

Research Article

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Gamified Mobile-Based Learning Approach: Efforts to Improve Students' Engagement and Learning Quality in Remote Schools in Indonesia

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Abstract

Background/purpose. As a developing country with a wide area, Indonesia often experiences problems with equal access and quality of learning, specifically in remote schools. To overcome these challenges, several studies have proposed using gamified mobile-based learning as an effective alternative. Therefore, this study aims to explore students' responses, teachers' experiences, and the challenges faced by implementing gamified mobile-based learning in schools.

Materials/methods. The study procedures were conducted using a qualitative approach with focus group discussions comprising 12 teachers from 12 schools in 5 provinces in Indonesia. The data collected were then analysed using thematic analysis, which includes familiarisation with the data, initial coding, searching for themes, reviewing themes, defining and naming themes, and producing the final report or narrative.

Results. The results showed that teachers implementing the technology received enthusiastic, enjoyable, and more engaged students' responses. The teachers could also improve innovation and development as well as learning materials and media. However, technical and non-technical challenges were the main obstacles to implementing the approach. These results offer an alternative framework for teachers in implementing the approach in schools.

Conclusion. In conclusion, the important results showed that gamified mobile-based learning could provide an alternative to improving students responses and teachers teaching quality in schools located in remote areas of Indonesia. This study also highlighted the importance of gamified mobile-based learning in improving teachers' teaching quality. Teachers could improve learning innovation and development as well as learning materials and media.



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1. Introduction

Indonesia is a developing country that typically experiences problems with equal access and quality of learning, specifically in schools located in remote areas (Sakti et al., 2021; Supianto et al., 2023). In addition, the areas often experience limited access to technology, inadequate infrastructure, as well as shortages in the quantity and quality of teachers, with some experiencing a lack of internet or digital devices (Azhari & Fajri, 2022). These challenges cause the inability to adopt technology in learning process, which is important in the digital era. Therefore, one important step to improve equal access to quality education is to ensure that all schools, including those in remote areas, have adequate facilities and access to the necessary technology.

The use of gamified mobile-based learning is an alternative to overcome infrastructure limitations in remote schools (Yadav & Oyelere, 2021). The approach combines game elements, such as points, levels, challenges, and rewards, which can change the way students interact with materials, making the learning process more engaging (Gao et al., 2020; Liu et al., 2020). In remote schools, this approach can provide opportunities for students to learn in a more enjoyable and less monotonous way, which can improve the retention of information and skills. In addition, it potentially increases intrinsic motivation and encourages engagement in learning (Alvarez et al., 2022; Baars & Viberg, 2022; Wong et al., 2019). The integration of various game elements in the form of rewards, challenges, and feedback has the potential to increase students' enjoyment, interest, and motivation (Wang et al., 2023). However, several studies have shown that the implementation of the approach in remote schools often faces various obstacles, such as limited accessibility to educational resources, lack of support from learning environment (Karakose et al., 2022), limited infrastructure, low levels of digital literacy, and teachers' digital literacy competencies. Previous studies have also shown that there are no convincing results regarding the effectiveness of the approach.

Behnamnia et al. (2020) investigated the use of game elements in improving the experience of children aged 3-6 years. The results of a case study showed that the approach potentially influenced the ability of students to develop creative skills, critical thinking, digital experiences, and positive attitudes. Other studies have also reported that the use of the approach through mobile devices can serve as an alternative to overcome these challenges (Benzon et al., 2024). The approach combines the principles of self-directed learning with gamification elements to increase students engagement and motivation. Integrating mobile technology offers unprecedented opportunities to enhance independence and engagement (Zang & Shen, 2024). In the context of remote schools, it has the potential to offer a more engaging and effective experience, leveraging easily accessible mobile devices rather than traditional educational infrastructure. By integrating game mechanics, students are expected to be more active in managing and evaluating their learning process as well as more motivated to achieve the predetermined goals. Although some studies show the importance of self-regulated learning (SRL) in the context of game-based learning, integrating the two effectively remains a challenge (Zheng et al., 2024). The use of gamified mobile without the support of a well-designed environment causes students to lose focus on the content (Liu, 2022), leading to worse outcomes (Chen et al., 2024).

Previous studies have explored the potential of gamification by digital platforms in developing students' independence (Alhalafawy & Zaki, 2022; Zhang et al., 2020) and outcomes (Ferreira da Rocha et al., 2024). The results showed that the design and adoption of gamification applications could be effectively integrated by meeting certain criteria. These include a clear relationship between the game and curricular content, teaching design adjusted to personalized and differentiated learning paths, a good collaboration between teachers, students, and families, compliance with data protection and security, consideration of various levels of functional diversity (Vázquez-Cano et al., 2023), and alignment with students interests (Huang et al., 2023; Li et al., 2022). Although similar studies have been widely conducted, existing literature on the use of the approach that focuses on

the experiences and challenges faced by teachers in remote schools in developing countries remains limited. Therefore, this study aims to explore students' responses, teachers' experiences, and challenges faced in implementing gamified mobile-based learning in remote schools in Indonesia. By understanding the teachers' experiences in the field, this study is expected to provide deeper insights into its benefits, difficulties, and potential. Specifically, this study aims to 1) explore students' responses to the implementation of the gamified mobile-based learning approach, 2) investigate teachers' experiences in applying the gamified mobile-based learning approach, and 3) identify the challenges faced by teachers in implementing the gamified mobile-based learning approach. The results are expected to provide practical and strategic recommendations for the wider implementation of this approach as well as contribute to the development of digital-based models that can improve education quality in remote areas.

2. Methodology

2.1. Study type and approach

This study adopted a qualitative approach with focus group discussions (FGD) (Saarijärvi & Bratt, 2021). This approach allowed for a deeper understanding of the social phenomenon of teachers' experiences in implementing gamified mobile-based learning through group discussions, and a group of teachers from several schools was gathered to discuss. FGD allowed for obtaining diverse perspectives, deepening participants' views, and identifying certain patterns in their answers (Akyıldız & Ahmed, 2021). The discussion process was guided by investigators who played a role in ensuring that each participant could express their opinions but remained focused on the study objectives.

2.2. Participants

This study involved 12 participants from 5 provinces in Indonesia, including Yogyakarta, Central Java, Bali, East Java, and Lampung. Participants were selected using a purposive sampling technique with the following criteria 1) teachers at the elementary school level, 2) teaching science subjects in upper grades, 3) implementing gamified mobile-based learning, and 4) voluntarily involved in the study. Based on these criteria, 12 participants were finally found with the demographics shown in Table 1.

Table 1. Demographic information of participants

Site	Teachers Number	Pseudonym	Teachers certification	Teaching experience
Yogyakarta	T1	Latif	Not yet	0-5 years
	T2	Rofiana	Already	> 15 years
	T3	Ofelia	Not yet	0-5 years
	T4	Rita	Already	0-5 years
East Java	T5	Sofi	Already	> 15 years
	T6	Andika	Already	> 15 years
Central Java	T7	Ridwan	Not yet	0-5 years
	T8	Gusik	Already	10-15 years
Lampung	T9	Desna	Not yet	0-5 years
	T10	Hasanah	Not yet	0-5 years
Bali	T11	Angela	Already	0-5 years
	T12	Larasati	Not yet	0-5 years

2.3. Data collection and study instruments

Data collection was carried out through a group discussion forum, and participants were divided into 5 focus groups based on their region of origin. In addition, it was ensured that in each FGD session, participants had the same opportunity and freedom to share their experiences. The diversity of participants, both in terms of region of origin, gender, and teaching experience, was expected to enrich the data collected (Bauml et al., 2020). For the FGD to remain focused, a prepared study guideline was used, and this included open-ended questions designed to explore various teachers' experiences in implementing gamified mobile-based learning, as shown in the FGD questionnaire. Therefore, the guideline helped maintain the focus of the discussion while providing flexibility for participants to explore themes emerging naturally during the conversation. This was important to ensure that the data obtained was relevant and useful in answering the study questions (Creswell & Poth, 2016).

List of FGD questions:

1. Have you ever used a digital application or platform to teach science? If yes, how was your experience?
2. What do you think about the use of technology in science learning in grade 5?
3. In your opinion, what are the advantages and challenges of implementing technology in your class?
4. To what extent are your students actively engaged in science learning at this time?
5. In your opinion, are students independent enough to manage their learning time and understand the subject matter independently?
6. What are the difficulties you face in teaching science, specifically students engagement?
7. In your opinion, what features should be in an application that can help students regulate their learning?
8. Do you feel a need to develop more gamified learning methods? Why is that?
9. To what extent do you feel ready to use gamified applications or methods in teaching? What do you think is needed to support readiness?
10. What are your expectations for the implementation of gamified mobile SRL in science learning in elementary schools?
11. How do you think this approach can help students better understand and master science material?
12. How do you usually evaluate students' understanding and engagement in science learning?

2.4. Data analysis

This study used thematic data analysis techniques (Braun et al., 2017), which included familiarization with the data, initial coding, searching for themes, reviewing themes, defining and naming themes, and producing the final report or narrative. The analysis was carried out systematically, from transcription of FGD recordings to data coding to find emerging patterns. This thematic data analysis technique helped generate complex participant experiences and provided rich insights into the experience of implementing gamified-based learning and the challenges faced (Clarke & Braun, 2021). During the data analysis process, the primary and secondary investigators coded the data separately. Furthermore, to ensure that the codes and themes generated were valid, the study team held weekly discussions to discuss, compare, and investigate the investigators' analytical insights to increase the degree of trust in the results. Through this stage, 3 important

themes were found in answering the study questions, namely students' responses, teachers' teaching quality, and challenges in implementing the approach.

3. Results

The data analysis results showed 3 important themes, namely students' responses, teachers' teaching quality, and challenges, as shown in Table 3.

Table 3. Themes and sub-themes emerging during the analysis

Theme	Sub-theme	Code	Extract data
Students responses	Motivated and happy	Enthusiastic, exciting, happy, not easily bored, motivated	"Students are active, feel happy, and very excited during learning process." "The use of gamified makes students not get bored quickly in learning. Besides facilitating teachers, it also eases students in learning."
	Interaction and engagement	Active, interactive, asking lots of questions	"Learning is exciting and fun as well as students feel enthusiastic about following the material because they feel learning is fun."
Teachers teaching quality	Learning innovation and development	Enriching learning experiences, more innovative learning, more interactive teaching	"Using gamified mobile, my learning becomes more innovative, effective, varied, and stimulates students curiosity."
	Improving quality of learning materials and tools	Replacing the lack of learning aids, more concrete learning materials	"Due to the lack of teaching aids in our area, the use of technology through this platform is really effective and very helpful."
Challenges	Technical challenges	Geographical conditions, internet access	"Technology is very dependent on the availability of electricity. Power outages often occur here; hence, learning with the help of technology is hampered."
	Non-technical challenges	Students gadget literacy, teachers technology literacy	"The dependence of my students on their smartphones and relying too much on their devices can reduce basic skills such as reading, writing, and calculating manually."

3.1. Students responses

3.1.1. Motivated and happy

Based on interviews with participants, the use of technology in learning had a significant impact on the level of students' engagement. Furthermore, one of the main results from the interviews showed that the use of gamification applications increased overall students' enthusiasm. One participant (T1) reported, "By using game applications, children were more enthusiastic and their

outcomes had improved." This showed that gamification not only motivated students to be more active but also encouraged them to be more engaged in the learning process. Students became more motivated to learn because learning process became more exciting and fun. "Implementing gamification increased the interest and enthusiasm of my students; however, I felt challenged and interested in learning with exciting experiences" (T2).

Students felt happy and excited, as stated by a teachers, "Students were active, felt happy, and very excited." The use of technology allowed students to learn more interactively and engagingly. Another teacher(T3) added, "It helped my students understand complex concepts in a more interactive, engaging, and fun way." Based on the participants' statements, it could be concluded that the use of gamification in the classroom encouraged students to feel more engaged and consider learning not only as absorbing information but also a fun experience.

The use of gamification reduced boredom among students. For example, T9 stated, "With the use of technology, students also did not get bored quickly." Application-based learning provided variations and challenges that kept students interested and did not lose focus. This was also reinforced by the teachers (T12), who stated, "The use of gamification can make lessons more challenging, interesting, and interactive, and students tend to be more motivated to engage when using digital tools that are considered fun and interesting."

Various participant reports showed that its implementation could increase motivation and make students feel happy. With the use of interactive and fun applications, students were not only more motivated to learn but also more active in following the material, gamification functions to increase interest, reduce boredom, and create a fun experience for students.

3.1.2. Interaction and engagement

This approach could create a more active, interesting, and interactive atmosphere in the classroom. One of the main results showed that the use of gamification applications could make activities more active and interesting, and one of the teachers (T7) stated, "Learning becomes more active and interesting. Additionally, students find it easier to understand science material when using a digital platform." With this approach, students were more engaged because digital platforms provided various ways to access and learn materials, which were not limited to textbooks.

Gamification and the use of technology played an important role in increasing students' interaction with materials. For example, the use of VR to explore the solar system or visualize photosynthesis provided a more concrete and in-depth experience. One of the teachers, T3, said in an interview, "Virtual reality can be used to explore the solar system or to make the study of photosynthesis more concrete." This showed how technology could enrich learning experience and allow students to interact directly with material that could have previously been difficult to understand without visual aids.

The use of gamification applications allowed students to interact directly with the material and instructions given. A teacher (T6) added, "Learning videos and interactive/gamification applications to learn the 5 senses can make the class super active with direct interaction." This application allowed students to listen to the explanations of teachers and actively participate, either through questions or independent exploration through interactive features in the application.

Students showed a high level of engagement by frequently asking questions and requesting more examples related to learning material. For example, one teacher (T1) stated, "Students actively participated by asking lots of questions and requesting more examples of the material being taught." This showed that gamification and the use of technology encouraged students to participate more actively and not just passively follow instructions. Students were also more likely to ask for videos or films related to the subject matter because students felt that learning was more fun and varied.

Another teacher (T2) added, "They ask for videos/films related to the material being taught because they feel that learning is fun because they do not have to be stuck with books."

The interview results showed that the approach not only enriched learning experience but also encouraged students to be more active in participating, either by asking questions, requesting examples, or using the various features available. The use of this digital platform succeeded in creating a more lively, interesting, and interactive atmosphere, however, students felt more engaged and motivated to follow the material.

3.2. Teachers teaching quality

3.2.1. Learning innovation and development

Most participants showed that gamified mobile-based learning could help teachers innovate and develop activities in the classroom. One teacher explained, "I integrate learning videos, virtual reality, augmented reality, and interactive applications such as Quizizz, Kahoot, and Canva to present a more enjoyable and memorable experience." The use of various technologies showed innovation in a more creative approach, allowing students to learn more interestingly and interactively. Technologies such as video, VR, and AR helped students visualize concepts that could be difficult to understand through verbal explanations alone. Meanwhile, interactive applications such as Quizizz and Kahoot made the classroom more enjoyable and motivated students to participate more actively. Another teacher (T6) explained, "My experience using digital platforms in science is that it is very helpful in managing learning in the classroom and can increase students motivation." By using gamification applications, teachers could organize classes more efficiently, divide students into groups, and provided materials in a more structured and organized way. This allowed teachers to facilitate learning more easily and effectively while maintaining students' engagement.

The application of technology greatly helped teachers overcome the limitations of teaching aids in the classroom. A teacher (T12) explained, "The use of technology in science learning in my class helps me in teaching. Due to the lack of teaching aids, the use of technology through this platform is really effective and very helpful." In situations where physical teaching aids were limited, technology became a useful alternative. Digital platforms, such as gamification-based applications, provide various features that allow students to learn through simulations, games, and challenges that enrich their experience. Moreover, gamification improved quality, specifically in science subjects. A teacher (T10) emphasized, "Gamified is a useful tool to improve quality of science learning in my class. Using technology, students can learn more effectively, efficiently, and enjoyably." Learning supported by gamification made it easier for students to better understand the material in a fun and non-boring way. The use of this technology also helped prepare students for future challenges, where digital skills were increasingly important.

Gamified mobile-based learning not only increased students' engagement but also supported innovation and development. By using various digital platforms, teachers could create more enjoyable experiences, manage classes more effectively, and overcome the limitations of teaching aids. Additionally, this technology helped prepare students to face an increasingly digital and challenging world in the future. Gamification was a valuable tool for teachers in improving quality as well as designing more engaging and efficient experiences.

3.2.2. Improving quality of learning materials and tools

The application of gamified-based learning helped teachers deliver materials more engagingly and effectively. One teacher (T5) stated, "The use of technology in science learning is very much needed because it will greatly assist teachers in delivering materials and showing examples that cannot be showed/brought directly into the classroom." With the help of technology, specifically gamification-based applications and other digital media, teachers could deliver materials that were

difficult to explain conventionally. For example, the use of video, animation, or virtual reality allowed students to see concepts that could not be physically shown in class, such as the process of photosynthesis or the structure of a complex ecosystem. Technology also functioned as a substitute and complement to traditional teaching aids, specifically in subjects that required clearer visualization. Another teacher (T7) explained, "For students, the use of technology can increase their enthusiasm during learning." Using a gamification platform, students could interact directly with the material through challenges or simulations, which allowed a better understanding concepts more deeply and enjoyably. The use of this digital tool overcame the limitations of physical teaching aids, such as 3D models or experimental materials that were difficult to access or bring into the classroom.

The use of gamification in learning could create a more interactive classroom environment, allowing students to participate more actively. One teacher (T2) added, "I think it is quite good because it can create an interactive classroom environment, enable critical thinking in compiling and processing data, as well as increase insight in the use of technology with sufficient supervision." In this context, gamification applications not only functioned as a tool to deliver material but also encouraged students to think critically, compile data, and explore further information through interactive features. Students were encouraged to find answers, conduct studies, and make decisions based on available data, which improved the overall learning quality.

Based on the interview data analysis, it could be concluded that gamified mobile-based learning played an important role in improving quality of materials and teaching aids. Technology helped teachers deliver more varied and interactive materials, allowing the use of digital teaching aids that could be provided conventionally. Additionally, the use of technology, such as gamification-based applications, increased students' enthusiasm, making learning more interesting and effective. This also created a classroom environment that supported critical thinking and data processing, which enriched students' experiences. This technology, with proper supervision, could be a useful tool in improving the quality of teaching and enriching the classroom experience.

3.3. Challenges

The use of gamified mobile-based learning by teachers faced various technical and non-technical challenges. This included internet access and geographical conditions, while non-technical challenges included students' gadget literacy and teachers' technology literacy.

3.3.1. Technical challenges

3.3.1.1. Internet access

One of the main technical challenges in implementing gamified mobile-based learning approach was the limited access to adequate internet. In an interview, a respondent (T4) stated, "Inadequate network is a major problem. Many students have difficulty accessing materials because of unstable internet connections." Moreover, dependence on the availability of electricity was also a major obstacle. Another participant (T11) added, "Technology is very dependent on the availability of electricity, and power outages often occur here, hence learning with the help of technology is hampered." This made the situation worse because even though technology and learning applications were available, their use could not be maximized without the support of adequate facilities. As a result, the distribution of quality science learning through gamified approach was uneven, as expressed by a teacher (T7), "Our technology facilities are inadequate, making the implementation of quality science learning uneven."

3.3.1.2. Geographical conditions

The technical challenge in implementing gamified mobile-based learning was the less supportive geographical conditions. Based on an interview, a teacher (T6) said, "Our school needs supporting

facilities and infrastructure, but we do not have these facilities." This condition was exacerbated by the additional costs and long time to prepare technology-based learning, as expressed by another respondent (T8), "There are additional costs that should be incurred for the procurement of supporting devices and infrastructure as well as a long time for preparation." Subsequently, geographical environmental factors also worsened the implementation, where remote or difficult-to-reach locations made the distribution of technology facilities more difficult. A principal (T3) expressed, "These less supportive geographical, environmental conditions limit access to the technology and facilities needed, hampering the effectiveness of implementing gamified mobile-based learning."

3.3.2. Non-technical challenges

3.3.2.1. Students gadget literacy

One of the non-technical challenges in implementing gamified mobile-based learning was low students gadget literacy. In an interview, a teacher said, "However, it also has quite serious challenges, such as the dependence of my students on their smartphones and relying too much on their gadgets can reduce basic skills such as reading, writing, and calculating manually." (T7). This showed that although technology could enrich learning, supervision was still needed to ensure technology did not replace traditional methods. Another challenge faced was the need for supervision in the use of technology because it was feared that students focus could shift from learning itself. As conveyed by another teacher (T1), "The ability of my students to learn independently, including managing study time and understanding lesson materials, varies greatly depending on their cognitive development, individual skills, and most importantly, support from their parents." Previous experiences in class or at home greatly influenced the ability of students to use technology for learning. Additionally, another participant stated that "It is also important to have features connected to the devices of parents; hence, the activities carried out by students can be monitored."

3.3.2.2. Teachers technology literacy

The non-technical challenge in implementing gamified mobile-based learning approach was the low technology literacy among teachers. Based on interviews, several teachers expressed difficulties in keeping up with the ever-changing technology developments. One teacher (T1) said, "The challenge is that teachers should be up to date with existing technology to keep up with students who are currently very smart at accessing the convenience of existing technology." Moreover, there were complaints about the complexity of features in technology, which often confused teachers. For example, "Sometimes the many features confuse me; the simpler but more meaningful is the better." This reflected the need for more efforts to improve teachers' technology literacy; however, they could optimally use technology in learning. This was explained by another teacher (T2), "Because some technology literacy is low, teachers should learn how to use technology hence they can guide children better."

4. Discussion

This study aimed to explore teachers' experiences in implementing gamified mobile-based learning to improve teaching quality in remote schools in Indonesia. The results of the data analysis showed that 1) the application of this approach could increase students' responses to be motivated and enjoyable as well as increase engagement. 2) This approach also helped teachers improve learning innovation and development as well as materials and media. 3) Additionally, the application of this approach had technical and non-technical challenges, which included geographical conditions and internet access, while non-technical challenges included low student and teacher gadget literacy. These 3 results were discussed adequately in the next section.

The first result showed that gamified mobile-based learning could be an alternative to improving quality in remote schools, specifically in increasing students' motivation and enthusiasm. Participants explained that students felt motivated and happy in participating in the use of technology. The use of game elements provided a fun experience and stimulated students to be more enthusiastic (Lin, 2022). This success was seen in the increasing enthusiasm of students because the individual felt directly engaged in a more interactive and interesting learning process. Therefore, learning became more enjoyable compared to traditional methods. The study confirmed previous results on the contribution of the approach in increasing students' motivation. Pratama Putra Husmildin et al., 2020 showed that it could increase students' motivation from 65.16% before using the application to 82.08% after using it. The interactive features of game-based applications allowed students to enter a state of flow easily and increase their motivation to learn (Chen & Hsu, 2020). It has also been shown to improve outcomes in terms of metacognition, motivation, and behaviour (Nurdin et al., 2023).

Apart from motivating students, the approach played a role in increasing interaction and engagement. Students who previously felt less connected to the teaching materials could now participate more actively through the interactive features provided by mobile-based platforms. Through activities such as group challenges or games, students felt more engaged and interacted with each other in an atmosphere that supported collaboration (Fonseca et al., 2023; Hamari et al., 2016; Huizenga et al., 2019). With more intensive interaction and engagement, students could learn together while enjoying a more dynamic and enjoyable learning process (Aguiar-Castillo et al., 2021; Sanchez et al., 2020). This result also strengthened previous results that gamification design could increase students' engagement. Fan and Wang (2020) and Leung et al. (2023) provided special conditions in this case that this increase in engagement could only occur when the gamification design paid attention to students' styles and modalities. Mobile-based gamification design suits the user's learning style. Therefore, mobile gamification design could provide an effective experience when designed according to students' styles and modalities. In contrast, Wan et al. (2021) emphasized that the use of technology focused more on improving students' academic performance, not on a deeper learning experience.

The results showed that gamified mobile-based learning provided great opportunities for teachers to innovate in developing more interesting and effective learning. With a game-based approach, teachers can design experiences that not only deliver material but also encourage students' creativity and participation (Behnamnia et al., 2020; Coleman & Money, 2020; Hartt et al., 2020). The use of technology allowed teachers to use various interactive features that could be adjusted to class needs, hence making students more active in the learning process (Haleem et al., 2022; Hamilton, 2022). This reflected the importance of learning innovation and development that could change the way teachers teach (Istiningsih et al., 2020; Suyatno et al., 2023), adopt more modern methods, and follow the characteristics of students in remote areas. However, learning quality could be significantly improved.

The application of technology contributed to improving quality of materials and media, specifically for those with limited access to conventional resources. By using game-based applications, teachers could enrich teaching materials with various interactive media, such as animations, videos, and quizzes, which could clarify and enrich students understanding (Chen et al., 2021; Dahlan et al., 2023). Additionally, the use of digital media in learning allowed materials to be presented more interestingly, however making it easier for students to understand the concepts being taught (Clark & Mayer, 2023). In this context, teachers in remote areas could access and adapt materials of higher quality and appropriate to the needs of students, which ultimately increased the effectiveness of their teaching.

The results showed that although the technology offered many benefits in improving education quality in remote areas, technical challenges remained a major obstacle. One significant challenge was the geographical conditions and limited internet access in some remote areas. Most areas in Indonesia, specifically those located in remote areas, often face difficulties in obtaining a stable internet signal. This hindered the use of mobile-based applications that required an internet connection to run interactive features and access materials (Kondoro et al., 2023; Marini et al., 2022). Teachers and students in remote areas often find it difficult to optimize the use of technology due to these limitations, which certainly affected the effectiveness of the approach.

Apart from technical challenges, non-technical challenges were also very relevant in the context of remote areas, specifically related to students' gadget literacy and teachers' technology literacy. Most students in remote areas were not accustomed to using gadgets optimally for learning purposes; however, they tended to have difficulty in using gamified applications to learn effectively. This result confirmed (An et al., 2024) that students' technology literacy could help improve their ability to be more engaged. Meanwhile, many teachers also face challenges in terms of technology literacy; however, they could find it difficult to integrate technology into their teaching methods (Pambudi et al., 2024). Lack of training or understanding of how to use technology effectively could hinder better-quality teaching (Akram et al., 2022; Hennessy et al., 2022). Therefore, developing technology literacy capacity for students and teachers was necessary however, the implementation of gamified mobile-based learning could run smoothly and effectively.

5. Conclusion

In conclusion, the important results showed that gamified mobile-based learning could provide an alternative to improving students' responses and teachers' teaching quality in schools located in remote areas of Indonesia. Students respond enthusiastically, as evidenced by increased motivation and happiness in participating in learning. These individuals also felt more engaged and actively interacted in activities, showing that this approach succeeded in creating a more dynamic and enjoyable atmosphere. This study also highlighted the importance of gamified mobile-based learning in improving teachers' teaching quality. Teachers could improve learning innovation and development as well as learning materials and media. However, most teachers reported that in implementing gamified mobile-based learning, technical and non-technical obstacles were still experienced. Geographical conditions and internet access were the most common technical obstacles faced, while low students' gadget literacy and teachers' technology literacy were non-technical obstacles. As a precaution in concluding by subsequent investigators, this study had several limitations. First, the limited number of participants, namely only 12 teachers from several schools in Indonesia, meant the results could not be generalized widely for all teachers in Indonesia. Second, this study only covered the perspectives of teachers, without directly involving students or other stakeholders in the education system, who could provide deeper insights into the influence of gamified mobile-based learning on students. Third, the focus of this study was only on the implementation of gamified mobile-based learning in remote areas, which could have different contexts and challenges if implemented in areas with more developed infrastructure. Future studies were advised to expand the number of participants and involved students directly to get a more comprehensive picture of the effectiveness of gamified mobile-based learning. The study could also examine more deeply the solutions that could overcome technical challenges, such as developing applications that were more friendly to limited internet access and technology literacy. Additionally, further studies could focus on developing training programs to improve technology literacy for teachers and students; however, the approach could be applied more effectively in various conditions, including areas with limited access to technology.

Declarations

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