SiAGA: Empowering Primary School Students in Wetland Areas with Technology and Meaningful Learning for Flood Mitigation

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ABSTRACT
SiAGA Empowering Primary School Students in Wetland Areas with Technology and Meaningful Learning for Flood Mitigation. Objectives: This study evaluates the effectiveness of the SiAGA application in enhancing flood disaster mitigation learning at the primary school level, using a meaningful learning approach. The application aims to help students understand and apply flood disaster knowledge through gamification, educational videos, and collaborative projects. Methods: A Research and Development approach with the ADDIE model. The subjects consisted of 150 students from three primary schools in Banjarmasin. Data were collected through questionnaires, comprehension tests, observations, and interviews, and analyzed using Independent Samples t-test. Findings: The findings of this study indicate that SiAGA application experienced significant improvements in the aspects of Relevance (N-gain= 0.53), Understanding (N-gain= 0.59), Retention (N-gain = 0.71), and Application (N-gain= 0.63) compared to the control group. The t-test results showed a t-value of 3.25 for Relevance ($p = 0.002$), 4.10 for Understanding ($p= 0.000$), 5.20 for Retention ($p= 0.000$), and 4.85 for Application ($p= 0.000$), indicating significant differences between the two groups across all measured aspects ($p < 0.05$) Conclusion: Technology-based solution is relevant to local conditions in disaster-prone areas and can significantly enhance meaningful learning in primary schools, helping students connect the material to their real-life experiences and apply it in real-world situations.

Keywords: SiAGA, Flood Disaster Mitigation, Technology, Meaningful Learning.

1. INTRODUCTION

Banjarmasin, located in a lowland area and surrounded by many rivers and canals, faces significant challenges every time the rainy season arrives. According to data from the Regional Disaster Management Agency, it is recorded that nearly every year several districts in the city experience flooding. In January 2025, 41 elementary schools in Banjarmasin were affected by floods, spread across several districts, including South Banjarmasin, East Banjarmasin, and North Banjarmasin [1]. This indicates that flood disasters not only threaten the environment but also disrupt teaching and learning activities in these schools.

Frequent flooding causes damage to school infrastructure, disrupts the learning schedule, and creates uncertainty for students in their education. In some cases, learning activities must be temporarily halted due to flooded schools or disrupted access to schools. The greater impact of this disaster is the lack of understanding and preparedness among students regarding flood disaster mitigation, which can reduce their ability to face emergency situations in the future [2,3].

In addressing this issue, it is essential for elementary school students to be provided with learning that is not only theoretical but also based on real-life experiences relevant to their local conditions. Flood disaster education needs to be taught in a meaningful way so that students can understand the causes, impacts, and mitigation steps they can take [4,5]. Meaningful learning refers to learning that connects taught materials to students' personal experiences, enabling them to understand and apply the knowledge in everyday life. Therefore, it is crucial to introduce flood disaster education early on in elementary schools so that students gain the knowledge and skills to face potential disasters in their surroundings [6].

Elementary school is a critical stage in shaping students' foundational knowledge and character. At this age, students are in a phase of rapid cognitive and social development, where they begin to link knowledge with real-life experiences. Therefore, education should be relevant to their lives and activate critical thinking and problem-solving skills. Meaningful learning is an educational approach that emphasizes connecting new knowledge with

existing knowledge or experiences that students already have. Meaningful learning helps students not only memorize information but also understand and apply it in real-world situations. In the context of flood disasters, students who learn meaningfully will be able to link their knowledge of disasters to concrete actions they can take to reduce risks or impacts [7].

Project-based learning is one effective way to implement meaningful learning in elementary schools. With this approach, students are actively involved in real projects relevant to their lives, such as designing flood mitigation systems for their local environment [8]. This project-based learning approach will increase student engagement, build collaboration skills, and develop critical thinking abilities, which are important for facing real-world challenges. However, despite its importance, the implementation of disaster-based learning in elementary schools is still very limited. Many schools lack the modules or resources needed to teach students about disasters, particularly flood disasters that are relevant to their geographical conditions.

As a profound concept, meaningful learning is not just about making students remember information. According to the theory of deep learning, this concept relates to students' ability to absorb, understand, and apply information in depth. Deep learning focuses on learning that goes beyond mere memorization or superficial acceptance of information, and instead emphasizes a comprehensive understanding of concepts and the ability to connect that information in various contexts.

Meaningful learning is an essential component of deep learning, where students not only understand the material but also relate and apply it to various real-life situations. Meaningful learning not only creates deep cognitive understanding but also enhances students' critical thinking and creativity. In the context of flood disasters, this means that students not only know what to do during a flood but also understand why those actions are important and how to apply them in real life. This is the essence of deep learning-based education, which allows students to internalize the material more effectively and act based on profound understanding [9].

To address this issue, the SiAGA (Adaptive, Cooperative, and Active Students) application was developed as a solution to provide meaningful flood disaster learning through technology for elementary students in Banjarmasin. SiAGA is designed with a learning by doing approach, where students can actively learn through interactive features such as gamification, educational videos, and collaboration-based projects. This application allows students to understand disaster concepts in a fun and easy-to-understand way while connecting them to real-life situations they face in flood-prone areas.

SiAGA provides real-life examples of flood mitigation as an implementation of meaningful learning, directly linked to students' lives. The features in this application not only present theories about floods and mitigation measures but also offer students the opportunity to practice that knowledge through simulations, games, and group-based projects. For example, in the gamification module, students are presented with challenges related to flood disasters, and they must choose the appropriate mitigation actions to minimize the impact. Additionally, the educational videos in this application showcase real flood mitigation efforts carried out by the community in Banjarmasin, such as the construction of canals and installation of water pumps, helping students see how the knowledge they learn is applied in a local context.

By integrating meaningful learning in the SiAGA application, students can learn in a way that is not only informative but also practical and contextual. This allows them to truly understand the impacts of disasters and be better prepared to face them, both personally and as part of their community. Thus, SiAGA not only provides meaningful learning but also equips students with practical skills that they can apply in everyday life.

2. METHOD

This study uses a Research and Development (R&D) approach with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) to develop and test the SiAGA application in flood disaster learning at the primary school level. The ADDIE model was chosen because it allows for systematic development of the application based on real field needs, thus producing effective solutions in education, particularly for flood disaster mitigation learning in disaster-prone areas such as Banjarmasin. Each stage of the ADDIE model is implemented to ensure that the developed application meets educational needs and has a positive impact on students.

In the Analysis phase, the researchers identified the needs to understand the local context and challenges faced by primary schools in Banjarmasin, especially those located in flood-prone areas. Interviews with teachers and

school principals were conducted to identify students' understanding of flood disasters and the challenges of delivering disaster mitigation materials. Additionally, the researchers assessed whether disaster-related content was included in the existing curriculum and identified the gaps that the SiAGA application needed to address. A technology readiness assessment was also carried out to ensure that available devices, such as Chromebooks and laptops, could support the use of the web-based application in schools.

In the Design phase, based on the analysis, the researchers designed the SiAGA application, which presents flood disaster mitigation learning content using a project-based and contextual approach. The application is designed to deliver content through educational videos, gamification, and collaborative projects that incorporate values such as mutual cooperation and social responsibility. The application design features a simple and attractive interface to ensure that students are comfortable accessing and interacting with the learning materials.

After the design phase, in the Development phase, the SiAGA application was built. This web-based application was designed to be accessible on various devices without requiring special installation, only needing an internet connection. Additionally, a user guide was prepared to assist both students and teachers in using the application. Before being trialed in the field, the application underwent validation by three experts: a disaster management expert, an educational media expert, and a primary education expert. Validation from the three experts indicated that the application was quite good, with scores of 87/100 from the disaster management expert, 88/100 from the educational media expert, and 91/100 from the primary education expert. These scores indicate that the SiAGA application met the required standards in terms of disaster content, media design, and pedagogical needs for primary school students.

In the Implementation phase, the SiAGA application was trialed in three primary schools located in flood-prone areas in Banjarmasin. The experimental group used the application for flood disaster learning, while the control group followed traditional learning methods. Data were collected using various instruments, such as questionnaires to measure student motivation, comprehension tests to evaluate how well students understood flood disaster mitigation concepts, and observations to assess student engagement in learning. Additionally, interviews with teachers and students were conducted to gather feedback on their experiences using the application.

In the Evaluation phase, the trial results of the SiAGA application were evaluated to assess its effectiveness in improving students' understanding, motivation, and engagement. Statistical tests using Independent Samples t-test were used to evaluate the differences between the experimental and control groups. Evaluation also included qualitative analysis through interviews to explore students' and teachers' experiences with the application. The evaluation results were used to revise the application to better meet the future learning needs of students.

To measure how well the SiAGA application creates meaningful learning, the instruments used in this study included a motivation questionnaire, comprehension tests, student engagement observations, and a meaningful learning scale. The motivation questionnaire measured students' interest in flood disaster materials and how much the application could enhance their engagement. The comprehension tests were designed to measure how well students understood flood disaster concepts after using the application. The engagement observation aimed to assess student participation in collaborative tasks and application-based projects. The meaningful learning scale was designed to evaluate how relevant the students felt the material was to their lives and whether they felt able to apply the knowledge in real-life situations.

The subjects of this study consisted of students from three primary schools in Banjarmasin located in flood-prone areas. The total number of subjects was approximately 150 students, divided into experimental and control groups. The selection of subjects was based on the readiness of schools to use technology and the relevance of disaster-related materials required by students in their local environment.

3. RESULTS AND DISCUSSION

3.1. Results

The results of the study show significant changes in various aspects, including relevance, understanding, retention, and application, as measured through pre-tests and post-tests in both the experimental and control groups. The table below presents a comparison of the pre-test and post-test results for both groups.

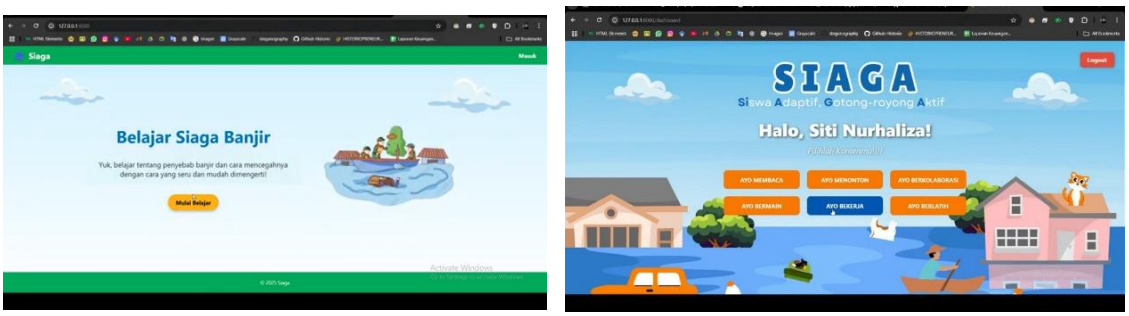

Figure 1. SiAGA website interface (*www.websiaga.com*)

Relevance

The Relevance aspect measures how much students can relate the learning material to their personal experiences and how much they feel the content is applicable to their lives. The results show a significant difference between the experimental and control groups. The control group had a pre-test mean of 12.3 and a post-test mean of 12.8, with an N-gain of 0.05, which falls into the low category. On the other hand, the experimental group showed a greater improvement, with a pre-test mean of 12.5 and a post-test mean of 16.5, resulting in an N-gain of 0.53, which falls into the moderate category. The t-test showed a t-value of 3.25 with a p-value of 0.002, indicating a significant difference between the two groups in terms of Relevance of the application-based learning.

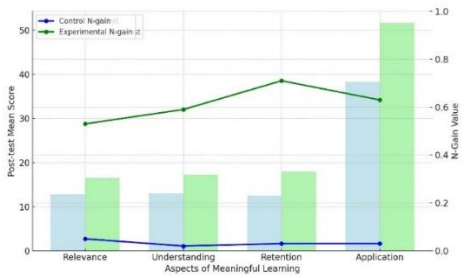

Figure 2. Scores Comparison of pretest and posttest scores

Understanding

The Understanding aspect measures how well students comprehend the importance of flood disaster mitigation. The control group had a pre-test mean of 12.8 and a post-test mean of 13.0, with an N-gain of 0.02, indicating a very small improvement and falling into the low category. In contrast, the experimental group showed a greater improvement, with a pre-test mean of 12.7 and a post-test mean of 17.2, resulting in an N-gain of 0.59, which falls into the moderate category. The t-test showed a t-value of 4.10 with a p-value of 0.000, indicating a highly significant difference between the experimental and control groups in terms of Understanding.

Retention

The Retention aspect measures how well students retain the material being taught, which is an important indicator of meaningful learning. The control group had a pre-test mean of 12.1 and a post-test mean of 12.5, with an N-gain of 0.03, which falls into the low category. On the other hand, the experimental group showed a greater improvement with a pre-test mean of 12.4 and a post-test mean of 18.0, resulting in an N-gain of 0.71, which falls into the high category. The t-test results showed a t-value of 5.20 and a p-value of 0.000, indicating a highly significant difference between the experimental and control groups in terms of Retention.

Application

The final aspect measured is Application, which includes the ability to apply the learned material to real-life situations. The control group showed a pre-test mean of 37.2 and a post-test mean of 38.3, with an N-gain of 0.03, indicating a very small improvement and falling into the low category. In contrast, the experimental group showed a significant improvement, with a pre-test mean of 37.6 and a post-test mean of 51.7, resulting in an N-gain of 0.63, which falls into the moderate to high category. The t-test showed a t-value of 4.85 with a p-value of 0.000, indicating a highly significant difference between the experimental and control groups in terms of Application.

Table 1. Statistical Test Results

Aspect	t-value	t-table (α = 0.05)	Sig. (p)	Conclusion
Relevance	3.25	2.00	0.002	Significant difference
Understanding	4.10	2.00	0.000	Significant difference
Retentiton	5.20	2.00	0.000	Significant difference
Application	4.85	2.00	0.000	Highly significant

The experimental group showed a significant improvement, with a pre-test mean of 37.6 and a post-test mean of 51.7, resulting in an N-gain of 0.63, which falls into the moderate to high category. The t-test showed a t-value of 4.85 with a p-value of 0.000, indicating a highly significant difference between the experimental and control groups in terms of relevance, understanding, retention, and application.

3.2. Discussion

Meaningful learning is a concept developed by David Ausubel, which focuses on the idea that learners can make connections between new information and their existing knowledge. This process promotes deeper understanding, retention, and application of knowledge. This study evaluates how SiAGA, a technology-based application, facilitates meaningful learning in flood disaster mitigation education for primary school students. The results indicate that SiAGA significantly enhances meaningful learning in four main aspects: Relevance, Understanding, Retention, and Application.

Relevance: Connecting Learning to Real-Life Contexts

The Relevance aspect measures how well students can relate the learning material to their personal experiences and real-life situations. In this study, the experimental group showed a significant improvement (N-gain = 0.53) in Relevance. This suggests that the SiAGA application effectively helped students see the direct connection between flood disaster mitigation learning and their daily lives, particularly in flood-prone areas.

This finding is consistent with recent research emphasizing the role of contextualized learning in increasing student engagement and motivation [10]. By incorporating local case studies of flood risks and mitigation strategies, SiAGA provided students with relevant, real-world scenarios that enhanced their engagement. According to Smith et al., context-based learning makes learning more meaningful and increases students' motivation to apply the knowledge in practical situations [11].

Understanding: Enhancing Comprehension of Key Concepts

The Understanding aspect refers to students' ability to grasp the underlying principles and meanings of the material, not just memorizing facts. In this study, the experimental group showed a significant improvement (N-gain = 0.59) in Understanding, indicating that the SiAGA application helped students not only comprehend the causes and impacts of flood disasters but also the importance of taking preventive measures.

Interactive and multimedia elements, such as educational videos and gamification, were crucial in facilitating this understanding. According to Hajj-Hassan et al., multimedia-based learning technologies help students understand complex topics by providing visual context and real-life examples [12]. By presenting flood mitigation strategies through videos that showcased local efforts in Banjarmasin, the application made the learning material more tangible and relatable for students.

Additionally, recent studies by Zhang et al., highlight the importance of integrating technology in the classroom to promote deep understanding. The use of interactive technologies increases cognitive engagement, which leads to a deeper comprehension of the material [13].

Retention: Encouraging Long-Term Retention of Knowledge

Retention in meaningful learning refers to the ability of students to remember and apply what they have learned over time. In this study, the experimental group demonstrated a significant improvement in Retention (N-gain = 0.71), which indicates that the SiAGA application facilitated long-term memory of the flood disaster mitigation concepts.

The inclusion of interactive and project-based learning features in the application, such as simulations and group projects, plays a significant role in retention. Studies by Novalia and Puspitasari et al.,have shown that

active learning methods, such as gamification and collaborative tasks, help improve retention by promoting active participation and allowing students to reinforce their learning through practice [14,15]. Puspitasari et al., further found that students retain information better when they are actively involved in problem-solving tasks rather than passive learning activities [15].

Application: Translating Knowledge into Action

Finally, Application refers to the ability to use the learned material in real-world contexts. In this study, the experimental group exhibited a significant improvement in Application (N-gain = 0.63), showing that the SiAGA application helped students apply flood disaster mitigation knowledge in real-world scenarios, such as designing flood prevention measures for their own neighborhoods.

This ability to apply knowledge is a key component of meaningful learning, as it requires students to engage in higher-order thinking and problem-solving. Research by Clark et al., emphasizes the importance of integrating both cognitive and affective aspects in learning, as this combination fosters the application of knowledge in authentic settings. According to Clark et al., students who engage in real-world applications of what they have learned are more likely to retain and use the information effectively [16].

Implications for Primary School Learning

The findings of this study have significant implications for the development of technology-based learning in primary schools. In particular, the study shows that interactive, project-based learning applications like SiAGA can greatly enhance students' engagement and learning outcomes, especially in contexts that require an understanding of local issues like flood disaster mitigation. Research by Purnama and Hidayat supports this conclusion, highlighting that technology-based learning significantly improves students' understanding and retention of complex topics [17].

The results also indicate that SiAGA can be used to support meaningful learning in a variety of subjects beyond flood disaster mitigation. The integration of interactive multimedia, project-based learning, and local context into educational applications provides students with a more engaging and relevant learning experience, which can be applied to other topics as well.The results of the study show that the SiAGA application successfully increased students' acceptance of flood disaster learning, reflected in a significant N-gain improvement in the experimental group (0.53) compared to the control group (0.05). This significant improvement aligns with the findings of Anderson et al., who stated that technology-based applications can enhance student engagement and acceptance of the learning presented. This suggests that application-based learning, which is relevant to local contexts such as flood mitigation in disaster-prone areas, can improve students' understanding and motivate them to actively engage in learning [18]. Previous research by Suryani and Setiawan also supports this finding, stating that technology-based learning can facilitate better student understanding, especially when the material taught is directly relevant to their lives [19]. This is consistent with Ausubel's theory of meaningful learning, which emphasizes the importance of linking new knowledge with students' prior experiences [20]. SiAGA, with its local context-based content, allows students to see the direct connection between learning and their daily lives.

4. CLOSURE

The SiAGA application effectively enhanced meaningful learning in primary school students, particularly in flood disaster mitigation. The experimental group showed significant improvements across all key aspects: Relevance (N-gain = 0.53), Understanding (N-gain = 0.59), Retention (N-gain = 0.71), and Application (N-gain = 0.63), compared to the control group. These results highlight how SiAGA helped students connect the learning material to their real-life experiences, deepen their comprehension, retain knowledge over time, and apply it in practical situations.With significant improvements in engagement and knowledge retention, SiAGA demonstrates the power of technology-based learning to provide more relevant, engaging, and practical education. This study suggests that SiAGA can be an effective tool in disaster education, especially in flood-prone areas, by making learning more meaningful and applicable to real-world challenges.

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