Exploring the Impact of Adaptive Real-Time Quiz Platforms with Differentiated Learning Features on Student Engagement and Learning Outcomes: A Mixed-Methods Approach

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***Abstract*—The integration of digital tools in education has significantly transformed traditional teaching and assessment practices, opening new pathways for enhanced engagement and learning. This study employs a mixed-methods approach to investigate the impact of a custom-developed adaptive real-time quiz platform, designed with differentiated learning features that tailor questions and feedback based on individual student needs to boost engagement and improve learning outcomes. A total of 100 high school students participated in the experiment, split into two groups: one group used traditional paper-based quizzes (n = 50), while the other engaged with the custom-developed adaptive digital quiz platform (n = 50) for real-time assessments. Quantitative data were collected via pre- and post-tests to assess knowledge retention and academic performance, showing a marked improvement in the experimental group compared to the control group (p < 0.001). Additionally, qualitative data from student interviews and surveys provided valuable insights into motivation and engagement levels. Results indicate that students using the custom-developed adaptive real-time quiz platform, with its differentiated learning capabilities, exhibited increased engagement, faster response times, and improved performance relative to the control group. This study contributes to the expanding educational technology literature by demonstrating the effectiveness of adaptive interactive quiz platforms as engaging, impactful tools for real-time learning and assessment, with promising implications for enhancing student outcomes through personalized learning.**

***Keywords*—interactive quiz platforms, differentiated learning, student engagement, real-time assessment, learning outcomes, educational technology**

I. Introduction

The integration of digital tools in modern education marks a significant departure from traditional teaching and assessment methods. Historically, education depended largely on face-to-face interactions, standardized testing, and static resources like textbooks. However, digital technologies have revolutionized educational practices, fostering more dynamic, interactive, and personalized learning experiences. This transformation is prominently seen in the widespread adoption of Learning Management Systems (LMS) and various digital platforms that enhance online learning, collaboration, and communication among educators and students [1–3]. Research indicates that digital education tools significantly enhance teaching and learning processes across diverse educational contexts. These tools create interactive and adaptive learning environments that boost student engagement and improve learning outcomes [4, 5].

Additionally, incorporating digital literacy into curricula is essential to align education with the demands of a technology-driven society, ensuring that students are well-prepared for the digital landscape of their professional lives [3, 6]. This adaptation not only enhances the relevance of education but also fosters self-regulated learning, which is crucial for student success in higher education [7, 8].

As traditional methods often fall short in meeting the diverse needs of today's learners, there is an increasing necessity for adaptive learning approaches that can provide personalized experiences tailored to individual student requirements. Despite these advancements, several challenges persist in the effective integration of digital tools in education. Traditional assessment methods, such as paper-based quizzes, often fail to effectively promote student engagement. These methods emphasize rote memorization and passive learning, which can lead to disengagement among students [9, 10]. The rigid structure of paper-based assessments can limit opportunities for interactive and collaborative learning, which are essential for fostering deeper engagement [11, 12]. Furthermore, there remains a notable gap in research regarding the impact of digital tools on real-time assessments. While many studies have explored the efficacy of digital platforms in enhancing learning experiences, few have specifically examined how these tools influence the assessment process, particularly real-time feedback mechanisms [13, 14]. This gap limits the understanding of the potential advantages of digital assessments in fostering student engagement and improving learning outcomes [15, 16].

Addressing these challenges involves leveraging the strengths of digital tools to create more engaging and effective assessment methods. Interactive real-time quiz platforms, such as Kahoot!, Quizizz, and ProProfs, have emerged as innovative tools designed to enhance student engagement and learning outcomes. These platforms allow educators to create dynamic quizzes that students can participate in using their devices, fostering an interactive and competitive learning environment [4, 17, 18]. Core features

of these platforms typically include user-friendly interfaces, the ability to customize quizzes with various question types, instant feedback mechanisms, and analytics that track student performance [5, 12]. Additionally, many of these platforms incorporate gamification elements, such as points, leaderboards, and visual stimuli, which further motivate students to engage actively with the content [4, 19].

However, while platforms like Kahoot! and Quizizz effectively use gamification elements to boost engagement, they often lack adaptive features that cater to individual learning needs. These platforms provide static question sets that may not adequately challenge all students or address their specific gaps in knowledge. In contrast, KuisQ integrates adaptive questioning and real-time analytics to personalize the learning experience. By dynamically adjusting question difficulty and delivering targeted feedback based on performance, KuisQ fosters a more inclusive and effective learning environment. This study aims to explore how these advanced features impact student engagement and learning outcomes compared to traditional and static digital tools.

In addition to interactive and gamified features, quiz platforms can further enhance engagement and learning outcomes by incorporating differentiated learning elements. By tailoring questions, feedback, and pacing to individual learning needs, these platforms provide a more customized educational experience that meets students at their current level. Adaptive quizzes, for instance, adjust question difficulty based on prior performance, ensuring that students are consistently challenged and supported, which aids in knowledge retention [17–19]. Immediate and personalized feedback further strengthens learning, as it allows students to identify areas for improvement, fostering a growth mindset that sustains motivation [20, 21]. Self-paced learning options also enable students to revisit challenging material as needed, enhancing comprehension and satisfaction [22–24]. Additionally, learning analytics within adaptive platforms empower educators to monitor student progress, facilitating timely adjustments that support individual success [25]. With these adaptive strategies, quiz platforms bridge the gap between standardized and personalized education, promoting a flexible, inclusive environment that aligns with each student's unique learning journey.

A pivotal advantage of digital tools is their capacity to provide real-time feedback, a critical component in modern educational practices that significantly enhances student learning experiences. Immediate feedback allows students to correct mistakes promptly and reinforce their knowledge, leading to better academic performance [26–28]. In medical education, for instance, real-time feedback has been instrumental in improving practical skills such as Cardiopulmonary Resuscitation (CPR) and surgical techniques, thereby elevating the quality of education [29–31]. Furthermore, digital platforms that deliver feedback can reduce instructors' workloads, enabling them to provide timely and meaningful responses to larger groups of students [32, 33]. The effectiveness of real-time feedback extends beyond immediate corrections to influencing skill acquisition and performance improvement. Real-time graphics and feedback systems in health education have been linked to better patient outcomes and enhanced skill retention among trainees [5, 34]. Additionally, the incorporation of feedback in various educational settings, including virtual environments, enhances learners' presentation skills and overall engagement [28, 35]. This underscores the importance of integrating feedback mechanisms into digital learning environments to maximize their potential benefits.

The primary objective of this research is to develop an interactive real-time quiz platform integrated with differentiated learning features to enhance student engagement and improve learning outcomes. By evaluating the effectiveness of this customized and adaptive platform compared to traditional paper-based quizzes, the study seeks to provide empirical evidence on its impact. Utilizing a mixed-methods approach, the research aims to integrate quantitative data, such as test scores and completion rates, with qualitative insights from student feedback and instructor observations. This comprehensive approach will offer a holistic view of how differentiated interactive real-time quizzes influence student motivation and academic performance.

To guide this exploration, the study addresses the following research questions:

RQ1: How do interactive real-time quizzes with differentiated learning impact student engagement compared to traditional paper-based quizzes?

RQ2: What is the effect of real-time feedback and differentiated learning from digital quiz platforms on students' academic performance?

RQ3: How do students and instructors perceive and respond to the differentiated learning features within interactive real-time quiz platforms?

Understanding the impact of digital tools on student engagement and academic performance is crucial for enhancing learning experiences and supporting educators in adopting effective teaching strategies. The findings from this research will contribute to the broader discourse on the effectiveness of digital platforms in improving learning outcomes and provide actionable insights for educators aiming to integrate these tools into their teaching practices.

II. Literature Review

A. The Role of Educational Technology in Learning

Interactive quiz platforms play a crucial role in modern education by integrating gamification and technology to enhance student engagement and learning outcomes. These platforms utilize features such as points, leaderboards, competition, and immediate feedback, fostering an interactive learning environment [36–38]. Platforms like Kahoot! and Quizizz leverage game-like elements to create a competitive yet collaborative atmosphere, making learning more engaging and enjoyable [37, 39, 40].

Gamification has been widely recognized as an effective strategy to enhance motivation and participation in digital learning environments [41–44]. Game elements such as points, badges, and leaderboards sustain students' interest, leading to increased interaction and improved learning experiences [45–47]. Research has demonstrated its positive impact across various disciplines, including computer science, mathematics, and nursing education, though its effectiveness depends on proper implementation and alignment with learner needs [48–52].

A key advantage of interactive quiz platforms is their ability to provide real-time feedback, which is essential for formative assessment. Instant feedback enables students to identify strengths and areas for improvement, promoting self-regulated learning and better knowledge retention [12, 53, 54]. Studies indicate that such platforms enhance learning outcomes by reinforcing memory pathways and encouraging repeated retrieval of information [55].

In blended learning models, digital tools like gamification have proven effective in boosting student engagement and motivation [56, 57]. When integrated with collaborative activities, these elements encourage active participation and improve learning outcomes [46, 58]. Additionally, the accessibility and flexibility of these platforms allow students to engage with learning materials at their convenience, catering to diverse learning needs, particularly in remote or blended learning environments [59, 60]. Features such as adjustable time limits and varied question types further enable educators to customize assessments based on student needs [61].

Recent research highlights the importance of adaptive technologies in fostering engagement across different cultural contexts. Educational technology enhances learning autonomy, particularly in language education, by offering multimodal input and authentic interaction opportunities [62]. Mobile-Assisted Language Learning (MALL) studies emphasize that socio-economic and cultural factors influence technology adoption, necessitating adaptable frameworks like the Technology Acceptance Model [63]. This adaptability ensures equitable access to technology, even in under-resourced settings, facilitating participatory learning experiences [64].

Collaborative features further contribute to engagement by promoting teamwork and peer learning. Group quizzes and discussion boards encourage student interaction, reinforcing both social skills and motivation [53, 65]. Research indicates that collaborative gamification fosters a sense of community, positively impacting both learning engagement and performance [48, 66].

However, the successful implementation of interactive quiz platforms depends on factors such as teacher preparedness, pedagogical strategies, and institutional support. Educators require proper training to integrate these tools effectively and assess their impact on student learning [67, 68]. Additionally, thoughtful gamification design is necessary to prevent excessive rewards and avoid trivializing learning experiences [52]. Addressing potential challenges such as technological distractions and digital equity is also crucial to maximizing the benefits of these platforms [69, 70].

The literature underscores that interactive quiz platforms, coupled with real-time feedback, significantly enhance student engagement and learning outcomes. These technologies transform traditional assessment methods into dynamic, interactive experiences that support formative assessment and self-regulated learning. This research builds on existing findings by developing and evaluating an adaptive real-time quiz platform to assess its effectiveness in improving student engagement and academic performance.

B. Interactive Quiz Platforms and Real-time Feedback

Interactive quiz platforms integrate gamification and technology to enhance student engagement and learning outcomes. Features like points, leaderboards, competition, and real-time feedback create an engaging learning environment [36–38]. Platforms such as Kahoot! and Quizizz use game-like elements to promote competitive and collaborative learning experiences [37, 39, 40].

A key advantage of these platforms is their ability to provide real-time feedback, which plays a crucial role in formative assessment. Immediate feedback allows students to identify strengths and areas for improvement, fostering self-regulated learning and improving knowledge retention [12, 53, 54]. Studies show that instant feedback is more effective than delayed feedback, leading to higher motivation and better learning outcomes [71–74]. Platforms that support real-time feedback also encourage repeated retrieval of information, reinforcing memory pathways and increasing student satisfaction [55].

Moreover, the accessibility and flexibility of these platforms support continuous learning by enabling students to engage with content anytime and anywhere, making them particularly beneficial in remote and blended learning environments [59, 60]. Customizable features, such as adjustable time limits, varied question types, and difficulty levels, help educators tailor assessments to students' needs, enhancing the effectiveness of quizzes [61]. Adaptive learning systems further improve student engagement by providing personalized feedback based on performance and progress. This is particularly beneficial in STEM education, where dynamically adjusting content and pacing enhances learning outcomes [75–77].

Differentiated learning within these platforms ensures quizzes adapt to individual learning levels and styles, increasing engagement and reinforcing learning experiences [78, 79]. However, the effectiveness of immediate feedback depends on task complexity—while instant feedback is beneficial for simple tasks, delayed feedback may be more effective for deeper cognitive processing in complex tasks [80, 81].

Unlike widely used platforms like Kahoot! and Quizizz, which rely on static question banks, KuisQ employs adaptive questioning, dynamically modifying questions based on real-time performance data. This feature ensures that students are neither overwhelmed nor disengaged, maintaining an optimal level of challenge. Additionally, KuisQ integrates detailed performance analytics, allowing educators to monitor student progress and make timely instructional adjustments. These analytics support real-time decision-making and enable the design of personalized learning interventions [82].

Collaborative features such as group quizzes and discussion boards further enhance engagement by fostering peer learning and teamwork. Research shows that collaborative gamification not only improves knowledge retention but also prepares students for real-world problem-solving scenarios [53, 65].

However, the successful implementation of these platforms depends on factors such as teacher preparedness, effective pedagogical strategies, and institutional support. Educators need proper training to integrate these tools effectively and assess their impact on learning [67, 68]. The quality of feedback, learner preferences, and instructional design significantly influence the success of immediate

feedback and adaptive learning systems [83, 84]. Additionally, addressing challenges such as technological distractions and ensuring equitable access is essential to maximizing the benefits of these platforms [69, 70].

The literature highlights that interactive quiz platforms with real-time feedback significantly enhance student engagement and learning. These technologies transform traditional assessment methods into dynamic, personalized experiences that support formative assessment and self-regulated learning. This study builds on these findings by developing and evaluating an adaptive real-time quiz platform, assessing its effectiveness in improving student engagement and academic performance.

Personalized adjustments in quiz platforms further enhance learning outcomes through adaptive questioning, modifying question difficulty based on student performance. Research confirms that quizzes improve learning, particularly when they incorporate immediate feedback [17, 18]. Personalized feedback helps students identify strengths and weaknesses, fostering a growth mindset and encouraging continued engagement with the material [20].

KuisQ's data-driven design sets it apart by offering real-time analytics dashboards, enabling educators to track student progress and optimize instructional strategies. These insights allow for the implementation of evidence-based interventions that align with students' learning needs. Additionally, learning analytics in quiz platforms enhance personalization by helping educators adjust content and pacing, ensuring that each student receives the necessary support to succeed [25].

Emerging trends in real-time feedback, learning analytics, and artificial intelligence contribute to inclusive education by offering personalized, adaptive learning experiences for diverse learners [85, 86]. These innovations foster engagement and motivation, creating equitable learning environments that support all students [87].

In conclusion, integrating adaptive learning technologies and personalized feedback is essential for improving student engagement, comprehension, and retention. By leveraging adaptive questioning, real-time feedback, and differentiated learning strategies, educators can create more inclusive, effective digital learning environments that cater to diverse student needs.

C. Student Engagement and Learning Outcomes

Student engagement is a multidimensional construct encompassing behavioral, emotional, cognitive, and social aspects, all of which contribute to academic success. Behavioral engagement includes observable actions such as class participation and assignment completion, forming the basis of active learning. Beyond physical participation, emotional engagement fosters a sense of belonging and motivation, influencing students' persistence in their studies [88, 89]. Cognitive engagement involves the mental effort invested in learning, including critical thinking and self-regulation, which enhance knowledge retention and academic performance [90–93].

Social engagement also plays a crucial role, particularly in collaborative learning environments, where peer and instructor interactions enhance the learning process. Studies show that collaboration fosters a sense of community and motivation, leading to more active participation [94, 95]. The Community of Inquiry (CoI) framework highlights the interplay of teaching, social, and cognitive presence, emphasizing how student engagement enhances satisfaction and perceived learning, particularly in online and blended learning environments [96–99].

Measuring student engagement is essential for understanding its impact on academic outcomes. Tools such as the Student Course Engagement Questionnaire (SCEQ) help quantify behavioral, emotional, and cognitive engagement, while observational studies capture real-time behaviors, offering a more comprehensive understanding of student interactions [100–102]. Learning analytics has emerged as a valuable tool for real-time monitoring, tracking engagement patterns such as time spent on tasks and participation in discussions, enabling data-driven teaching strategies [103–105].

Integrating learning analytics with traditional measurement tools provides real-time insights that can be used to enhance student learning experiences [14, 106]. Frameworks such as Self-Determination Theory (SDT) and Community of Inquiry (CoI) explain how engagement influences academic success. SDT posits that when students' psychological needs for autonomy, competence, and relatedness are met, intrinsic motivation increases, leading to deeper engagement [107]. Meanwhile, the CoI framework underscores the importance of balancing cognitive, social, and teaching presence to foster critical thinking and meaningful learning [108].

Strategies to enhance engagement include timely and personalized feedback, fostering social interaction, and incorporating multimedia and interactive elements to sustain student motivation [109, 110]. Collaborative learning through group activities and peer instruction has been shown to significantly improve engagement and learning outcomes [111, 112]. Interactive tools such as Twiddla, Padlet, and Mentimeter promote active learning by integrating collaboration, real-time feedback, and gamification, which boost student participation and motivation [113–115].

These tools create dynamic learning environments where students feel more connected to the material and engage both cognitively and socially. The integration of gamification and real-time feedback further enhances the learning experience, allowing students to receive immediate performance insights, promoting self-regulated learning [116, 117].

Learning analytics further strengthens these approaches by enabling personalized feedback and adaptive learning interventions. AI-driven analytics can predict at-risk students and recommend targeted strategies to improve engagement and performance [118, 119]. This data-driven approach ensures that teaching strategies align with student needs, maximizing the effectiveness of interactive learning technologies.

In conclusion, understanding the behavioral, emotional, cognitive, and social dimensions of engagement is crucial for developing effective teaching strategies and optimizing learning outcomes. By utilizing surveys, observational methods, and learning analytics, educators can better measure engagement and its impact on academic performance. Furthermore, integrating interactive quiz platforms with gamification and real-time feedback enhances engagement, providing a practical and scalable approach for improving

student learning experiences. This research will explore how these platforms can be leveraged to maximize student engagement, contributing to academic success and richer educational experiences.

III. Method

A. Research Design

The research design of this study adopts a mixed-methods approach to comprehensively assess the impact of an interactive real-time quiz platform featuring differentiated learning components on student engagement and learning outcomes. This method integrates both quantitative and qualitative data collection, providing a robust analysis that combines objective numerical results with subjective participant experiences. The study involves a total of 100 high school students, structured into an experimental design with two main groups: the control group and the experimental group. The control group, comprising 50 students, engages with traditional paper-based quizzes, serving as the baseline for comparison. Conversely, the experimental group, also consisting of 50 students, utilizes a custom-developed adaptive real-time quiz platform that incorporates features such as adaptive questioning and real-time, personalized feedback to accommodate individual learning needs.

The research is carried out in four key phases to ensure a systematic and comprehensive analysis. The preparation phase focuses on developing and pre-testing the interactive quiz platform to validate its functionality and effectiveness before full implementation. This step ensures that potential technical issues are addressed and that the platform aligns with the study's objectives. The implementation phase involves the active administration of the intervention, wherein the control group completes paper-based quizzes and the experimental group participates in the adaptive digital quizzes. This structured comparison provides insight into how different assessment methods affect student engagement and performance. The data collection phase is conducted, during which quantitative data are gathered through pre-tests and post-tests to measure academic performance improvements.

Simultaneously, qualitative data are collected via student surveys and semi-structured interviews to obtain insights into students' perceptions, motivation, and engagement levels. This dual approach enables the capture of both numerical performance metrics and nuanced feedback from participants, fostering a comprehensive understanding of the study's outcomes.

Finally, the analysis phase synthesizes the quantitative and qualitative findings. Quantitative data are analyzed using statistical tests, such as paired t-tests, to identify significant differences between the control and experimental groups. Thematic coding is applied to qualitative data to extract common themes related to student engagement, motivation, and the effectiveness of differentiated learning features. This holistic analysis helps draw meaningful conclusions on the impact of the adaptive quiz platform on student outcomes. The sequential flow of these phases is illustrated in Fig. 1, which outlines the comprehensive research design, ensuring clarity in the methodology and facilitating replication in future studies.

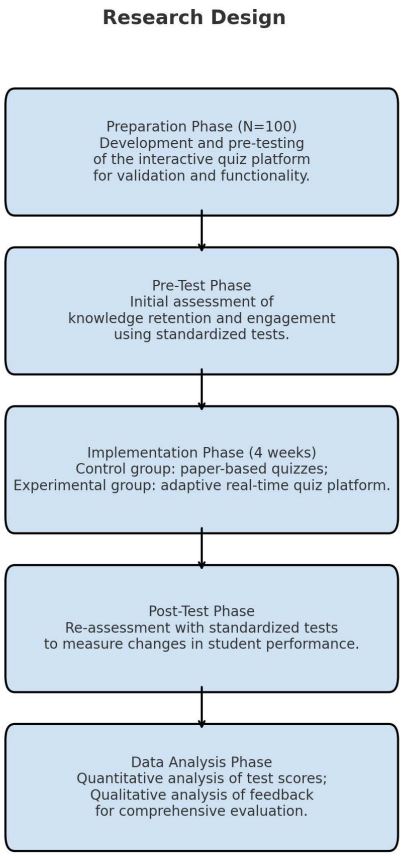

Fig. 1. Research design.

B. Participants

The study's participants comprised a total of 100 high school students from a secondary school in Padang, Indonesia. These students were selected using purposive sampling to ensure a balanced representation of students with similar academic backgrounds and access to necessary digital devices for participating in the study. The participants were evenly divided into two groups: 50 students in the control group (using traditional paper-based quizzes) and 50 students in the experimental group (utilizing the adaptive real-time quiz platform). The selection aimed to reflect diverse backgrounds while maintaining comparability across groups to draw reliable conclusions.

Ethical considerations were strictly adhered to throughout the study. Consent forms detailing the study's objectives, procedures, and potential risks were distributed to both students and their parents or guardians prior to participation. Only students whose parents or guardians provided informed consent were included in the study. In addition, participants were informed of their right to withdraw from the study at any time without any negative consequences. To ensure privacy and data protection, all student data were anonymized before analysis. The adaptive real-time quiz platform, KuisQ, incorporated robust encryption protocols to safeguard personal information and performance data. Access to the database was restricted to authorized researchers, and data were stored on a secure server compliant with international standards for data privacy, such as GDPR (General Data Protection Regulation). Long-term data management policies were also implemented to prevent misuse of student data. Data retention was limited to the duration necessary for analysis and publication of findings, after which all

identifiable information was securely deleted.

Only aggregated, anonymized data were retained for potential follow-up studies or educational improvements.

However, the long-term implications of using student data on educational platforms like KuisQ necessitate further attention. While robust encryption and anonymization protocols were implemented, concerns related to data sovereignty, algorithmic transparency, and potential biases in predictive analytics must be addressed. Future research should prioritize auditing data usage practices and developing transparent algorithms to ensure ethical compliance and equity in educational outcomes.

Gender distribution was also carefully balanced to mitigate any potential biases related to gender differences in technology use or engagement.

The demographic details of the participants are summarized in Table 1, which provides an overview of the distribution by gender, age, and academic performance level, ensuring transparency in the composition of the study groups.

Table 1. Demographic characteristics of study participants

Demographic Characteristics	Control Group (n = 50)	Experimental Group (n = 50)	Total (n = 100)
Gender			
Male	25	24	49
Female	25	26	51
Age (Years)			
15	15	17	32
16	20	18	38
17	15	15	30
Academic Performance Level			
High	18	19	37
Medium	22	21	43
Low	10	10	20

This table facilitates a comprehensive understanding of participant demographics, aiding in the interpretation of the study findings and ensuring a balanced comparison between the control and experimental groups.

C. Instruments

To comprehensively evaluate the impact of the adaptive real-time quiz platform on student engagement and learning outcomes, three primary instruments are utilized: the custom-developed interactive quiz platform, assessments designed to measure knowledge retention and performance, and semi-structured interviews aimed at capturing qualitative insights into students' and instructors' perceptions of the platform and its differentiated learning features. These instruments collectively provide a balanced approach to understanding both the quantitative and qualitative aspects of the study's objectives.

1) Interactive quiz platform

The interactive quiz platform utilized in this study, KuisQ, is accessible at https://kuisq.my.id/. KuisQ is designed with a focus on differentiated learning, offering adaptive features that meet the unique needs of each learner to foster a more personalized and effective educational experience. This approach is crucial in contemporary education, where accommodating varying learning paces, styles, and abilities is vital for promoting student engagement and achievement.

KuisQ is developed using Node.js as the primary backend technology, chosen for its event-driven architecture that supports high concurrency and ensures efficient real-time data processing. This allows KuisQ to manage multiple users simultaneously, making it ideal for interactive educational platforms where immediate feedback and seamless data flow are essential. The front-end is structured with HTML5 and CSS3, ensuring a visually appealing and responsive design that works across various devices. These technologies, combined with JavaScript for dynamic content updates, create an intuitive user experience that supports real-time quiz interactions and adaptive content delivery.

To detail the capabilities of KuisQ and its role in supporting differentiated learning, Table 2 outlines the platform's main features, each contributing to an adaptive and engaging educational environment.

Table 2. Core features of KuisQ

Feature	Description
Adaptive Questioning	Tailors question difficulty based on real-time performance, providing challenges that align with each student's competence level.
Immediate Feedback	Delivers instant, personalized feedback to guide students and reinforce their learning.
Customizable Quiz Formats	Offers a range of question types, including multiple-choice and short-answer, to cater to different learning preferences.
Data Analytics	Integrates analytics for teachers to monitor performance trends, enabling informed instructional adjustments.
User Authentication	Implements secure login protocols to ensure data privacy and secure access, suitable for formal educational use.

KuisQ's commitment to differentiated learning is evident in its adaptable quiz structure and personalized interaction features. The platform's adaptive questioning mechanism utilizes a sophisticated algorithm based on Item Response Theory (IRT) and real-time performance tracking to dynamically adjust question difficulty. For instance, as a student demonstrates a higher level of understanding, KuisQ increases the complexity of questions by introducing higher-order thinking problems that promote critical analysis and application. Conversely, if a student struggles, the platform generates questions of reduced complexity, focusing on foundational concepts to build confidence and mastery without discouragement.

To calibrate the adaptive algorithms, a two-phase process was implemented. First, a pilot study was conducted to collect baseline data from a representative sample of students. The collected responses were analyzed to determine item difficulty levels, discrimination parameters, and guessing probabilities, which were then used to refine the algorithm's scoring model. In the second phase, iterative testing was performed using real-time data from classroom implementations to fine-tune the algorithm, ensuring that it accurately reflects individual learning trajectories across diverse student groups.

This adaptive algorithm considers not only the correctness of responses but also the response time and patterns of errors, ensuring a nuanced understanding of the learner's abilities. Additionally, immediate feedback loops are seamlessly integrated into the adaptive mechanism, providing explanations, hints, and targeted learning resources based on the student's performance. This real-time adaptability fosters a growth mindset, empowering students to learn at their own pace while staying motivated and engaged.

Unlike platforms like Kahoot! and Quizizz, which rely on static question banks and predefined difficulty levels, KuisQ's dynamic adjustments ensure that every student engages with content that aligns with their individual learning needs. This tailored approach significantly enhances knowledge retention, promotes deeper comprehension, and ultimately leads to improved learning outcomes. To further illustrate the unique capabilities of KuisQ compared to other platforms like Kahoot! and Quizizz, Table 3 provides a structured comparison based on key features such as adaptive questioning, immediate feedback, and analytics.

Table 3. Comparative Analysis of interactive quiz platforms

Feature	Kahoot!	Quizizz	KuisQ
Adaptive Questioning	No	No	Yes
Real-Time Feedback	Yes	Yes	Yes (Personalized)
Gamification Elements	Extensive	Moderate	Limited
Retention Impact	Moderate	Moderate	High
Motivation Impact	High (short-term)	High (short-term)	High (sustained)

This comparison underscores the distinctive advantages of KuisQ, particularly in its ability to provide personalized and adaptive learning experiences that cater to diverse educational needs

The immediate feedback feature reinforces this adaptive approach by delivering tailored responses that help students recognize their strengths and pinpoint areas for improvement. This real-time feedback acts as a continuous learning loop, encouraging students to reflect on their answers and adapt their strategies accordingly. Such an approach not only enhances retention but also fosters a growth mindset by promoting resilience and proactive learning habits.

KuisQ also supports self-paced learning, allowing students to take quizzes at their own speed and revisit challenging sections as needed. This is particularly effective for students who require more time to grasp complex concepts or need to review material to reinforce their understanding. By catering to various learning paces, KuisQ ensures that each student can engage meaningfully with the content and progress according to their capabilities.

Furthermore, KuisQ accommodates different learning styles by integrating visual and auditory cues into the quizzes. This multi-modal approach aids comprehension, particularly for visual and auditory learners, by presenting information in varied formats that align with their preferred learning methods.

To provide a seamless user experience, the login screen of KuisQ (Fig. 2) features user authentication functionality to ensure secure access. After logging in, users are directed to the main dashboard (Fig. 3), which provides an overview of their progress and available quizzes. For instructors, the quiz creation interface (Fig. 4) allows customization of quiz settings to tailor assessments to student needs. During quiz sessions, students interact with the platform through a dynamic quiz interface (Fig. 5), which facilitates real-time engagement with adaptive questions. After completing a quiz, the results page (Fig. 6) provides personalized feedback and performance analysis, helping students identify areas for improvement.

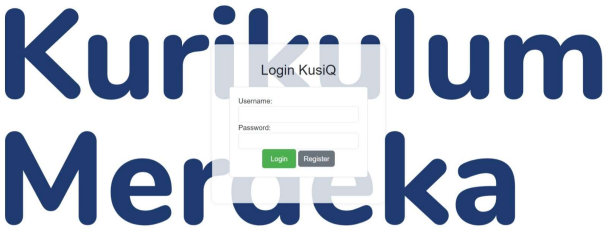

Fig. 2. Login screen with user authentication functionality.

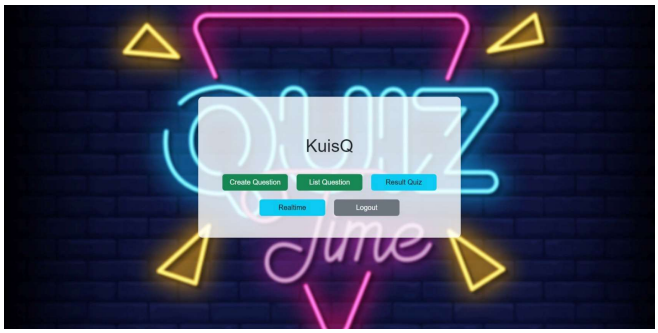

Fig. 3. Main dashboard interface of KuisQ.

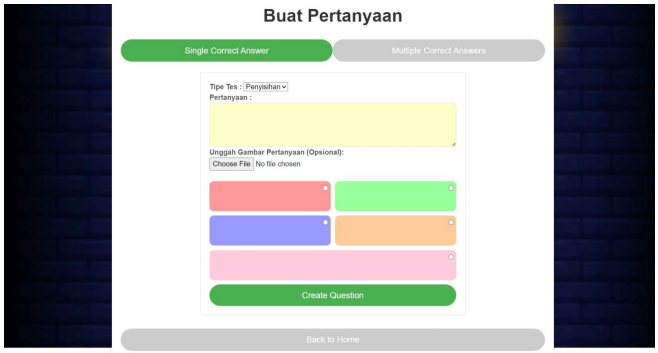

Fig. 4. Quiz creation interface highlighting customization options for instructors.

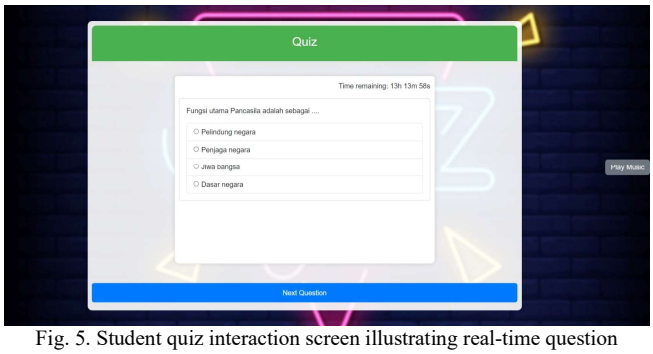

Fig. 5. Student quiz interaction screen illustrating real-time question engagement.

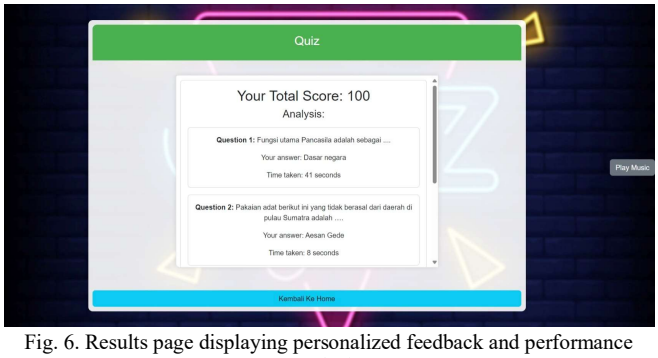

Fig. 6. Results page displaying personalized feedback and performance analysis.

These visual examples underline how KuisQ's adaptive

features and user-centric design support differentiated learning. The combination of adaptive questioning, immediate feedback, and customizable quiz formats facilitates a comprehensive, tailored learning experience, empowering students to reach their full potential in an engaging, responsive educational setting.

2) Assessments

To comprehensively evaluate the impact of KuisQ on student engagement and differentiated learning, a structured assessment approach was utilized. This approach included pre-test and post-test assessments, formative assessments embedded within the platform, and self-assessment activities designed to promote reflective learning. The combination of these assessments provided a well-rounded understanding of both the quantitative and qualitative aspects of student performance. First, the assessment framework began with a pre-test conducted before the intervention phase to establish a baseline of students' existing knowledge. This initial evaluation was crucial for creating a reference point that allowed for accurate measurement of academic progress. The post-test, which was administered after the intervention phase, mirrored the structure of the pre-test. This design facilitated a direct comparison of student performance before and after the use of KuisQ, enabling the collection of measurable data that reflected learning gains attributed to the platform's adaptive features. Next, formative assessments were integrated throughout the intervention to provide continuous feedback and maintain student engagement. These assessments allowed students to receive immediate, personalized feedback, enabling them to identify areas for improvement and adjust their learning strategies in real time. For educators, these insights proved valuable for identifying trends in student performance and making timely instructional adjustments. To further enhance reflective learning, KuisQ included self-assessment tools. These tools encouraged students to evaluate their own understanding and progress, fostering self-awareness and the development of a growth mindset. By participating in self-assessment, students could set learning goals and better understand their academic journey, promoting proactive and independent learning behaviors. The different types of assessments used in this study, along with their purposes and features, are summarized in Table 4 below.

Table 4. Assessment structure and components

Assessment Type	Purpose	Key Features
Pre-Test	Establish baseline knowledge levels	Multiple-choice, true/false, short-answer
Post-Test	Measure learning gains post-intervention	Identical structure to pre-test for comparison
Formative Assessments	Provide continuous learning feedback	Embedded in KuisQ, adaptive questioning
Student Self-Assessments	Encourage reflective learning and goal setting	Self-paced, personalized insights

Table 4 outlines the main assessment types applied in this research, highlighting their purposes and key features. This comprehensive approach ensured that the impact of KuisQ on student learning and engagement could be effectively measured, providing valuable insights into the effectiveness of differentiated learning practices.

3) Semi Structured Interviews

To complement the quantitative assessments and provide a more nuanced understanding of students' experiences with KuisQ, semi-structured interviews were conducted. These interviews aimed to gather qualitative insights into how students interacted with the platform, perceived its effectiveness, and suggested potential areas for enhancement. The structured yet flexible nature of these interviews allowed for the exploration of specific themes while accommodating spontaneous input from participants. This approach provided a comprehensive understanding of both the strengths and areas for improvement within the platform's implementation. The interviews focused on several key areas related to KuisQ's usage and its differentiated learning features. Questions were designed to elicit responses that captured participants' reflections on the platform's adaptive questioning, immediate feedback, usability, and impact on learning motivation. These insights were crucial for assessing the holistic impact of KuisQ on student engagement and learning outcomes. Table 5 outlines the structure of the semi-structured interviews and the specific components evaluated during these sessions.

Table 5. Components of semi-structured interviews

Interview Component	Description	Evaluation Criteria
Platform Usability	Participants' feedback on the ease of use and user experience of KuisQ.	Ease of navigation, user-friendliness, satisfaction
Learning Engagement	Reflections on how KuisQ's adaptive features affected their engagement during learning.	Level of motivation, interaction depth, sustained interest
Feedback Quality	Participants' perceptions of the immediate feedback provided by KuisQ.	Usefulness, clarity, contribution to learning
Adaptive Learning Impact	Insights on how the adaptive questioning influenced their learning progress.	Perceived difficulty balance, adaptability, learning support
Multimedia and Visual Integration	Impressions of the multimedia elements used in the quizzes.	Relevance, contribution to different learning styles
Suggestions for Improvement	Ideas provided by participants for enhancing the platform's effectiveness.	Actionable recommendations, feasibility

These interviews incorporated open-ended questions that encouraged detailed responses, allowing students to share both positive and critical perspectives on their interactions with KuisQ. The insights gained from these sessions highlighted the features that were most impactful, the challenges encountered, and areas where the platform could be refined to better meet learner needs.

In addition to structured interview questions, participants were encouraged to elaborate on their personal learning experiences with KuisQ. This provided context-rich data that complemented the quantitative findings and supported a deeper exploration of how differentiated learning was facilitated through the platform. The combination of targeted questions and open-ended discussions allowed for a comprehensive evaluation of KuisQ's role in promoting student engagement and learning outcomes.

D. Data Collection and Analysis

To ensure a comprehensive understanding of KuisQ's

impact on student engagement and learning outcomes, data collection was carefully designed to integrate both quantitative and qualitative methods. This dual approach facilitated a robust analysis, enhancing the reliability and depth of the study's findings by cross-referencing data from multiple sources. The quantitative data collection began with the administration of pre-test assessments conducted prior to the intervention phase. This initial stage was essential for establishing a baseline of students' academic performance, serving as a reference point for subsequent comparisons. A power analysis was conducted using G*Power software to determine the appropriate sample size for detecting medium to large effect sizes with 80% power at a significance level of 0.05. This analysis confirmed that the sample size of 200 participants was sufficient for the intended statistical tests, ensuring the validity of the findings.

The reliability and validity of the questionnaire used in this study were assessed prior to its deployment. Reliability testing using Cronbach's Alpha resulted in a score of 0.87, indicating high internal consistency. To ensure content validity, the questionnaire was reviewed by three experts in educational technology, who provided feedback on the alignment of items with the study's objectives. Adjustments were made based on their suggestions to enhance clarity and relevance.

Following the four-week intervention period, post-test assessments were conducted using the same format as the pre-test. This consistency ensured that any changes in student performance could be accurately attributed to the adaptive features of KuisQ, such as real-time feedback and tailored question difficulty. The measurable data collected from these assessments allowed for an objective evaluation of learning gains. Qualitative data collection complemented the quantitative findings by providing in-depth insights into students' experiences. Semi-structured interviews were conducted with participants from the experimental group after the post-test phase. These interviews were designed to capture the students' perceptions of KuisQ's usability, its impact on their learning journey, and the effectiveness of its differentiated learning features. The semi-structured format allowed students to express their thoughts freely while enabling the researchers to delve deeper into areas of particular interest, such as the immediate feedback and personalized learning paths provided by KuisQ.

The analysis phase integrated both statistical and thematic approaches to draw meaningful conclusions. Quantitative data from the pre- and post-tests were analyzed using paired t-tests, as this method effectively identifies significant differences in student performance before and after the intervention. This approach aligns with the study's objectives by providing evidence of learning gains attributable to KuisQ's adaptive features. Descriptive statistics, such as means, standard deviations, and confidence intervals, were also calculated to provide a detailed overview of performance trends. These metrics ensured a clear representation of the intervention's impact. This statistical method highlighted whether the observed learning gains were substantial and supported the effectiveness of KuisQ's adaptive approach.

On the qualitative side, thematic analysis was employed to extract and categorize recurring themes from the semi-structured interviews. Prominent themes included increased engagement, the perceived benefits of immediate feedback, and the adaptability of the platform to individual learning needs. By combining quantitative results with qualitative insights, the data analysis provided a comprehensive understanding of KuisQ's educational impact. This integrated approach ensured that the selected metrics, such as t-tests, were not only methodologically appropriate but also closely aligned with the research objectives, offering a nuanced view of KuisQ's effectiveness. The findings reflected not only objective performance metrics but also the subjective experiences of students, painting a full picture of how KuisQ's features contributed to their learning process.

IV. Results

A. Impact on Student Engagement with Interactive Real-Time Quizzes (RQ1)

To evaluate the impact of the KuisQ platform on student engagement, we utilized pre-test and post-test assessments to measure changes in students' engagement levels following the intervention. The assessments were designed to gauge not only academic performance but also students' perceptions of their engagement during the quiz-taking experience.

Prior to the intervention, both the experimental group, which used the KuisQ platform, and the control group, which engaged with traditional paper-based quizzes, displayed similar levels of engagement, with mean pre-test scores reflecting an average engagement level of 72.45 (Standard Deviation [SD] = 5.18) for the experimental group and 71.89 (SD = 5.03) for the control group.

Post-intervention assessments revealed a marked increase in engagement levels among students using KuisQ. The experimental group achieved a mean post-test score of 88.54 (SD = 4.75), indicating a significant enhancement in engagement due to the interactive nature of the platform. In contrast, the control group, while showing improvement, only reached a post-test mean score of 76.23 (SD = 4.95). This difference underscores the effectiveness of KuisQ in fostering a more engaging learning environment through its interactive features. Table 6 summarizes the pre-test and post-test scores for both groups, illustrating the significant improvement in the experimental group's engagement levels.

Table 6. Pre- and post-test scores of engagement levels by group

Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	t-value	p-value
Experimental	72.45 (5.18)	88.54 (4.75)	−15.67	<0.001
Control	71.89 (5.03)	76.23 (4.95)	−7.91	<0.001

As shown in Table 6, the results of the paired sample t-test further confirm the significance of these findings, with the experimental group demonstrating a t-value of −15.67 ($p < 0.001$) and the control group a t-value of −7.91 ($p < 0.001$). These statistics indicate that KuisQ not only improved students' performance but also significantly enhanced their engagement levels during the learning process. Fig. 7 illustrates the overall pre-test and post-test mean scores by group, showcasing the notable increase in engagement levels for students utilizing the interactive features of KuisQ compared to those in the traditional learning environment.

In conclusion, the introduction of the KuisQ platform has proven to significantly elevate student engagement,

reinforcing the value of interactive and adaptive learning technologies in contemporary educational settings. The results suggest that when students are provided with engaging tools tailored to their individual learning needs, their overall academic experience is markedly enhanced, leading to greater motivation and improved learning outcomes.

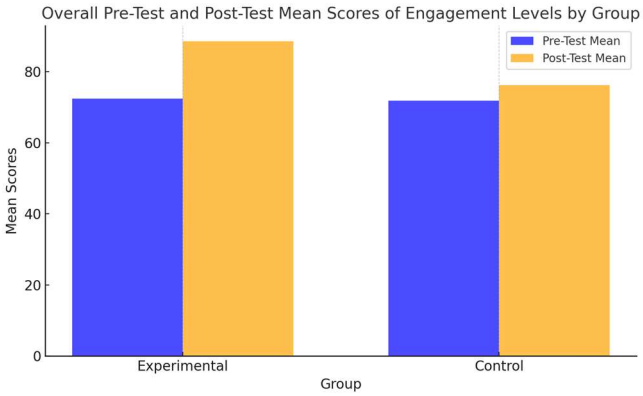

Fig. 7. Overall pre-test and post-test mean scores of engagement levels by group.

B. Comparison of Learning Outcomes between Digital Quiz Platforms and Traditional Paper-Based Quizzes (RQ2)

To evaluate the effectiveness of the KuisQ platform in enhancing student learning outcomes, we conducted pre-test and post-test assessments focusing on students' academic performance before and after the intervention. The pre-test scores for the experimental group, which utilized KuisQ, averaged 73.40 (SD = 6.25), while the control group, engaging with traditional paper-based quizzes, averaged 72.15 (SD = 6.10). These baseline scores demonstrate that both groups had similar levels of knowledge prior to the intervention. Following the intervention, the post-test results revealed a notable improvement for the experimental group, with an average score of 90.32 (SD = 5.12). In contrast, the control group achieved a post-test mean of 77.68 (SD = 5.88), indicating that while they also improved, the enhancement was less pronounced than that of the experimental group. The substantial difference in post-test scores suggests that the interactive features of KuisQ significantly contributed to learning gains. Table 7 summarizes the pre-test and post-test scores for both groups, illustrating the significant differences in learning outcomes:

Table 7. Pre- and post-test scores of learning outcomes by group

Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	t-value	p-value
Experimental	73.40 (6.25)	90.32 (5.12)	25.93	<0.001
Control	72.15 (6.10)	77.68 (5.88)	43.54	<0.001

As shown in Table 7, the results of the paired samples t-test confirm the significance of these findings. The experimental group exhibited a t-value of 25.93 ($p < 0.001$), highlighting a substantial improvement in scores due to the KuisQ platform. The control group also showed a significant increase in their scores, with a t-value of 43.54 ($p < 0.001$), although the improvement was not as pronounced as that of the experimental group. Fig. 8 illustrates the overall pre-test and post-test mean scores by group, showcasing the significant increase in scores for students utilizing the interactive features of KuisQ compared to those in the traditional learning environment.

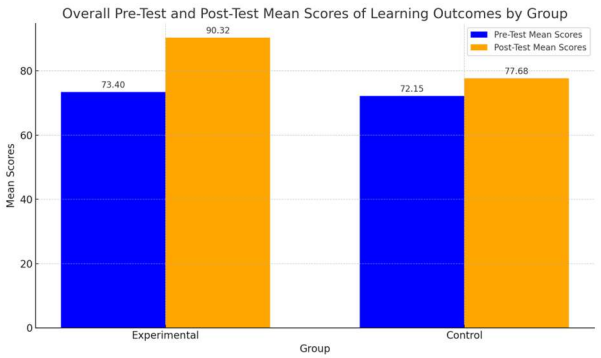

Fig. 8. Overall pre-test and post-test mean scores of learning outcomes levels by group.

In conclusion, the data indicates that the KuisQ platform substantially enhances learning outcomes for students. The integration of interactive quizzes appears to be a powerful tool in promoting academic achievement, reinforcing the value of technology in educational settings. The results suggest that the engaging and adaptive nature of KuisQ not only improves knowledge retention but also fosters a more effective learning experience for students.

C. Student and Instructor Perceptions of Differentiated Learning Features in Interactive Real-Time Quiz Platforms (RQ3)

To explore the perceptions of both students and instructors regarding the differentiated learning features of the KuisQ platform, qualitative data were collected through semi-structured interviews and surveys. This data provided rich insights into how effectively the platform supports diverse learning needs, as well as the overall experience of using the technology in an educational context.

A prominent theme identified from the qualitative analysis was the positive reception of the adaptive questioning feature, which allows the platform to tailor the difficulty of quiz questions in real-time based on student performance. Students expressed that this capability was beneficial in maintaining their engagement and providing an appropriate level of challenge. For instance, one student noted, "The questions adapted perfectly to my level; I felt challenged but not overwhelmed." This sentiment highlights the effectiveness of KuisQ in fostering an inclusive environment that meets varying learner capabilities, see Table 8 for details.

Table 8. Themes and codes from student interviews

Theme	Codes	Example Quotes
Adaptive Questioning	Personalized challenge	"The adaptive questions kept me engaged and motivated."
Increased Engagement	Higher interest, sustained focus	"I found myself more interested when the questions matched my level."
Feedback Effectiveness	Immediate feedback, clarity	"The instant feedback helped me understand where I went wrong."
User-Friendliness	Easy to navigate	"I had no trouble using the platform; it was very user-friendly."

Another significant theme emerged regarding the overall learning experience with KuisQ. Many students indicated that the interactive nature of the platform contributed to a more

engaging and effective learning process. They highlighted that the blend of real-time feedback and adaptive learning paths not only enhanced their understanding of the material but also increased their confidence in tackling challenging concepts. As shown in Table 9, a majority of students agreed that KuisQ made learning more interactive and helped boost their confidence in engaging with quizzes. For example, a student shared, "The instant feedback was really helpful; it made me feel more confident in my abilities."

Table 9. Survey results on learning experience

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
KuisQ made learning more interactive.	50%	40%	7%	2%	1%
The platform boosted my confidence.	55%	35%	5%	3%	2%
I enjoyed the quizzes on KuisQ.	60%	30%	5%	3%	2%

As shown in Table 8 and Fig. 9, a substantial majority of students reported that KuisQ enhanced their learning experience, reinforcing the platform's role in facilitating a supportive educational environment.

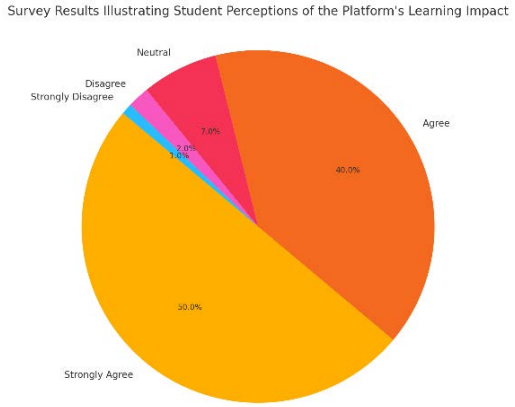

Fig. 9. Survey results illustrating student perceptions of the platform's learning impact.

Instructors also provided valuable feedback regarding the platform's differentiated learning features. They noted that KuisQ's analytics allowed them to monitor student progress and adapt their teaching strategies accordingly. One instructor remarked, "The ability to track individual student performance through the analytics dashboard is invaluable; it helps me tailor my approach based on real data." This insight underscores the platform's potential to empower educators in addressing diverse learner needs effectively, as shown in Table 10 and Fig. 10.

In summary, both students and instructors recognized KuisQ as an effective tool for fostering differentiated learning. The platform's adaptive features, immediate feedback, and engaging interface contribute to a positive educational experience, enhancing both student motivation and learning outcomes. This feedback highlights the significant role that interactive technologies can play in modern education, supporting diverse learning needs and promoting a culture of continuous improvement in teaching practices

Table 10. Instructor feedback on KuisQ

Aspect	Positive Feedback	Neutral Feedback	Constructive Critique
Analytics and Monitoring	85%	15%	"More detailed analytics would help."
Student Engagement	80%	20%	"Engagement levels are high, but sustaining interest over time is essential."
Usability of the Platform	90%	10%	"Very user-friendly for both students and teachers."

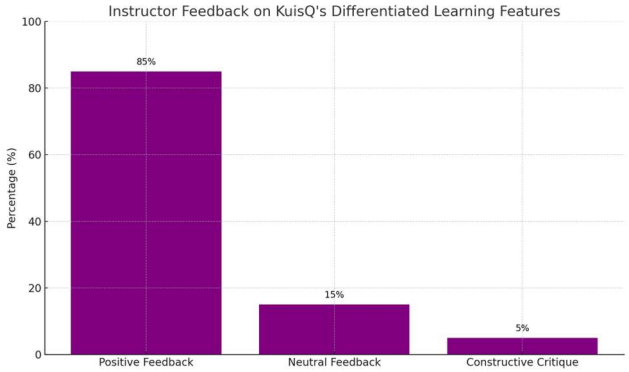

Fig. 10. Instructor feedback on KuisQ's differentiated learning features.

V. Discussion

The findings of this study reveal that the KuisQ adaptive real-time quiz platform significantly enhances student engagement and learning outcomes compared to traditional paper-based assessments. This aligns with previous research that emphasizes the transformative role of digital technologies in modern education. The results support the theoretical framework established in the literature review, specifically highlighting the importance of interactive educational tools and differentiated learning strategies.

The KuisQ platform's interactive features led to increased student engagement, as evidenced by the substantial rise in post-test engagement scores. This finding corroborates the insights from the literature regarding the positive impact of interactive quiz platforms on student motivation and participation (as discussed in Section II. A). Specifically, studies have shown that gamified elements and real-time feedback contribute to a more stimulating learning environment [4, 5]. The participants' experiences echo the principles of Constructivist Learning Theory, which posits that active engagement with content promotes deeper learning and retention [120].

KuisQ, developed as part of this research, is designed to adapt questions in real-time based on student performance. This adaptive mechanism was specifically created to support personalized engagement, ensuring that students remain challenged without feeling overwhelmed. This approach aligns with the principles of adaptive learning as described by Wang [121], highlighting the importance of creating inclusive and effective learning environments for diverse student populations. These findings are further supported by the work of Gorbunovs *et al*. [25], which demonstrates that adaptive platforms can enhance engagement and learning outcomes.

The findings also demonstrate that the experimental group achieved significantly higher post-test scores compared to the

control group, which is consistent with the research literature advocating for the use of adaptive learning technologies to improve academic performance [7, 22]. The use of KuisQ allowed for tailored learning experiences that catered to individual student needs, as outlined in the Universal Design for Learning (UDL) framework [122]. This adaptability not only enhances learning outcomes but also ensures that students are adequately challenged without feeling overwhelmed. Unlike platforms like Kahoot! and Quizizz, which primarily offer gamification and standardized questions, KuisQ's adaptive questioning mechanism dynamically adjusts question complexity based on individual performance. This ensures that each student engages with material at an appropriate level of challenge, promoting deeper comprehension and retention. These findings are particularly relevant for addressing the needs of lower-performing students. KuisQ's ability to scaffold instruction through tailored question difficulty allows these learners to build foundational knowledge incrementally and avoid the frustration often associated with static assessments [78].

The study's results resonate with Bandura's (1977) theory of self-efficacy, where immediate feedback from KuisQ helped bolster students' confidence, promoting a growth mindset and encouraging further academic exploration. Moreover, the platform's adaptability aligns with findings by Wang [121], who emphasized the role of adaptive digital tools in improving metacognitive skills, such as self-monitoring and strategic planning. These skills are essential for long-term knowledge retention and self-regulated learning, highlighting the broader potential impact of KuisQ on educational outcomes.

The qualitative data revealed that both students and instructors recognized the value of differentiated learning features in KuisQ. The platform's ability to adjust question difficulty based on individual performance supports the principles of differentiated instruction, which advocates for tailoring educational experiences to meet diverse learner needs [9]. In contrast to Kahoot! and Quizizz, which often provide static assessments, KuisQ delivers a personalized and dynamic learning experience by leveraging real-time analytics and adaptive questioning. These features create a learning environment that not only engages high-performing students but also supports those needing additional scaffolding, ensuring inclusivity and effectiveness for all learners. This aligns with findings from Gorbunovs *et al*. and Debeer *et al*., further emphasizing the potential of adaptive platforms in promoting engagement and academic success [25, 78].

These findings have significant implications for educational practice, highlighting the need for educators to integrate adaptive learning tools like KuisQ into their teaching strategies. The analytics provided by the platform enable instructors to monitor student progress in real-time, allowing for data-informed instructional decisions. As emphasized by Pardo *et al*. [32], such data-informed strategies are essential for addressing learning gaps effectively and enhancing teaching efficacy.

Moreover, the evidence presented in this study suggests that adaptive platforms like KuisQ should be prioritized in educational policies aimed at increasing equity and effectiveness in learning. These tools not only enhance academic outcomes but also equip educators with innovative methods to meet the diverse needs of their students.

While the results of this study are promising, there are limitations that should be addressed in future research. The sample size was limited to one educational institution, which may restrict the generalizability of the findings. Future studies should include a larger and more diverse participant pool to validate the results. Challenges related to access to digital devices and stable internet connectivity may have influenced the study's results by introducing bias among participants. Students with better access are likely to demonstrate higher engagement, whereas those facing access barriers may participate less actively or encounter interruptions in the learning process. This can reduce the representativeness of the findings, particularly when applied to educational settings in under-resourced areas. Students in under-resourced areas may face barriers in utilizing such technologies due to limited availability of devices or stable internet connections. To address this, future research should explore the feasibility of implementing adaptive platforms in low-resource settings and investigate potential solutions, such as device-sharing programs or offline functionalities.

Furthermore, preliminary observations suggest that the sustainability of KuisQ usage depends on its ability to scale effectively across diverse educational contexts. High-resource environments can fully leverage KuisQ's features, while low-resource settings may require simplifications or alternative implementations, such as modular algorithms or offline functionality. Future research should investigate the long-term retention rates and educational impact of KuisQ in varying socio-economic and cultural environments. This includes assessing the platform's adaptability over extended periods and identifying strategies to ensure consistent engagement and effectiveness, regardless of resource availability.

Additionally, while real-time feedback is a key strength of KuisQ, it may also pose challenges for some students. The immediate nature of the feedback can create pressure, particularly for those who are less confident in their abilities. Incorporating customizable pacing options could help mitigate this issue by allowing students to interact with the platform at a speed that aligns with their comfort level. Lastly, the adaptive questioning mechanism, while effective, requires careful calibration to ensure that it accommodates a wide range of learning speeds and styles. Future enhancements could include allowing instructors to adjust the degree of adaptation or providing more comprehensive training for educators to optimize the use of adaptive features. Such modifications would further strengthen the inclusivity and effectiveness of adaptive platforms like KuisQ.

In summary, the KuisQ adaptive real-time quiz platform has proven to be an effective educational tool that significantly enhances student engagement and learning outcomes. The findings align with established theories and literature on interactive learning environments, differentiated instruction, and the role of technology in education. This research contributes to the ongoing discourse on educational technology, emphasizing the potential of adaptive tools to create more inclusive, engaging, and effective learning experiences.

VI. Conclusion

This study highlights the potential of the KuisQ adaptive real-time quiz platform as a transformative tool in modern education. By leveraging adaptive questioning and immediate feedback, KuisQ effectively enhances student engagement and academic performance.

The findings emphasize the platform's ability to address diverse learner needs through differentiated instruction, creating a more inclusive and supportive learning environment. The key contribution of this research lies in demonstrating how adaptive learning technologies can promote personalized education while equipping educators with actionable insights through learning analytics. These insights enable timely instructional adjustments, fostering data-driven teaching practices that enhance learning outcomes. Beyond its immediate impact on engagement and performance, KuisQ also exemplifies the broader potential of educational technology to support self-regulated learning and metacognitive development. This positions the platform as a valuable asset for educators aiming to implement innovative assessment strategies that align with contemporary pedagogical frameworks. Future research should investigate the scalability and long-term effects of adaptive platforms like KuisQ across diverse educational settings. Additionally, exploring their integration into hybrid and online learning environments could further expand their applicability. In conclusion, the KuisQ adaptive real-time quiz platform represents a significant advancement in personalized education. By integrating interactive and adaptive features, it offers a powerful approach to improving student outcomes and enriching the learning experience. These findings contribute to the ongoing discourse on educational technology, reinforcing its critical role in shaping future teaching and learning practices

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Syahrul Ramadhan conducted the research, including the design and implementation of the KuisQ platform and the collection of data through assessments and interviews. Atmazaki Atmazaki analyzed the quantitative and qualitative data, performing statistical tests and thematic analysis to evaluate the impact of the platform on student engagement and learning outcomes. Ayu Gustia Ningsih contributed to the literature review, providing insights into the existing research on differentiated learning and interactive technology in education. Yenni Hayati wrote the manuscript, integrating all sections and ensuring clarity and coherence throughout the paper. Mita Domi Fella Henanggil reviewed and provided feedback on the manuscript. Nursaid Nursaid provided resources and validation, ensuring that the research methodology and findings aligned with academic and ethical standards. Fauzi Rahman contributed to data curation and project administration, supporting the organization and structuring of the research process. Bima Mhd Ghaluh contributed substantially to the refinement of the manuscript and provided key insights during the data analysis phase, ensuring the validity and reliability of the findings. All authors reviewed and approved the final version of the manuscript.

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