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THE USE OF GAMALAMA APP TO IMPROVE EARTHQUAKE DISASTER MITIGATION AWARENESS IN ISLAMIC JUNIOR HIGH SCHOOLS

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ABSTRACT
The integration of mobile-based gamification applications in education is crucial for enhancing student engagement and learning outcomes. This study analyzed the effectiveness of the GaMALaMA application, a mobile gamification tool, in improving students' earthquake disaster mitigation awareness (EDMA) in Islamic junior high schools. An experimental research design with a pretest-posttest control group approach was employed, involving 55 students from a state Madrasah Tsanawiyah (MTs) in Ternate City, Indonesia. The results showed a significant improvement in EDMA among students who used the GaMALaMA app in addition to science textbooks compared to those who used only textbooks. This improvement was attributed to the incorporation of game design elements, such as points, challenges, levels, time constraints, rules, and leaderboards, which stimulated student engagement and supported independent learning beyond the classroom. The experimental group showed a high level of EDMA improvement ($\langle g \rangle = 0.76$), while the control group showed a medium level ($\langle g \rangle = 0.64$). These findings suggest that mobile-based gamification can enhance science learning in Islamic junior high schools. The study highlights the importance of teacher and parent cooperation in supporting students' use of gamification apps for independent learning outside school hours.

Keywords: Disaster awareness education, Earthquake disaster mitigation awareness (EDMA), Gamification apps, Mobile-based gamification, Science Education

INTRODUCTION
The integration of gamification into Information and Communication Technology (ICT)-based learning has revolutionized student engagement by creating more interactive and enjoyable learning experiences (Arici & Yilmaz, 2023; Daramola, 2023; Bolaji & Adeoye, 2022). In recent decades, ICT tools such as animations, interactive simulations, mobile learning, and digital games have been widely recognized for enhancing science education (Bouasangthong et al., 2024; Bolaji & Ajia, 2023; Srisawasdi & Kroothkeaw, 2014). These technologies have enabled more flexible and accessible learning opportunities, bridging geographical and temporal barriers, which is particularly crucial in subjects like science that often require practical, hands-on engagement (Dwiana et al., 2022; Ben Ouhai et al., 2022; Bolaji & Onikoyi, 2024). The widespread adoption of these tools has not only been shown to improve conceptual understanding but also foster student motivation and engagement, facilitating a deeper connection to learning material (Akinoso, 2023; Bolaji & Jimoh, 2023; Wanjara & Ogembo, 2024; Saprudin et al., 2023).

In Indonesia, the use of ICT in science education faces challenges, including students' disengagement from learning applications (Ningrum et al., 2021; Saprudin et al., 2023). This issue is especially evident in regions prone to natural disasters, such as North Maluku, where earthquake awareness is critical (Watkinson & Hall, 2017). Despite these challenges, recent

studies indicate that the use of ICT can significantly improve student participation and learning outcomes in science subjects (Saprudin et al., 2021; Sigit et al., 2022). However, the full potential of these digital tools has yet to be realized in disaster-prone areas, particularly with regard to earthquake disaster mitigation awareness (EDMA), which remains a neglected aspect of the curriculum (Saprudin et al., 2024; Gunada et al., 2020). The integration of gamified learning experiences in these regions could prove to be a viable solution for addressing this gap, offering a more engaging and region-specific learning experience for students (Ningrum et al., 2019; Saprudin et al., 2021).

Previous studies have extensively explored the impact of gamification on student motivation, engagement, and learning outcomes in science education (Chans & Portuguez, 2021; Gordon et al., 2013; Mekler et al., 2017; Alfaqiri et al., 2022; Campillo-Ferrer et al., 2020; Pesare et al., 2016; Wang et al., 2017). However, there remains a lack of research on how gamification can be leveraged to enhance students' awareness of disaster mitigation, particularly in the context of earthquakes. While gamification has been shown to improve student engagement and learning outcomes, its application in the context of disaster education is still underexplored (Abramovich et al., 2013; Kyewski & Krämer, 2018; Al-Hafdi & Alhalafawy, 2024). This study fills this gap by investigating the effectiveness of the GaMALaMA mobile application, a gamified tool, in improving earthquake disaster mitigation awareness among Islamic junior high school students in North Maluku. The research specifically analyzes the impact of the app in complementing traditional science textbooks and how it can be integrated with region-specific disaster knowledge.

METHOD

This research employed an experimental method with a pretest-posttest control group design, as detailed by Susilawati et al. (2025). The study involved two groups: the experimental group, which used science textbooks complemented with the GaMALaMA app, and the control group, which used only science textbooks. Both groups participated in pre-tests (O1, O3) before learning and post-tests (O2, O4) after learning. A total of 55 grade VIII students from a Madrasah Tsanawiyah (MTs) in Ternate City, Indonesia, were randomly selected and divided into two groups. The experimental group consisted of 27 students (14 male, 13 female), and the control group consisted of 28 students (15 male, 13 female). The earthquake learning program, delivered via the science textbooks and GaMALaMA app, was implemented using a blended learning approach over two weeks with four face-to-face meetings. Students' earthquake disaster mitigation awareness (EDMA) was assessed through a multiple-choice instrument containing 36 pre-tested questions. To evaluate the increase in EDMA, the normalized gain was calculated, as suggested by Hake (1998). The statistical analysis method used to process the results is described further by Fiandini et al. (2024), Rahayu et al. (2024), and Afifah et al. (2022).

The earthquake learning program in this study was designed using a blended learning approach, which combined both offline (face-to-face) and online learning experiences, as shown in Table 1. The program spanned two weeks and involved four face-to-face meetings, where students engaged with both science textbooks and the GaMALaMA app. The students were guided through various levels of learning content structured to increase their earthquake disaster mitigation awareness (EDMA). Data on students' EDMA were collected through a multiple-choice test consisting of 36 questions, which had been pre-tested for reliability. The normalized gain was calculated to measure the increase in EDMA, following the method described by Hake (1998).

Table 1. The Earthquake Learning Program Complemented with GaMALaMA App

Week	Meeting	Offline (Face-to-Face)	Online
I	1	● Pre-test ● Learning mechanisms through science textbooks complemented with GaMALaMA app ● Discussion Levels 1	Level 1, Level 2, Level 3, Level 4, Level 5, Evaluation (can be selected according to student preference)
	2	Discussion Levels 2 and 3	
II	3	Discussion Levels 4 and 5	
	4	Post-test	

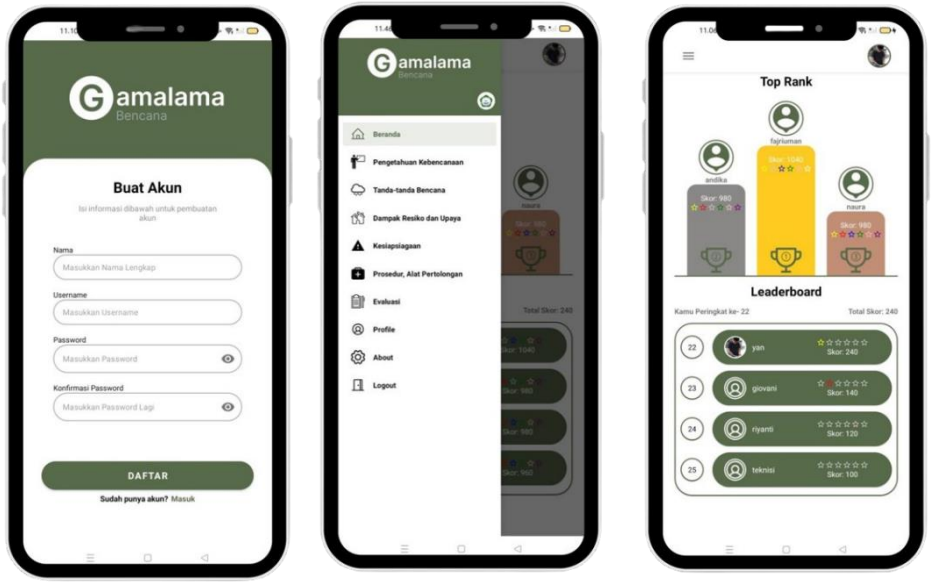
The program was structured to offer a progressive learning experience, with each meeting building on the previous one to reinforce the students' understanding of earthquake disaster mitigation. By the end of the program, students were expected to demonstrate an improved awareness of the topic, as measured by the post-test results. This blended learning model allowed for flexibility and personalized learning while ensuring comprehensive coverage of the material through both online and offline methods. The statistical analysis of the pre-and post-test data was used to assess the learning program's effectiveness in improving EDMA.

RESULTS AND DISCUSSION

Description of GaMALaMA App

The GaMALaMA app, named after an active volcano in Ternate City, North Maluku, is designed to present earthquake-related learning materials through a gamified approach. Inspired by the region's vulnerability to volcanic earthquakes, the app incorporates game-like elements, with levels that students must pass to engage with the content. The app presents material on five subtopics across five levels, each with an associated quiz to test knowledge. These subtopics include disaster knowledge (Level 1), disaster signs (Level 2), risk impacts and mitigation (Level 3), preparedness (Level 4), and first aid procedures for victims (Level 5). The app also features an evaluation section containing 30 multiple-choice questions to assess students' understanding of the entire material. Students are rewarded with stars based on their performance in each level and the evaluation, with each level offering a maximum of 120 points and the evaluation allowing up to 600 points.

Key features of the GaMALaMA app include registration options, where students can create an account and recover passwords; a profile page that displays the student's information and star rewards earned; and material presentation, which integrates text, images, sound, animation, and video to enhance learning. The app also includes a quiz function, which allows students to retake quizzes multiple times to improve their scores. A leaderboard ranks the top three students based on their points and time, while the achievement page provides an overview of all students' performance. The app's design encourages both mastery learning and remedial teaching, ensuring that students can revisit and improve their understanding of earthquake-related topics.



(a) **(b)** **(c)**

Figure 1. The Interface of the GaMALaMA App; (a) Registration Feature, (B) List of The Earthquake Topic Materials, (C) Leaderboard Feature

Validation Result of GaMALaMA App

The validation results of the GaMALaMA apps, presented in Table 2, were conducted by experts in various fields, including media, science content, language, and pedagogy. According to media experts, the app received very valid ratings across all three validation aspects, indicating high user satisfaction and effective overall functionality. The usability aspect, in particular, received excellent feedback, with scores above 80% in all areas, signifying very valid overall quality. Similarly, the validation by science content experts demonstrated very valid ratings for all five aspects, with a percentage above 80%, which indicates the high quality of the material and its presentation. The language experts rated the app highly, with a score above 85%, particularly emphasizing the accuracy of language use, making it suitable for the target audience. The pedagogical expert validation also indicated very valid results, with the highest score in the application of the gamification concept (92%) and the lowest score in the application of meaningful learning theory (80%).

The overall results from the validation process reveal that the GaMALaMA application demonstrates a high level of feasibility for integration into science education, particularly in delivering content related to earthquake phenomena. This strong feasibility is evident in both the technical functionality of the app and its pedagogical compatibility with science learning objectives. Expert evaluations further substantiate the app's relevance and effectiveness for educational settings, emphasizing its alignment with current curriculum standards and instructional best practices. These evaluations underscore that the GaMALaMA app is not only suitable for classroom use but also holds considerable promise in transforming the traditional science learning experience.

By incorporating gamification strategies—such as interactive challenges, point systems, and scenario-based simulations—the app actively engages students in the learning process. This engagement is critical in subjects like earth science, where abstract and complex concepts often pose difficulties for learners. The app's design encourages exploration, critical thinking, and problem-solving, thereby facilitating a deeper understanding of seismic activity and its real-world implications. Furthermore, the use of game-based learning elements helps maintain

student interest, increase motivation, and promote sustained interaction with the subject matter. In sum, the GaMALaMA app serves as an innovative educational tool that not only supports the acquisition of scientific knowledge but also fosters meaningful and enjoyable learning experiences for students.

Table 2. The expert validation results

Expert	Validation aspect	Percentage (%)	Average (%)
Media expert	Usability	92	
	Information quality	88	88
	Service interaction quality	85	
Content	Material description suitability	89	
expert	Material accuracy	86	
	Material sophistication	84	87
	Presentation techniques	87	
	Presentation supports	87	
Language	Language use accuracy	90	
expert	Communicativeness	88	89
	Suitability with student development	88	
Pedagogic	Learning material presentation strategy	86	
expert	Applying Meaningful Learning Theory	80	
	Applying Mastery Learning Theory	88	87
	Applying remedial learning	88	
	Applying gamification concepts	92	

The Effectiveness of The GaMALaMA App in Improving Students' EDMA

The statistical test results in Table 3 indicate that the data on students' Earthquake Disaster Mitigation Awareness (EDMA) improvement in both the experimental and control groups are normally distributed and homogeneous. Overall, the increase in EDMA was significantly greater in the experimental group compared to the control group. The experimental group's improvement was categorized as high, with a normalized gain of 0.76, while the control group showed a medium increase, with a normalized gain of 0.64. These findings suggest that the GaMALaMA app, when used as a complement to science textbooks, has a substantial impact on students' EDMA.

Table 3. Statistical test results of normalized gain

Description	Group	
	Experiment	Control
Average $\langle g \rangle$	0.760	0.640
Standard Deviation	0.581	0.073
Normality Test *One-Sample Kolmogorov-Smirnov Test (Sig.)*	0.923	0.843
Homogeneity Test *Test of Homogeneity of Variances (Sig.)*	0.093	
T-test *Independent Samples Test*	Sig. 0.000 t_{count} = 57.115	
Effect Size	0.300 (small)	

Although the effect size is categorized as small, this study identified the impact of using GaMALaMA app as a complementary tool to science textbooks in the experimental group. The small effect size can be attributed to the mobile phone usage policy at the research site, which restricts students from using their phones during school hours, limiting their interaction with the GaMALaMA app. However, the app was also designed for independent learning, allowing students to interact with it outside of school hours. The teacher's limited control outside of school hours, through reminders via WhatsApp, presents a limitation of this study. Future research could address this by encouraging collaboration with parents to ensure students are adequately supported while using the app outside of school.

It is important to highlight the improvement in students' EDMA across various indicators. The study assessed five key areas of EDMA, including Disaster Knowledge (DK), Disaster Signs (DS), Risk and Damage (RD), Preparedness (PP), and First Aid and Procedures (PE). Each indicator was measured for both the experimental group, which used the GaMALaMA app in conjunction with science textbooks, and the control group, which used only the science textbooks. Figure 2 illustrates the normalized gain in EDMA for both groups, showing a comparative increase in the experimental group across all indicators.

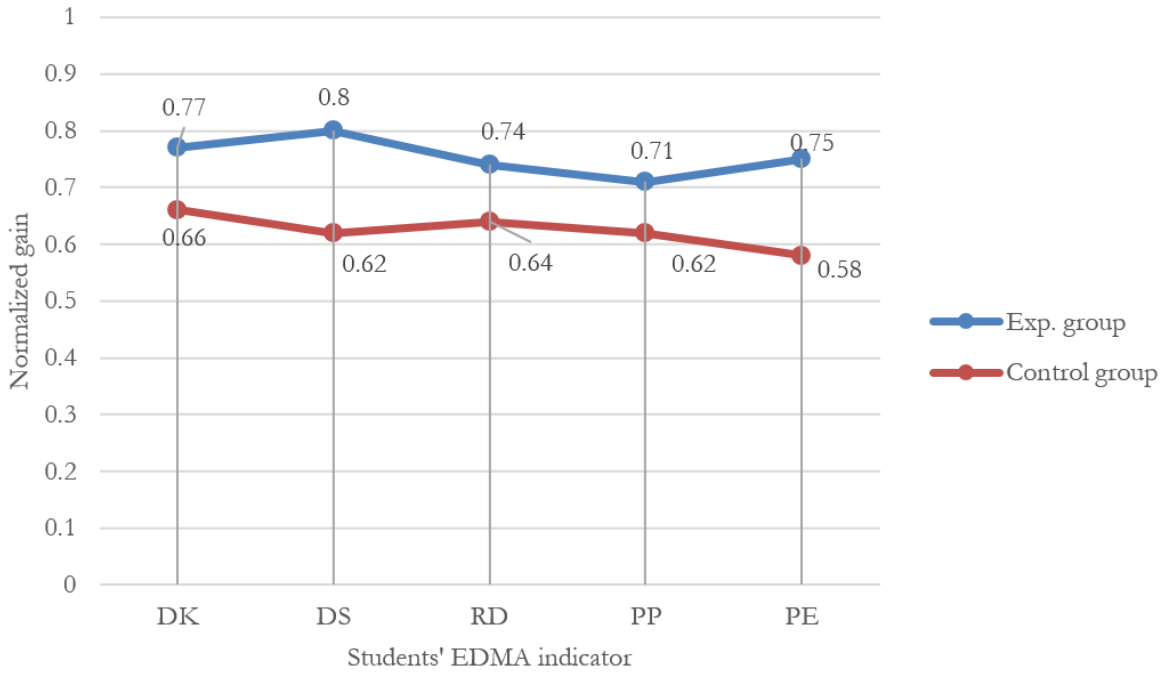


Figure 2. Students' EDMA for each indicator

The data presented in Figure 2 shows that students' EDMA increased across all indicators, including DK, DS, RD, PP, and PE. The DK indicator, which assessed students' ability to explain the basic concepts of earthquakes, differentiate between tectonic and volcanic earthquakes, and identify the causes and impacts of tectonic earthquakes, showed a higher increase in the experimental group than the control group. The increase in the experimental group was categorized as high (0.76), while the control group experienced a medium increase (0.64). The experimental group demonstrated a stronger understanding of earthquake-related concepts, particularly in identifying earthquake sources in Ternate and explaining earthquake recording instruments.

For the DS indicator, which required students to identify signs of active tectonic plates and natural phenomena indicative of volcanic earthquakes, the experimental group showed a significant improvement, with a high score of 0.80. In contrast, the control group showed a medium increase with a score of 0.62. Similarly, for the RD indicator, students were required to explain factors affecting earthquake damage, seismic vulnerability, and risk reduction efforts. The experimental group achieved a high increase (0.74) compared to the medium increase (0.64) in the control group. These results suggest that the GaMALaMA app contributed to a more substantial understanding of earthquake risks and mitigation strategies in the experimental group.

The PP indicator, which focused on disaster management activities, earthquake preparedness, and knowledge of evacuation routes, saw a high increase in the experimental group (0.71), while the control group showed a medium increase (0.62). Lastly, the PE indicator, assessing students' knowledge of the Early Warning System (EWS), rescue measures, and first aid tools during earthquakes, also demonstrated a higher increase in the experimental group (0.75) compared to the control group (0.58). These findings highlight the effectiveness of using the GaMALaMA app in enhancing students' EDMA across all relevant earthquake-related indicators.

Based on the findings of this research, there are several points to discuss. This study introduces several novel aspects to the field of ICT-based education (Hew et al., 2016; Hursen & Bas, 2019; Owen & Licorish, 2020). First, it integrates gamification into earthquake learning programs tailored to the specific disaster context of North Maluku, a region prone to frequent earthquakes (Ningrum et al., 2020; Lessy & Ningrum, 2020; Ningrum et al., 2024). Second, this study empirically validates the use of the GaMALaMA app, providing quantitative evidence of its effectiveness in improving EDMA among students (Saprudin et al., 2019; Reyes et al., 2024). The unique design of the app incorporates local research on seismic vulnerability (Charlton, 2000), making the learning experience more relevant and engaging for students (Alnaser & Forawi, 2024; Ros-Morente et al., 2018). The combination of these elements provides a fresh perspective on using gamified learning tools in disaster mitigation education, particularly in the context of Islamic junior high schools, which has not been explored in previous research. The primary objective of this research is to evaluate the effectiveness of the GaMALaMA app in improving earthquake disaster mitigation awareness (EDMA) among Islamic junior high school students in North Maluku, and this can be expanded for their teachers (Ibarrientos, 2024; Odefunsho et al.,2023).

By comparing the results of students who use the GaMALaMA app alongside science textbooks with those who use only traditional learning resources, this study provides empirical evidence of the app's impact on student learning outcomes (Beichumila et al., 2022; Chen et al., 2024). This research also explores the role of gamification in making science learning more engaging and contextually relevant, fostering a deeper understanding of disaster preparedness and response among Islamic junior high school students in earthquake-prone areas (Karmaker & Rahman, 2024).

The GaMALaMA app, as a complementary tool to science textbooks, facilitates independent learning outside of school hours (Huang, 2019; Karatay et al., 2024). This application removes the constraints of time and space, allowing students to continue their learning experience at their own pace (Khan et al., 2017). The app's design, including interactive elements such as points, challenges, and levels, significantly enhances student engagement (Borrás-Gené et al., 2019; Poondej & Lerdpornkulrat, 2016; Othman & Ching, 2024; Pesare et al., 2016). By offering an immersive learning experience, the app has helped students remain committed to learning, thus improving their knowledge and fostering positive behavioral changes in disaster preparedness (Saprudin et al., 2024; Suryana et al., 2020). Previous research

supports these findings, demonstrating that gamification in education can lead to significant improvements in students' knowledge (Kaya & Ercag, 2023; Casanoves et al., 2023), particularly in fields such as disaster preparedness (Pitchay et al., 2024; Bai et al., 2024; Liu et al., 2022). The positive impact on students' EDMA reflects the effectiveness of using gamified approaches in educational settings (Dong et al., 2024; Hidayat & Wardat, 2024).

A key feature of the GaMALaMA app is its ability to allow students to repeat study materials, quizzes, and evaluations, providing them with the flexibility to revisit content until they achieve mastery. This feature encourages students to engage with the app more consistently and deeply, increasing the likelihood of knowledge retention (Lampropoulos & Sidiropoulos, 2024; Makinde et al., 2023). The inclusion of a leaderboard within the app adds an element of competition, which has been shown to motivate students to improve their performance (Parody et al., 2022; Ortiz-Rojas et al., 2019). This competitive element encourages students to strive for higher scores, which aligns with research that indicates gamification increases students' motivation to perform well and complete learning tasks (Rose et al., 2016; Pesare et al., 2016), particularly in science education (Beltozar-Clemente et al., 2022; Rizal et al., 2023). Moreover, as a complement to traditional textbooks, the GaMALaMA app supports independent online learning, enabling students to stay motivated and engaged in learning even outside school hours, resulting in better overall learning outcomes (Barata et al., 2015; Shah, 2022).

The results of this research demonstrate the effectiveness of gamification in enhancing students' EDMA. According to Gamification Theory, incorporating game elements such as points, levels, challenges, and leaderboards into the learning process can significantly increase student engagement and motivation, which in turn enhances learning outcomes (Deterding et al., 2011; Anderson et al., 2015; Arciosa, 2022). In this study, the GaMALaMA app utilized these gamification features (Kaeophanuek & Chaisriya, 2022; Pradana et al., 2023), leading to higher engagement levels in the experimental group compared to the control group, as evidenced by the substantial improvement in EDMA scores (Nurtanto et al., 2021). The app's ability to foster active learning and provide instant feedback through quizzes and evaluations aligns with the core principles of Gamification Theory, which posits that such interactive elements not only boost engagement but also support mastery learning (Mekler et al., 2017; Kyewski & Krämer, 2018). As students interacted with the app outside of school hours (Sailer & Sailer, 2021)., the gamified structure encouraged continuous learning, reinforcing the idea that motivation driven by game mechanics can lead to significant improvements in disaster preparedness knowledge (Chen et al., 2015). These findings confirm the potential of gamification as an effective tool for increasing both engagement and learning outcomes in educational contexts (Lutfi & Hidayah, 2021; Campos-Pajuelo et al., 2022; Okariz et al., 2023). Particularly in enhancing awareness of real-world issues such as earthquake preparedness (Nasmirayanti et al., 2022).

The technological ease of the GaMALaMA app also contributes significantly to its success, as students find it easy to navigate and interact with the content (VanUitert et al., 2024; Rahman et al., 2018). This seamless integration of technology and learning encourages continued student engagement and interaction with the application (Chen et al., 2015; Mukagihana., et al., 2021; Nirina et al., 2024). The findings of this study add to the growing body of knowledge on the effectiveness of technology-assisted learning tools in enhancing educational outcomes (Ouahi et al., 2024), particularly in the context of religious education, which has been well-studies, documented in recent research (Sulyman et al., 2024; Sumarna & Gunawan, 2024; Daud, 2024; Karmaker & Rahman, 2024; Ahillon et al., 2024; Ayub, 2021; Sanni, 2023). This study extends these findings by demonstrating the potential of gamified mobile applications, like GaMALaMA, to effectively improve Islamic school students' EDMA in science education, offering valuable insights for future educational practices and research (Adnan, 2022; Ürek, 2024; Wardiana, 2024).

CONCLUSION

The GaMALaMA app has been developed as a complementary tool to science textbooks in Islamic junior high schools, particularly for teaching about earthquakes. By incorporating game elements such as points, challenges, levels, time, rules, and leaderboards, the app has significantly enhanced student engagement, leading to improved Earthquake Disaster Mitigation Awareness (EDMA). Students who used the GaMALaMA app alongside their textbooks showed a notable improvement in EDMA compared to those who only used the textbooks. This study underscores the critical importance of collaboration between teachers and parents to support students' independent learning outside school hours, particularly at home. Teachers play a pivotal role in developing and aligning mobile-based gamification tools with the curriculum, while parents are essential in overseeing, motivating, and assisting students in their learning activities. With strong cooperation between both parties, students are more likely to stay focused, develop independent learning skills, and achieve optimal academic outcomes.

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