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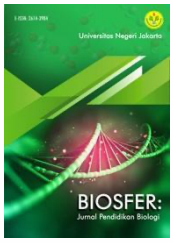

Eco-quest: Integrating gamification and direct observation in biology education

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ABSTRACT

Biology education requires interactive digital media capable of supporting direct observation activities and student engagement. However, the application of gamification-based media integrated with field observations in biology education remains limited and is rarely evaluated in terms of its validity and practicality. This study aims to analyze the validity and practicality of a gamification-based Google Sites platform named "Eco-Quest" for observation-based biology learning. The study employed a Research and Development (R&D) approach using Tessmer's formative evaluation model, which includes expert review and one-to-one evaluation stages. Study participants consisted of three expert validators and ten students. Data were collected via expert validation sheets and student response questionnaires, then analyzed descriptively using a 1–5 rating scale and percentage conversion. The expert validation results showed an average score of 3.37, categorized as valid, while the system test achieved an average score of 4.63, categorized as excellent. The study findings indicate that the integration of gamification features, visual navigation, and observation-based activities enhances student engagement, interaction, and the effectiveness of task management. The aspects students found most helpful were the gamification system and visual display, while the main challenge identified was internet connectivity. Therefore, the "Eco-Quest" platform is suitable for use in biology education and requires further development through improved accessibility and testing of learning outcomes.

INTRODUCTION

Biology learning ideally emphasizes active student engagement through direct observation, scientific inquiry, and the integration of digital technology relevant to 21st-century education (Persito et al., 2025; Zebua, 2025). The integration of technology in biology learning is important because it supports scientific literacy, critical thinking skills, and contextual learning experiences. One form of technology integration is the use of gamification-based digital learning media, which has the potential to increase motivation, interaction, and student participation in learning activities.

However, biology learning in practice is still frequently dominated by conventional methods such as lectures and textbook-centered instruction. As a result, student engagement remains low and learning experiences become less meaningful. In addition, observation activities are often not systematically integrated with digital learning media, and the use of gamification in biology education remains limited (Clodia et al., 2025). Furthermore, direct observation activities are often not systematically integrated with digital media, and the use of gamification remains limited in terms of both development and implementation. Consequently, student engagement and the quality of the learning experience obtained are not yet optimal. A study (Basri et al., 2022) reported that student engagement in high school biology learning was low, at 40.86%. Another study also noted that the use of gamification in learning remains rare because teachers are still largely unfamiliar with this approach, resulting in low teacher perceptions of gamification (Rini et al., 2021).

This issue is important because biology learning emphasizes direct observation and contextual interaction with biological phenomena. Without valid and practical digital media, technology integration in biology education may fail to support authentic learning experiences and meaningful student engagement. Therefore, validation and practicality testing are necessary before broader implementation to ensure pedagogical suitability and usability.

The gap between these ideal conditions and the actual reality raises significant pedagogical issues. Many digital learning materials are developed without undergoing adequate content validity and practicality testing. According to Samaloisa & Bilo (2024), when instruction fails to accommodate the characteristics of learners familiar with digital technology, the potential for increased motivation and participation in learning is suboptimal. This has implications for the quality of the material, its alignment with the curriculum, and its effectiveness in supporting the achievement of competencies. Therefore, testing the suitability of media before implementation is a crucial step to ensure its quality and effectiveness (Ulfah & Imam, 2025).

As one approach to addressing these issues, integrating gamification via digital platforms such as Google Sites, combined with hands-on activities, offers a relevant alternative. Google Sites provides a structured, interactive, and easily accessible way to present learning materials. According to Aeni & Mahpudin (2025), Google Sites can help teachers design learning experiences that are visually engaging, systematic, and tailored to students' needs. Meanwhile, gamification elements such as challenges, points, and feedback can boost learning motivation. This integration not only provides a digital learning experience but also preserves biology's characteristic as a science grounded in real-world phenomena.

Recent research indicates that integrating gamification with digital learning media can enhance motivation, student engagement, and learning outcomes in science education, as reported in a systematic review that found a positive impact of game elements on student motivation and engagement (Jihadillah, 2025). Previous studies have demonstrated that gamification can improve students' motivation, engagement, and learning outcomes in digital learning environments (Hallifax et al., 2023; Jihadillah, 2025). Several studies have also explored the use of Google Sites as an interactive learning platform because of its accessibility and flexibility in supporting digital instruction (Arrahma et al., 2024; Laili et al., 2025).

However, the content validity and practicality of the media are often not thoroughly assessed before implementation, resulting in a gap between media design and the expected pedagogical quality, as evidenced by a study on the development of gamification-based learning media that included subject-matter and media-expert validation (Suryadi, 2025).

Furthermore, other literature reviews indicate that gamification has a significant impact on digital literacy and student engagement, but issues related to limited access to technology and educator readiness remain obstacles (Al Hafiz et al., 2025). Other research confirms that while gamification is generally effective in enhancing motivation and learning outcomes, further studies are needed to prioritize the validation and practicality of gamified media as a fundamental stage of development to

ensure quality and appropriate implementation in more complex learning contexts (Haq et al., 2025). Although various studies have shown that gamification is effective in improving student motivation and learning outcomes, studies that specifically assess the content validity and practicality of gamification-based media integrated with direct observation activities in biology learning remain limited.

Based on the above discussion, this study aims to analyze the content validity and practicality of Google Sites as a medium for integrating gamification through direct observation in biology education. The results of this study are expected to serve as a basis for determining the suitability of the medium before its widespread use and to contribute to the development of innovative, high-quality technology-based learning media in biology education.

METHODS

Research Design

This study employed a Research and Development (R&D) approach using Tessmer's formative evaluation model, consisting of self-evaluation, expert review, one-to-one evaluation, small-group evaluation, and field testing (Plomp & Nieveen, 2013). This model was used to assess the feasibility and usability of the developed gamification-based learning media. The stages of Tessmer's formative evaluation used in this study are presented in Figure 1.

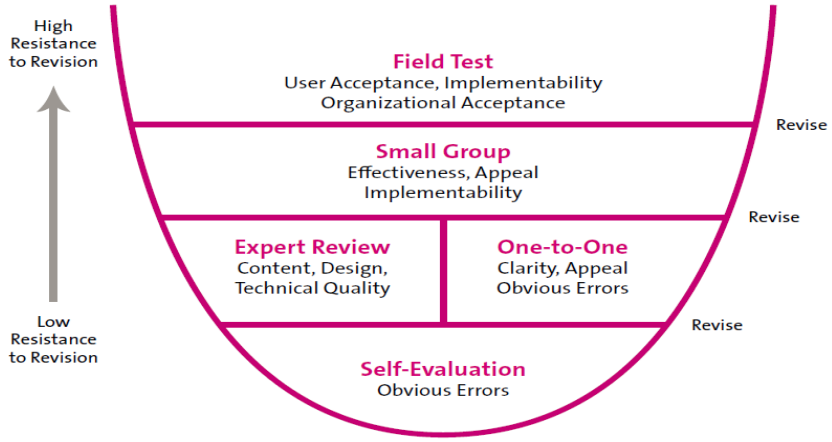

Figure 1. Tessmer's formative evaluation stages (Plomp & Nieveen, 2013)

Population and Samples

The research subjects were divided into two groups: experts and students. During the expert review phase, three experts were involved, each with experience in research, teaching, and community service relevant to the characteristics of the media being developed. In the one-to-one evaluation phase, the research subjects were ten students who had taken the Environmental Knowledge course. This course was selected for its material, which integrates scientific concepts with social and community contexts, and for its teaching approach, which combines classroom activities with fieldwork**.** The results of the population and sample data are shown in Table 1.

Table 1.
Population and Samples

Participants	Number	Characteristics
Media Experts	3	Experts in biology education, educational technology, and learning media.
Students	10	Biology Education students who had completed the Environmental Knowledge course.

Instrument

The instruments used in this study were a media expert validation sheet and a user response questionnaire. The validation sheet was used to assess the media's design, language, visual elements, and usability, while the response questionnaire measured students' perceptions of the media's ease of use, workflow clarity, and effectiveness in supporting gamification-based learning.

Procedure

The study was conducted at the Department of Biology Education, Faculty of Teacher Training and Education, Lambung Mangkurat University, Banjarmasin, over a four-month period (April–June 2025). The initial phase of the study involved developing a gamification-based Google Sites platform integrated with field observation activities (Draft I). Subsequently, Draft I was validated by experts during the expert review phase and pilot-tested with students during the one-to-one evaluation phase. The results from both phases were used to refine the platform.

Data Analysis Techniques

The expert validation and pilot test data were analyzed using a four-point rating scale. The mean score for each assessed aspect was calculated and interpreted using the validation criteria adapted from Suryani et al. (2016). The validation criteria consist of four categories: 3.6–4.0 = highly valid and can be used without revision; 2.6–3.5 = valid and can be used with minor revisions; 1.6–2.5 = less valid and can be used after major revisions; and 1.0–1.5 = invalid, cannot yet be used, and requires further consultation.

RESULTS AND DISCUSSION

This study developed gamification-based learning media using Google Sites through expert review and one-to-one evaluation stages adapted from Tessmer's formative evaluation model. The development results indicate that the "Eco-Quest" media has an integrated structure, characterized by a homepage that provides access to the game start, teammates, and guidelines, as well as a Quest Zone comprising main, side, and bonus quests to support students' gradual engagement. Each quest includes a task description, a completion mechanism, and a Google Drive-based submission system that enables real-time activity monitoring. Overall, this medium not only demonstrates visual and interactive aspects but also incorporates a structured learning flow aligned with gamification principles and classroom implementation needs, as shown in Figure 2.

Figure 2. Development Of Google Sites As A Gamification Medium

As indicated by the media expert validation results for the Google Site presented in Table 3, the validation results show that the gamification-based Google Sites product "Eco-Quest" received a "valid" rating with an average score of 3.37. This study aligns with research by Laili et al. (2025) on "Google Sites Learning Media Development," which states that Google Sites-based media tend to have high feasibility due to ease of access and flexibility of use. However, this study not only confirms this

feasibility but also reveals variations in quality across aspects, particularly in the visual and instructional components.

The design and navigation aspects received a "highly valid" rating; this result indicates that the media meets the principles of usability and learnability—that is, the ease with which users can understand and operate the system. High scores on the indicators of design alignment with gamification objectives and navigation clarity (4.00) suggest that the quest structure and interaction flow have been systematically designed. This study aligns with Arrahma et al. (2024) Google Sites Innovation Study, which emphasizes that the primary strengths of Google Sites lie in its ease of navigation and integration of learning features. Furthermore, from a gamification perspective, a clear structure is crucial to enhancing user engagement by providing well-defined direction and objectives.

However, compared to previous studies that generally focused on in-class learning, the field-observation-based context of this study poses additional challenges. This is evident in the "design supports field observation" indicator, which scored only 3.33 (valid), suggesting that designs effective in classroom settings may not necessarily be adaptable to out-of-classroom conditions.

Regarding language and instruction, the scores were relatively lower, particularly for instruction clarity (3.00), indicating potential ambiguity in understanding the task flow. This study differs from the findings of Qona'ah et al. (2024), which generally reported that instructions were easy to understand. This difference can be explained by the complexity of the gamification design applied in this study. The use of a quest system (main, side, bonus) increases users' cognitive load because students must understand not only the content but also the game rules and the task-completion flow. In learning theory, this condition relates to cognitive load, where insufficiently clear instructions can increase extrinsic cognitive load and hinder understanding (Chastanti et al., 2024). Thus, the more complex the gamification structure, the greater the need for clarity and consistency in instructions.

The typography and color aspects, which received the lowest score (3.08), indicate that visual quality does not yet fully support the conditions for media use. This result does not fully align with Tiarani's (2024) Google Sites Media Analysis, which states that Google Sites' visual appearance is generally optimal. This discrepancy indicates that visual quality is context-dependent. In this study, the media was used for outdoor activities, making factors such as lighting, color contrast, and font size more critical than in classroom settings. Research by Atikah et al. (2025) confirms that low visual readability can disrupt focus and increase users' cognitive load, thereby impacting learning effectiveness.

Regarding the illustration and media aspects, the score falls within the valid category (3.50), indicating that the visuals used are relevant to biological objects but are not yet fully optimal in supporting contextual understanding. In biology education, visualizations serve as concrete representations that aid the process of observing and interpreting objects (Surata et al. 2024). Therefore, illustrations must not only be relevant but also capable of clarifying phenomena observed in the field.

Overall, compared to previous research, this study indicates that the validity of Google Sites as a learning medium is not uniform across all aspects. Its primary strengths lie in its design and navigation, which align with principles of usability and engagement, while its relative weaknesses are in visual elements and the clarity of instructions—factors that are significantly influenced by the context of use and the complexity of gamification. This research provides a theoretical contribution: the effectiveness of digital-based learning media is determined not only by the platform used but also by the alignment among design, implementation context, and the cognitive load experienced by users.

Table 3.
Results Of Media Expert Validation Of Google Sites

No	Indicator	Average	Category
Design & Navigation			
1	Design aligned with gamification goals & biology content	4.00	Highly valid
2	Clear and user-friendly menu navigation	4.00	Very valid
3	Compatible with laptops and smartphones	3.67	Very valid
4	Display supports field observation	3.33	Valid
5	Balance of visual elements	3.33	Valid
6	Hyperlink layout, data upload, barcode	3.33	Valid
Average		**3.61**	**Very valid**

No	Indicator	Average	Category
Language and Instruction			
7	Clear, effective, and communicative language	3.33	Valid
8	Easy-to-understand gamified mission instructions	3.00	Valid
9	Accurate use of biological terminology	3.67	Very valid
10	Readability level appropriate for students' abilities	3.33	Valid
11	Consistency of explanation format	3.00	Valid
Average		**3.27**	**Valid**
Illustration & Media			
12	Illustrations of biological objects	3.67	Highly valid
13	Visual clarity supports the interpretation of field observations	3.33	Valid
Average		**3.50**	**Valid**
Typography & Color			
14	Text is clearly legible outdoors	3.00	Valid
15	Harmonious color composition	3.33	Valid
16	Accuracy of font type & size	3.00	Valid
17	Neatness of spacing & paragraphs	3.00	Valid
average		**3.08**	**Valid**
Total Average		**3.37**	**Valid**

The findings presented in Table 3 indicate that the strongest aspect of the developed media lies in design and navigation. This suggests that students were able to access and operate the platform efficiently, which supports the usability principle in digital learning environments. According to Hallifax et al. (2023), clear progression systems and navigation structures are important components in gamification because they help users understand goals and maintain engagement. However, lower scores in typography and instructional clarity indicate that visual readability and information delivery remain critical challenges, especially in outdoor observation activities. This finding implies that effective gamification is not solely determined by game elements but also by how information is visually and cognitively presented. The display structure in the guideline indicates that the media serves not only as an information provider but also as a facilitator of systematic learning activities, as shown in Figure 3.

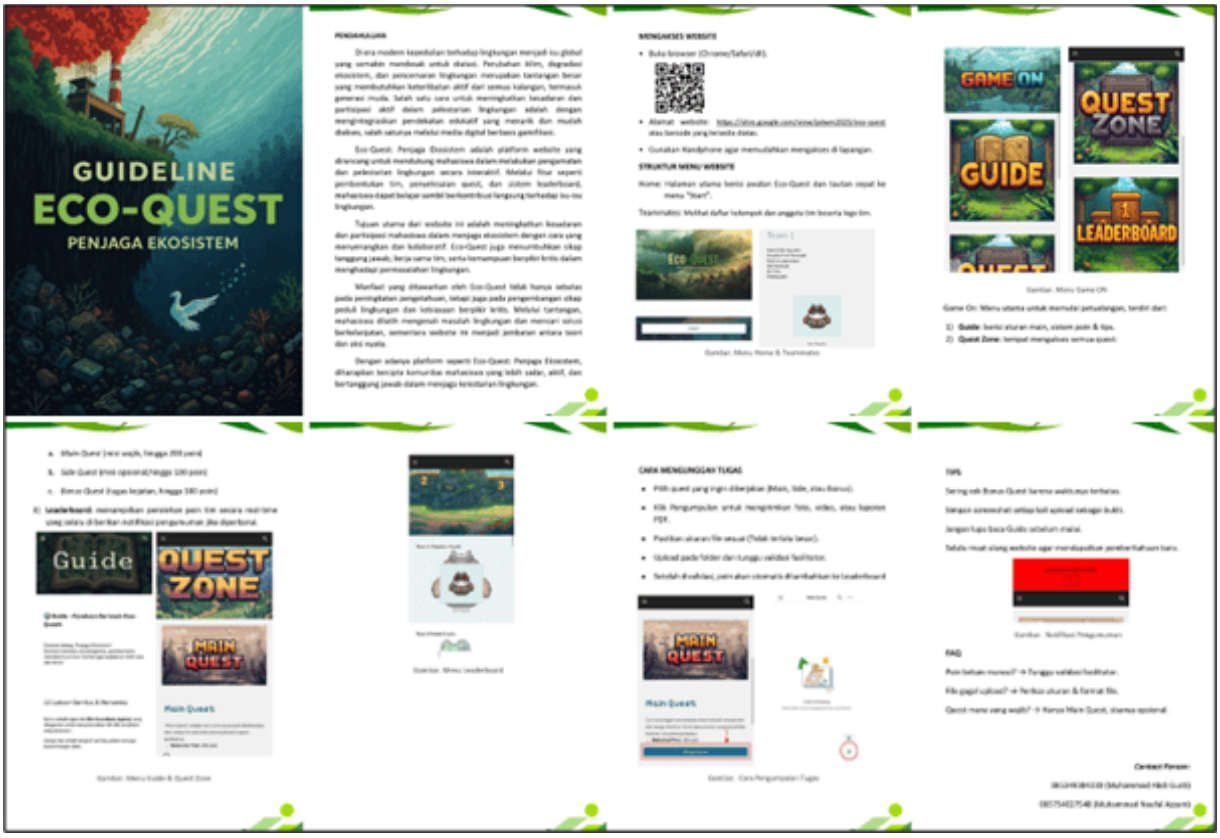

Figure 3. ECO-QUEST Guidelines for Using Google Sites

Based on the data presented in Table 4, the pilot test results for the gamification-based Google Sites system "Eco-Quest" indicate an average total score of 4.63, classified as "very good." This study indicates that the medium is not only valid in terms of design but also highly accepted and usable from users' perspectives. The high score on the indicator of recommendation for use in lectures (4.80) indicates that users consider this medium worthy of widespread implementation. This aligns with research by Laili et al. (2025), which found that *Google Sites-based* media can increase user interest and acceptance due to its flexible, easily accessible nature.

The results on functional aspects, as evidenced by indicators such as ease of locating the assignment submission page and increased interaction, indicate that the system has met usability principles, particularly in ease of navigation and clarity of system structure, with an average score of 4.70. This study aligns with Arrahma et al. (2024), who assert that the strength of Google Sites lies in its integrated features that facilitate users' access to and management of learning activities. From a digital learning design perspective, a user-friendly system reduces technical barriers, allowing learners to focus more on learning activities.

From a gamification perspective, high scores on gamification element indicators, with a challenge score averaging 4.70 and a more enjoyable experience score of 4.60 compared to traditional methods, indicate that the implementation of quest mechanisms can enhance user engagement. This aligns with the research by Hallifax et al. (2023), which confirms the concept of gamification stating that elements such as challenges, goals, and progression systems can increase learners' intrinsic motivation. Thus, the high scores in this aspect indicate that the gamification design in the media has aligned with its theoretical principles.

In terms of instructional aspects, the score on the clarity indicator for understanding the task flow (4.50) shows an improvement over the previous expert validation results. This indicates that the revisions made have successfully improved instructional clarity. In multimedia learning theory, the clarity of instructions and the structure of information play a crucial role in reducing users' cognitive load, thereby enhancing the effectiveness of information processing (Ceken & Taskin, 2022). Thus, the increase in scores in this area indicates that design improvements have positively impacted students' learning experiences. Furthermore, the increase in motivation and effectiveness compared to conventional methods suggests that the media not only enhances the learning experience but also influences learning behavior, consistent with the findings of Qona'ah et al. (2024).

The high practicality score in Table 4 indicates that the "Eco-Quest" platform effectively supported students' learning experiences during observation activities. The improvement in task flow clarity relative to the expert validation stage indicates that the revisions effectively reduced users' extraneous cognitive load. This aligns with multimedia learning theory, which emphasizes that clear instructional design enhances the efficiency of information processing (Ceken & Taskın, 2022). Furthermore, the positive responses toward gamification elements indicate that challenge-based learning can strengthen intrinsic motivation and encourage active participation.

Table 4.
Results Of The Google Sites System Trial

Evaluated Aspects	Average	Category
Alignment of Google Site's interface with requirements	4.60	Very good
Clarity of task flow	4.50	Very good
Ease of finding the assignment submission location	4.70	Very good
A more enjoyable experience than traditional methods	4.60	Very good
Motivates me to complete tasks on time	4.50	Very good
Gamification elements create challenges	4.70	Excellent
Google Sites enhances interaction	4.70	Very good
Effectiveness compared to conventional collection methods	4.60	Very good
Recommendation for use in lectures	4.80	Very good
Average	4.63	Very good

The results of the system evaluation, based on the checklist in Table 5, indicate that the components most helpful to users were the gamification and visual elements, each cited by 8 students, followed by page navigation and instruction clarity. Based on these data, this study demonstrates that integrating gamification elements and visual design plays a dominant role in supporting the learning

experience. This aligns with research by Zainuddin et al. (2020), which adds that gamification significantly increases student engagement and active participation in digital learning. Furthermore, effective visuals serve not only as aesthetic elements but also as cognitive tools that support understanding and information retention.

Regarding constraints, the majority of respondents (9 students) stated that the main obstacle was internet connectivity, and none found the interface confusing. This indicates that, in terms of design, the platform has met the principles of usability and ease of use. This study is supported by Hassan et al. (2021), who state that digital learning systems with clear navigation and a simple structure are more readily accepted by users. However, network constraints indicate that the success of web-based media implementation is determined not only by design quality but also by external factors such as technological infrastructure. Furthermore, only a small proportion of students felt unfamiliar with the system, indicating that the platform has a high level of learnability and is easily adaptable by new users. This aligns with research by Damayanti et al. (2020), which confirms that a positive user experience contributes to ease of use and satisfaction in digital learning.

Regarding workload, all respondents stated that the media were more helpful than conventional methods. These findings indicate that gamification systems do not increase the workload but rather support more effective task management. From the perspective of cognitive load theory, structured and interactive designs can reduce extrinsic cognitive load, thereby improving learning efficiency (Barret et al. 2021). Additionally, gamification can enhance self-regulation in learning through clear goal-setting and challenge systems. Overall, the checklist data indicate that integrating gamification, visualization, and ease of use increases engagement and enhances task management effectiveness. On the other hand, external factors such as internet connectivity continue to pose obstacles to implementation.

Table 5.
Results Of The Google Site System Trial Based On The Checklist

Evaluated Aspects	Section	Number of students
Most Helpful Section	Gamification system	8
	Visuals & interface	8
	Page navigation	5
	Clear instructions	5
Main issue	Internet connection	9
	Confusing interface	0
	Not very familiar	2
	No issues	1
Workload	More helpful	10
	Same	0
	Adds to the workload	0

Ideal biology education emphasizes active engagement through direct observation (Woods & Copur-Gencturk, 2024), scientific inquiry (Kotsis, 2024), and the use of digital technology (Otto et al., 2024) can be achieved through the integration of gamification design based on digital platforms (Jonas & Ogodo, 2025) that aligns with the principles of student centered learning. The “Eco-Quest” platform demonstrates that the integration of quest-based task structures, ease of navigation, and visual support facilitates students’ exploratory activities in real-world contexts, thereby strengthening contextual knowledge construction. Within the framework of constructivism and experiential learning theory, this interactive, challenge-based learning experience encourages students not only to receive information but also to construct understanding through direct interaction with biological objects and their surrounding environment (Lebert & Vilarroya, 2024; Schutte et al., 2025). Furthermore, from the perspective of cognitive load theory, the findings of this study indicate that the success of integrating digital technology into learning is determined not only by innovative features but also by a balance between design complexity, clarity of instructions, and the context of use to avoid excessive cognitive load. Thus, the importance of observation-based biology learning and digital technology lies not only in the use of the medium but also in the appropriateness of pedagogical design capable of optimizing student engagement, authentic learning experiences, and the effectiveness of information processing.

CONCLUSION

The findings of this study demonstrate that the gamified Google Sites platform "Eco-Quest" is valid and practical for use in observation-based biology education. The integration of gamification elements, visual navigation, and contextual observation activities successfully supported student engagement, interaction, and task management during field learning activities. These findings indicate that integrating digital platforms with direct observation can support more meaningful, student-centered learning experiences. However, internet connectivity remains a major challenge in implementation, indicating the need for further optimization of accessibility and infrastructure support. Future research is recommended to examine the platform's effectiveness on students' cognitive learning outcomes and its broader classroom implementation.

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