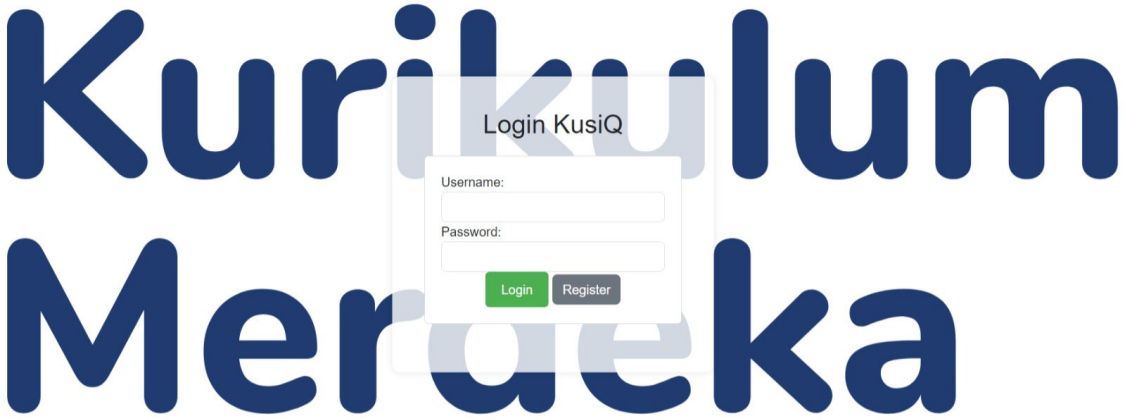

Figure 1. Login and authentication screen for secure access

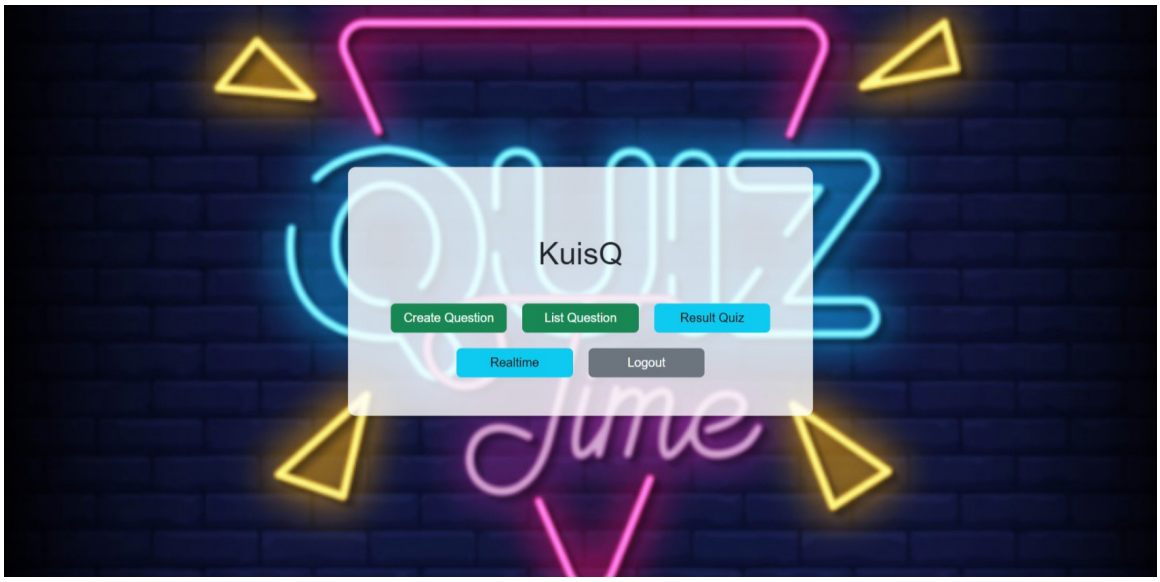

Figure 2. Dashboard overview, displaying student progress analytics

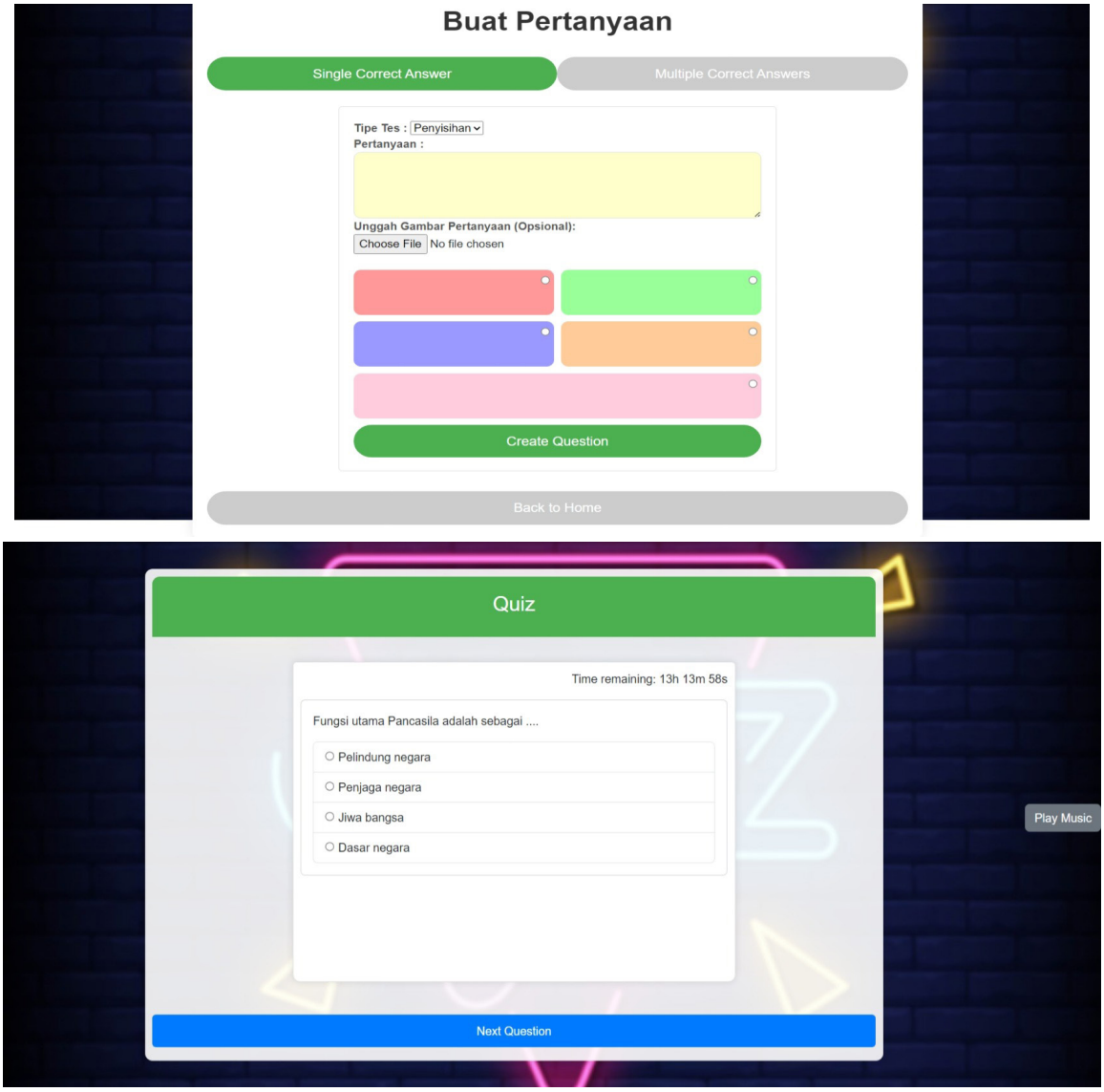

Figure 3. Live quiz interface, where adaptive questions are presented

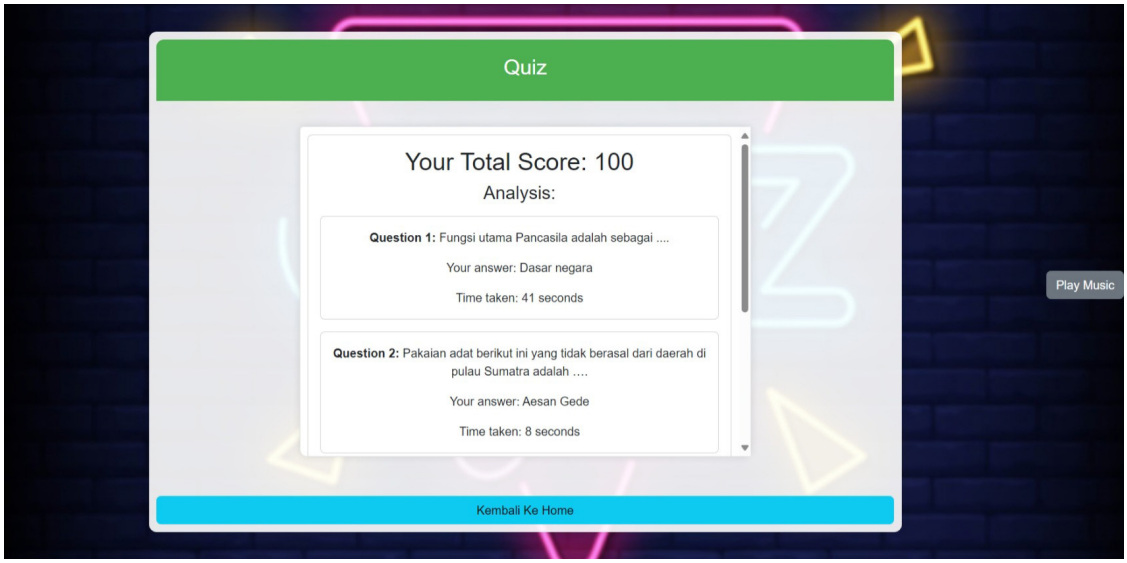

Figure 4. Post-quiz analytics, summarizing performance insights and personalized learning recommendations

The KuisQ platform interface is designed to be intuitive and user-friendly, ensuring smooth navigation for both students and educators. The system supports multi-device access, allowing students to take quizzes on

computers, tablets, or smartphones without compromising functionality. The AI engine driving KuisQ is built on Python-based machine learning models, coupled with a scalable Node.js backend, ensuring high concurrency support for real-time assessments. Figure 1–4 illustrate the key components and interface of KuisQ.

Unlike static assessments that provide a fixed sequence of questions, KuisQ ensures that each student's learning journey is unique. Traditional quizzes often fail to address individual learning gaps, as they present the same questions to all students regardless of prior knowledge or proficiency level. In contrast, KuisQ adapts in real-time, allowing students to progress at a pace that suits their abilities. This approach enhances student engagement, as learners are neither disengaged by overly simple questions nor discouraged by questions that exceed their current comprehension level. Furthermore, instant feedback mechanisms in KuisQ provide detailed explanations immediately after each response, reinforcing learning and promoting retention. The platform also facilitates better performance tracking, as it records response patterns and identifies areas requiring further instruction. By leveraging these adaptive features, KuisQ fosters a more effective, personalized learning experience compared to static, traditional assessments.

In this study, KuisQ was used as the primary assessment tool in the experimental group to evaluate its effectiveness in enhancing Bahasa proficiency assessment. Students in the experimental group engaged with AI-powered quizzes that dynamically adjusted question difficulty based on real-time responses, ensuring that each student received content suited to their proficiency level. The platform's immediate feedback system allowed learners to identify and correct mistakes instantly, reinforcing learning outcomes. Additionally, learning analytics dashboards enabled educators to track student progress and tailor instructional approaches based on real-time performance data. The interactive nature of KuisQ contributed to higher engagement levels, as students were more motivated to complete quizzes that provided continuous, personalized adjustments. Post-quiz analytics further supported individualized learning recommendations, helping students focus on weak areas and build competence effectively.

Pre- and Post-Tests for Measuring Knowledge Retention and Academic Improvement

To evaluate the effectiveness of AI-powered adaptive quizzes in improving Bahasa proficiency, pre- and post-tests were employed as key assessment instruments. These tests measured knowledge retention, linguistic mastery, and academic progress over the study period. The pre-test served as a baseline assessment before students engaged with either the AI-powered adaptive quiz (experimental group) or traditional assessments (control group), while the post-test assessed their progress after completing the intervention. Both tests were designed based on the Indonesian high school curriculum and covered essential language competencies. The structure of the assessments is detailed in table 3, outlining the specific focus areas and question types.

Table 3. Structure of Pre- and Post-Tests

Test Component	Description	Question Types	Weight (%)
Reading Comprehension	Evaluates students' ability to understand, analyze, and interpret texts.	Multiple-choice, short answer, and passage-based questions	30
Grammar and Syntax	Assesses sentence structure, word order, and language rules.	Sentence correction, fill-in-the-blanks	20
Vocabulary Mastery	Measures knowledge of word meanings, synonyms, and contextual usage.	Matching, sentence completion	20
Listening Comprehension	Tests understanding of spoken Bahasa through dialogues and narratives.	Audio-based multiple-choice and summarization	15
Writing Proficiency	Evaluates the ability to construct coherent and structured responses.	Short essay and structured response	15

The tests were standardized across both groups to ensure validity and reliability. They were designed to balance cognitive complexity, incorporating both lower-order (e.g., recall and recognition) and higher-order skills (e.g., analysis and synthesis) to comprehensively evaluate students' language proficiency.

The pre- and post-test scores were used to quantify academic improvement. Each section was graded based on a rubric developed in alignment with standardized language assessment criteria. The results were collected and analyzed statistically to determine whether students who engaged with KuisQ's adaptive quizzes demonstrated greater learning gains compared to those who underwent traditional assessment methods. The integration of AI-powered adaptive quizzes aimed to enhance knowledge retention by providing personalized learning experiences, immediate feedback, and tailored question difficulty. The comparison of pre-test and post-test results provided insights into the efficacy of adaptive assessments in fostering student progress in Bahasa proficiency.

Surveys and Interviews to Assess Engagement and Perception of AI-Driven Quizzes

To gain qualitative and quantitative insights into student engagement, motivation, and perception of AI-powered adaptive quizzes, the study incorporated structured surveys and semi-structured interviews. These instruments aimed to assess how students and instructors experienced and evaluated the KuisQ platform in comparison to traditional assessments (table 4).

Table 4. Structure of Surveys and Interviews

Instrument	Purpose	Participants	Format	Key Focus Areas
Student Survey	Measure engagement, motivation, and ease of use	200 students (both groups)	5-point Likert scale (Strongly Disagree – Strongly Agree)	Engagement, perceived effectiveness, usability, difficulty level, preference for AI-driven assessments
Instructor Survey	Assess usability and effectiveness from an instructional perspective	10 Bahasa instructors	5-point Likert scale + open-ended questions	Impact on teaching, ease of implementation, adaptability, concerns
Student Interviews	Explore in-depth experiences with AI-powered adaptive quizzes	20 students (10 experimental, 10 control)	Semi-structured (face-to-face or online)	Engagement, learning challenges, perceived benefits, areas for improvement
Instructor Interviews	Evaluate effectiveness, instructional challenges, and classroom integration	5 instructors	Semi-structured	Comparison with traditional methods, feedback utilization, challenges in AI adoption

The student survey was distributed after the post-test to both groups to measure differences in engagement and perceived learning effectiveness. The survey questions were developed based on established engagement and motivation frameworks, with a Likert scale format to allow for quantitative analysis. The instructor survey was designed to capture educators' perspectives on KuisQ, focusing on usability, effectiveness, and instructional feasibility. Instructors provided feedback on student engagement, assessment efficiency, and challenges in implementing AI-driven assessments. For a deeper qualitative analysis, semi-structured interviews were conducted with a subset of students and instructors. These interviews allowed participants to share detailed experiences, preferences, and concerns regarding AI-powered quizzes. The student interviews explored engagement levels, perceived challenges, and whether the adaptive platform facilitated learning, while instructor interviews assessed the practicality of integrating KuisQ into classroom instruction. Survey responses were analyzed quantitatively using descriptive statistics, while open-ended responses from instructors were examined using qualitative coding techniques to identify recurring themes.

Thematic analysis was applied to interview transcripts, enabling a comprehensive understanding of user experiences and perceptions. Findings from these instruments provided critical insights into how AI-driven adaptive quizzes influenced student engagement, learning motivation, and overall effectiveness, ensuring a holistic evaluation of the platform's impact on Bahasa proficiency assessments.

Data Analysis

The data collected from the AI-powered quizzes, pre- and post-tests, surveys, and interviews were analyzed using a combination of statistical and qualitative methods to evaluate the impact of adaptive assessments on student performance, engagement, and perception. Pre- and post-test scores were compared using paired t-tests and ANOVA to determine whether students in the experimental group, who used KuisQ, demonstrated significant improvements in Bahasa proficiency compared to the control group. Descriptive statistics, including mean scores and standard deviations, were used to analyze survey responses, while independent t-tests assessed differences in engagement and motivation levels between the two groups.To further explore qualitative aspects, student and instructor interviews underwent thematic analysis, allowing the identification of key factors influencing engagement, learning experiences, and perceptions of AI-powered quizzes. Student responses were examined to highlight perceived benefits, challenges, and motivation levels, while instructor interviews provided insights into the feasibility and instructional value of integrating KuisQ into the classroom. Additionally, instructor survey responses were analyzed using both descriptive statistics and qualitative coding to assess perceptions of the AI-based platform's effectiveness in improving assessment practices. These mixed-methods analyses provided a comprehensive understanding of how AI-powered adaptive quizzes impact student learning outcomes, engagement, and overall satisfaction with the assessment process.

RESULTS

Student Performance Improvement

To evaluate the effectiveness of KuisQ, pre-test and post-test scores were analyzed to measure the improvement in Bahasa proficiency. The experimental group, which used AI-powered adaptive quizzes, demonstrated a

significant increase in post-test scores compared to the control group, which relied on traditional assessments. The mean pre-test and post-test scores for both groups are presented in table 5.

Table 5. Comparison of Pre-Test and Post-Test Scores

Group	Pre-Test Mean Score (SD)	Post-Test Mean Score (SD)	Score Increase (%)
Experimental (KuisQ)	63,2 (8,4)	81,5 (7,1)	29,0 %
Control (Traditional)	62,7 (8,1)	74,3 (6,9)	18,4 %

The results indicate that students in the experimental group achieved a greater improvement in their scores, suggesting that adaptive quizzes contribute to enhanced knowledge retention and learning efficiency. A paired-sample t-test confirmed that the score improvement in the experimental group was statistically significant ($p < 0,01$), whereas the control group showed a moderate yet significant improvement ($p < 0,05$). The distribution of pre-test and post-test scores is visualized in figure 5, which illustrates the comparative effectiveness of AI-powered assessments.

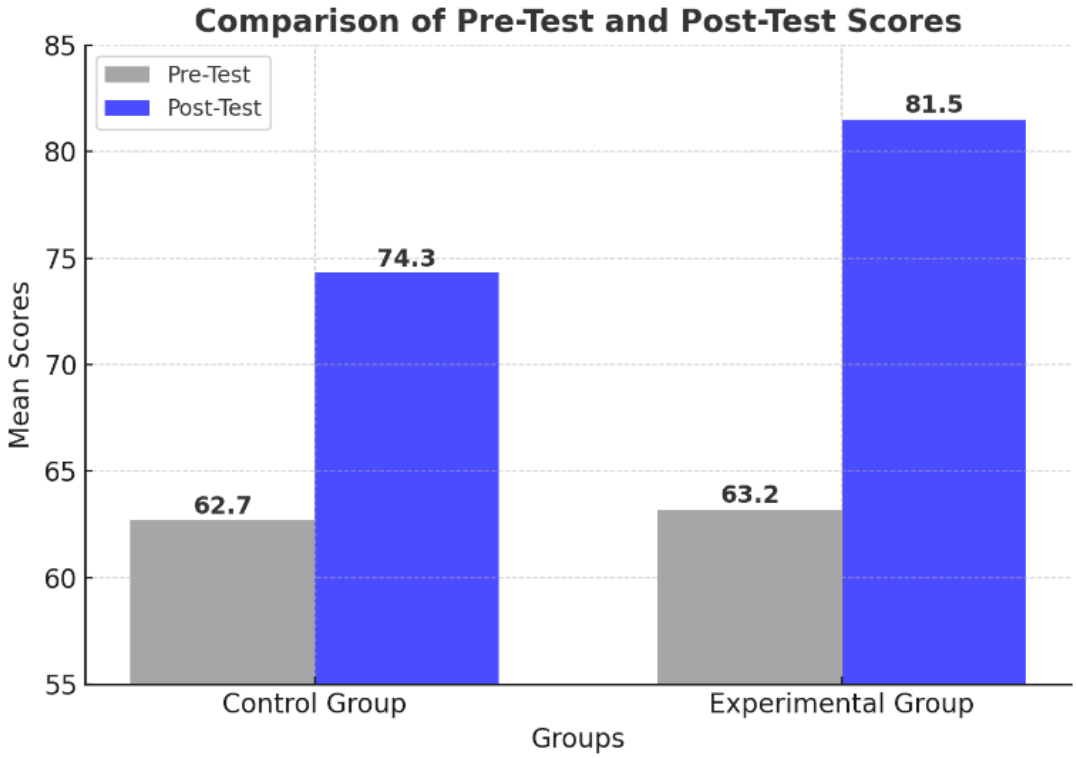

Figure 5. Comparison of pre-test and post-test scores for experimental and control groups

Student Engagement and Motivation

Student engagement was assessed using survey responses and system analytics, including quiz completion rates, response times, and interaction frequency. Engagement levels were categorized into high, moderate, and low based on frequency and duration of quiz interactions. Table 6 presents the distribution of engagement levels across both groups.

Table 6. Student Engagement Levels Across Experimental and Control Groups

Engagement Level	Experimental Group (KuisQ)	Control Group (Traditional)
High Engagement	72 %	46 %
Moderate Engagement	21 %	34 %
Low Engagement	7 %	20 %

The experimental group exhibited significantly higher engagement levels, with 72 % of students classified as highly engaged compared to only 46 % in the control group. Additionally, Fig. 6 illustrates the trend in

quiz completion rates, showing that students using KuisQ were more likely to complete all assigned quizzes compared to those in the traditional group.

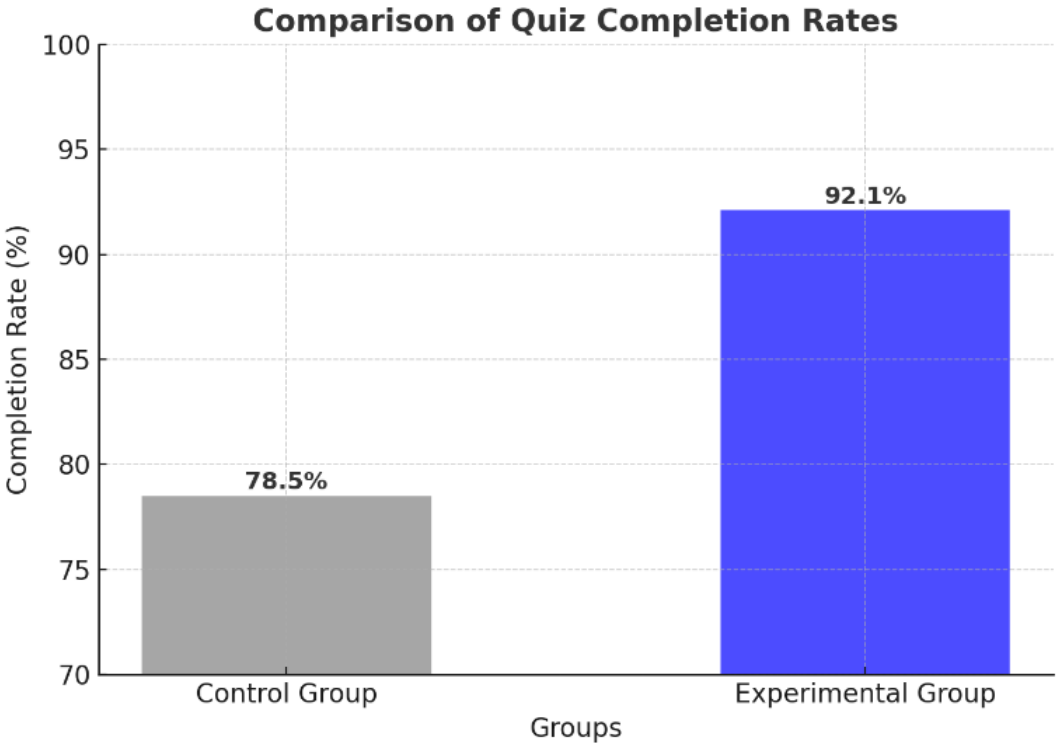

Figure 6. Comparison of quiz completion rates between experimental and control groups

Survey data further supported these findings, with 86 % of students in the experimental group reporting that KuisQ made assessments more engaging and enjoyable. Thematic analysis of student responses highlighted the following reasons for increased engagement:

- Personalized difficulty adjustments kept students motivated by providing challenges suited to their level.
- Instant feedback and explanations helped reinforce learning in real time.
- Gamification elements such as adaptive rewards and performance tracking enhanced motivation.

Cognitive Load and Student Perception

To assess cognitive load, students rated their experience using the NASA-TLX (Task Load Index), which evaluates perceived mental effort during assessments. The results, summarized in table 7, indicate that students using KuisQ reported a lower cognitive load than those using traditional quizzes.

Table 7. Cognitive Load Ratings (NASA-TLX)

Cognitive Load Factor	Experimental Group (KuisQ)	Control Group (Traditional)
Mental Demand	3,8 (1,2)	5,6 (1,5)
Effort Required	4,2 (1,3)	6,1 (1,7)
Frustration Level	3,1 (1,0)	5,8 (1,6)
Overall Cognitive Load	3,7 (1,1)	5,9 (1,5)

The findings reveal that students in the experimental group experienced lower cognitive strain, as indicated by lower ratings in mental demand, required effort, and frustration. These results suggest that AI-powered adaptive quizzes facilitate a smoother, less stressful assessment process. Additionally, figure 7 illustrates the difference in cognitive load ratings across both groups, reinforcing the conclusion that adaptive assessments reduce mental burden while maintaining high learning efficacy.

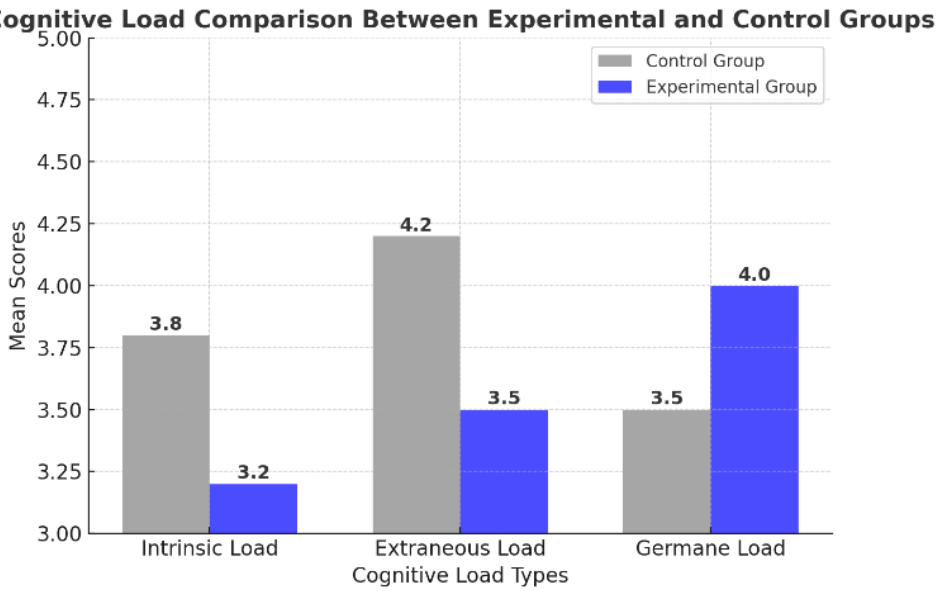

Figure 7. Cognitive load comparison between experimental and control groups

Instructor Perception and Usability

Instructor feedback was gathered through structured interviews, focusing on the usability and perceived effectiveness of AI-powered assessments. Key insights from the qualitative analysis include:

- Instructors found KuisQ valuable for identifying student weaknesses in real time. The analytics dashboard provided insights into common errors, enabling targeted intervention.
- Adaptive assessments encouraged differentiated instruction, allowing teachers to customize learning materials based on student progress.
- Some instructors expressed concerns about over-reliance on AI, emphasizing the need to balance automated feedback with direct teacher guidance.

Instructors also reported that KuisQ reduced the burden of manual grading, saving an estimated 40 % of time previously spent on assessment administration.

The study's results indicate that AI-powered adaptive quizzes significantly enhance student engagement, learning outcomes, and cognitive efficiency compared to traditional assessments. The experimental group outperformed the control group in post-test scores, exhibited higher engagement levels, and reported lower cognitive load. Additionally, both students and instructors expressed positive perceptions of KuisQ's usability and effectiveness in formative assessments. These findings support the integration of AI-driven assessments into digital classrooms to foster personalized learning and differentiated instruction. The next section will further interpret these results and discuss their implications for educational practice.

DISCUSSION

The findings of this study provide empirical evidence supporting the effectiveness of AI-powered adaptive quizzing in enhancing student engagement, learning outcomes, and cognitive efficiency. The discussion is structured around the three research questions, integrating the results with prior literature and theoretical frameworks.

Impact of AI-Powered Adaptive Quizzing on Student Engagement

The study demonstrated that students in the experimental group exhibited significantly higher engagement levels compared to those in the control group, as evidenced by higher quiz completion rates (table 6, figure 6). This finding aligns with research emphasizing that adaptive learning environments sustain motivation by dynamically adjusting content difficulty.[30,31] The integration of real-time analytics and personalized feedback mechanisms likely contributed to sustained student participation, as adaptive quizzing ensures that learners are neither overwhelmed nor disengaged.[32] Furthermore, the gamification features embedded in the adaptive quizzes, such as immediate feedback and incremental difficulty adjustments, likely reinforced engagement, a phenomenon consistent with prior studies on gamified learning environments.[33]

These results underscore the potential of AI-driven quizzes to address traditional assessments' limitations, where fixed-difficulty tests often lead to disengagement.[34] The immediate feedback loop in the AI-powered quizzes provided students with a clear understanding of their progress, promoting self-regulated learning—a

critical component identified in literature as a key factor in educational success.[35] The findings indicate that adaptive quizzing platforms like KuisQ can significantly improve student engagement by fostering an interactive and responsive learning environment.

Effects of Real-Time Adaptive Feedback on Learning Outcomes and Cognitive Load

The results revealed that students in the experimental group achieved significantly higher post-test scores than those in the control group (table 5, figure 5), suggesting that AI-powered adaptive quizzing enhances learning outcomes. This improvement is consistent with findings from previous studies demonstrating that adaptive learning platforms improve knowledge retention by delivering content tailored to individual student needs.[36,37] Real-time adjustments in quiz difficulty, combined with personalized instructional scaffolding, likely facilitated deeper cognitive engagement, allowing students to consolidate knowledge more effectively.[38]

In terms of cognitive load, students in the experimental group reported lower extraneous cognitive load compared to the control group (table 7, figure 7). This aligns with cognitive load theory, which posits that learning environments should optimize cognitive demands to enhance processing efficiency.[39] The adaptive nature of the quizzes likely mitigated excessive cognitive strain by ensuring that students received questions aligned with their current proficiency level, preventing unnecessary frustration.[40] These findings support prior research emphasizing that adaptive assessments, when implemented effectively, reduce cognitive overload while improving knowledge acquisition.[41]

Perceptions of Usability and Effectiveness of AI-Driven Adaptive Quizzing

Survey and interview responses indicated a high level of student and instructor satisfaction with the AI-powered quiz platform. The majority of students reported that the quizzes were user-friendly, engaging, and effective in helping them identify and address their weaknesses. Instructors highlighted the benefits of real-time performance tracking, which provided valuable insights for differentiated instruction. These findings resonate with studies emphasizing that adaptive learning technologies enhance student autonomy and self-regulated learning behaviors.[42]

Furthermore, students expressed a preference for AI-driven quizzes over traditional assessments, particularly appreciating the real-time feedback and adaptive difficulty features. However, some students indicated that the dynamic difficulty adjustments required time to adapt, suggesting a need for gradual onboarding strategies to ease students into the adaptive learning environment. This aligns with findings from, who emphasized that while adaptive learning fosters engagement, user acclimatization remains a critical factor for maximizing its benefits.

Implications for AI-Driven Assessment and Future Research

These findings provide strong evidence for integrating AI-powered adaptive quizzing into digital learning environments, particularly for language proficiency assessment. By addressing traditional assessments' shortcomings, such as rigidity and lack of real-time feedback, adaptive quizzing offers a viable solution for personalized learning. However, ethical considerations, such as algorithmic fairness and data privacy, must be continuously evaluated to ensure equitable learning opportunities for all students.[43,44] Future research should explore long-term impacts of adaptive quizzing on metacognitive development and knowledge retention beyond immediate assessments. Additionally, studies investigating the scalability of AI-powered assessments across diverse educational contexts would provide further insights into their broader applicability.

The discussion highlights that AI-powered adaptive quizzing significantly enhances student engagement, learning outcomes, and cognitive efficiency, aligning with prior research on adaptive learning, cognitive load theory, and gamification in education. By dynamically adjusting content difficulty and providing real-time feedback, these assessments offer a personalized and effective learning experience. While challenges remain in ensuring accessibility and minimizing cognitive overload, the findings underscore the transformative potential of AI-driven assessments in modern education.

CONCLUSSIONS

This study examined the impact of an AI-powered adaptive quizzing system on student engagement, learning outcomes, and cognitive load in Bahasa proficiency assessments.

The findings indicate that adaptive quizzes significantly enhance engagement, improve learning performance, and optimize cognitive load management compared to traditional assessments. Students using the AI-driven quizzes achieved higher post-test scores, demonstrated increased completion rates, and reported greater motivation due to real-time feedback and adaptive difficulty adjustments. The system fostered personalized learning experiences, increased autonomy, and improved retention, aligning with research supporting adaptive learning and AI-driven assessments. Despite these benefits, challenges remain, including algorithmic transparency, data privacy, and institutional readiness. Future research should explore long-term effects and

strategies for ensuring equitable access. Overall, this study reinforces the potential of AI in transforming digital assessments, paving the way for more personalized, effective, and scalable learning experiences.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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