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DEVELOPMENT OF AUGMENTED REALITY-BASED LEARNING BOOKS TO IMPROVE STUDENT PREPAREDNESS FOR LANDSLIDE DISASTERS AT SMA NEGERI 1 KERJO, KARANGANYAR REGENCY

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ABSTRACT

Student preparedness in facing landslide disasters is an important aspect in disaster risk reduction in educational units. However, disaster learning in secondary schools is still dominated by conventional teaching materials that lack visualization and have not been optimally integrated with the Disaster Safe Education Unit (SPAB). This study aims to develop SPAB-based textbooks equipped with Augmented Reality (AR) technology to improve students' understanding and preparedness for landslide disasters. The study used the Research and Development (R&D) method with the ADDIE model. The research subjects consisted of 32 students of Class XII. F7 SMA Negeri 1 Kerjo. The research instrument used validation by material experts and media experts. Based on the research results, it can be concluded that the Disaster Safe Education Unit (SPAB)-based learning book enriched with Augmented Reality (AR) technology is declared feasible and effective for use in landslide disaster mitigation learning. The validation results showed a score of 79.2 from material experts and 80 from media experts, both of which are in the feasible category. Effectiveness testing on 32 students showed improved learning outcomes, with an average score increasing from 56.2 in the pretest to 83 in the posttest, and an N-Gain value of 56%, which is considered quite effective. These findings confirm that integrating SPAB-based textbooks with AR visualizations can significantly improve students' understanding and preparedness, while also serving as an alternative, innovative learning medium relevant to disaster education in schools.

Keywords: *augmented reality; book development; disaster preparedness; landslides*

INTRODUCTION

Natural disasters, particularly landslides, pose a serious threat that can disrupt the continuity of the educational process and endanger the safety of school residents (Hidayah et al., 2021). Data from the National Disaster Management Agency (BNPB) shows that landslides are one of the most frequent disasters in Indonesia. Between 2021 and 2023, more than 3,000 landslides were recorded across

various regions, particularly in areas with hilly topography and high rainfall (Lasaiba, Tetelepta, & Leuwol, 2023). Central Java Province is an area with a high level of landslide vulnerability (Isnaini, 2019), A number of incidents have had a direct impact on residential areas and educational facilities, including secondary schools located in disaster-prone areas. This situation demonstrates that educational institutions in landslide-prone areas require systematic efforts to build early disaster preparedness.

Disaster education in schools is an important strategy in disaster risk reduction efforts (Ammelia et al., 2022). However, the implementation of disaster management learning is still dominated by theoretical and text-based approaches, thus failing to develop students' visual, spatial, and procedural understanding of disaster processes and mitigation measures (Bachri et al., 2024; Buston et al., 2025; Salam et al., 2025). Several previous studies have developed Augmented Reality (AR)-based learning media in the fields of geography and disaster management (Faradina et al., 2025), which has been reported to increase students' learning interest and conceptual understanding. However, these studies generally have not explicitly integrated AR media with the Disaster Safe Education Unit (SPAB) Program framework, nor have they placed landslide disaster preparedness as the primary focus of their teaching materials development.

Based on this gap, this study offers a novelty through the development of a disaster textbook that integrates SPAB principles with Augmented Reality technology as an interactive and contextual learning medium. This integration is expected to not only improve students' conceptual understanding of landslides but also strengthen their preparedness in facing potential disasters in the school environment. Thus, this study is directed at addressing issues related to the quality, ease of use, and effectiveness of SPAB-based textbooks with AR technology support in supporting disaster education at the secondary school level.

MATERIALS AND METHODS

This research uses a Research and Development (R&D) approach, referring to the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation)

(Zamsiswaya, Syawaluddin, & Syahrizul, 2024). During the analysis phase, student and school needs related to disaster learning, particularly regarding landslides, were identified. Data were collected through interviews, observations, and documentation studies to formulate material characteristics appropriate to the local context and student needs.

The design and development phase involved the creation of a Disaster Safe Education Unit (SPAB)-based textbook equipped with Augmented Reality (AR) features. AR technology was used to present interactive visualizations, such as simulations of landslides, their causes, impacts, and mitigation measures (Sadewa, Andreswari, & Erlansari, 2019). This textbook was designed in stages, taking into account pedagogical aspects, content appropriateness, and technology integration.

Validation was conducted by subject matter experts and media experts to assess the suitability of the content and interactive displays. A limited trial was conducted with a small group of students to evaluate the textbook's readability and ease of use. Subsequently, a large-scale trial was conducted at SMA Negeri 1 Kerjo to measure the textbook's practicality and effectiveness in improving student understanding and readiness. Questionnaires and tests were used to collect quantitative data, which were then analyzed descriptively and comparatively. This study involved 32 12th-grade students, consisting of 12 boys and 20 girls. The research subjects were selected from the same class considering the uniformity of academic characteristics and learning environments. The research design used was a pre-experimental one, where treatment was given to one group without a comparison group. Learning was carried out according to a pre-designed scenario, and data collection was conducted before and after the treatment to observe changes in student learning outcomes.

The research instrument was validated through expert validity, involving experts with expertise in the field of materials and learning to assess the suitability of the content, the clarity of the indicators, and the instrument's integration with the research objectives. The indicators used in this study were adapted from the learning design of "Ketika Bumi Tak Lagi Diam." The indicators are as follows:

Tabel 1. Indicator Pretest and Posttes

Indicator	KKO Taksonomi Bloom	Material
Able to give ideas about the earth that keeps moving	C3, C4, C4	The Living Earth, the Moving Land
Able to understand what a landslide is	C3, C4, C4	What is a landslide?
Able to understand landslide events in the surrounding area	C4, C4	The Story Behind the Collapsed Land
Able to provide disaster mitigation solutions	C5, C5, C4	Science for Disaster Mitigation
Able to provide a role as the younger generation in landslides	C6, C4	Landslides and Us: The Role of the Young Generation
Able to provide solutions as a form of empathy for landslide disasters	C4, C6, C6	When Empathy Becomes the Solution
Able to provide ideas in the form of real actions in the area of landslide disasters	C4, C5, C6	When Empathy Becomes the Solution

Source: Researcher Analysis

Based on **Table 1**, it can be seen that the pretest and posttest questions were developed using eight indicators consistent with the development of the "Ketika Bumi Tak Lagi Diam" product. These indicators are tailored to the material contained in the product. The indicators are also accompanied by Bloom's Taxonomy Core Competency Framework (KKO), beginning with C3 (Applying), C4 (Analyzing), C5 (Evaluating), and C6 (Creating) (Bloom, 1956).

The data obtained were then analyzed using the N-Gain test to determine the level of improvement in learning outcomes after treatment was given. **Equation 1** determines the N-Gain Formula.

$$N - Gain = \frac{posttest - pretest}{skor\ ideal - pretest} \quad (1)$$

With the N-Gain Value acquisition category shown in **Table 2**.

Table 2. N-Gain Value Acquisition Category

N-Gain Score	Category
G > 0.7	High
0.3 ≤ g ≤ 0.7	Medium
G < 0.3	Low

Source: (Sugiyono, 2017)

The calculation of learning effectiveness in this study was carried out using Normalized Gain (N-Gain), which is used to see the level of improvement in student learning outcomes after being given treatment. The N-Gain value is obtained by comparing the difference between the posttest and pretest scores to

the difference between the maximum score and the pretest score, so that the improvement that occurs can be assessed proportionally. Through this calculation, learning effectiveness is not only reviewed from the final results, but also from the magnitude of changes in student abilities before and after learning. The higher the N-Gain value obtained, the more effective the learning implemented in improving student understanding and learning outcomes.

During the implementation of the research, ethical aspects of the research were still taken into account by obtaining permission from the school and approval from the students, and all data collected was used solely for academic purposes without including the personal identity of the respondents.

RESULTS AND DISCUSSION

The results of this study indicate that the development of a Disaster Safe Education Unit (SPAB)-based learning book enriched with Augmented Reality (AR) technology has high validity, good practicality, and significant effectiveness in improving student preparedness for landslides. The development process, through five ADDIE stages, resulted in a disaster-themed book that combines a contextual approach with interactive technology support.

According to Sugiyono (2015) The ADDIE development model includes five main stages: Analysis, Design, Development, Implementation, and Evaluation. Based on this model, the first stage is analysis, which focuses on identifying learning needs and problems, including the suitability of materials, the availability of textbooks, and students' learning conditions. The next stage is design, which includes formulating learning objectives, determining materials or topics, and systematically compiling teaching materials according to students' needs. In the development stage, materials are compiled and written in textbooks that are tailored to the characteristics and needs of students in the learning process. The implementation stage is the process of applying the development product, namely teaching materials, in learning activities. The evaluation stage is carried out formatively at each stage of product development to assess suitability and effectiveness based on the model used. The ADDIE stages are explained in the flowchart in **Figure 1.**

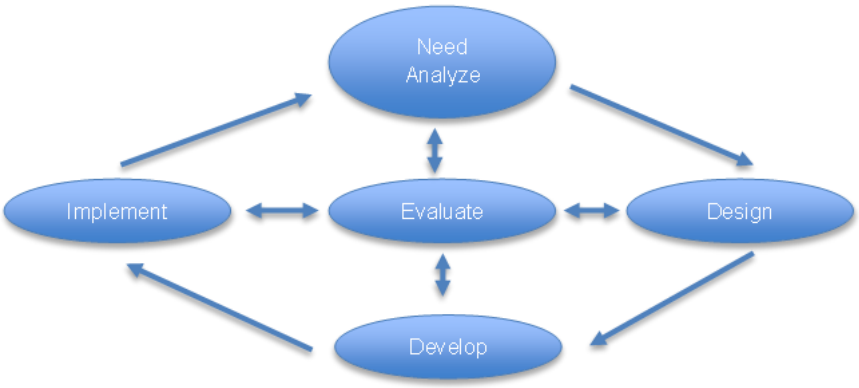

Figure 1. Stages ADDIE

The ADDIE model is a systematic approach widely used in learning development. The initial stage, analysis, is aimed at identifying learning needs, student characteristics, and problems that arise during the learning process. The results of this analysis form the basis for the design stage, which includes developing learning objectives, selecting materials, strategies, and methods, as well as planning media and assessment formats appropriate to the previously identified learning needs.

The next stage is development, the process of translating the learning design into tangible products, such as teaching materials, learning media, and evaluation instruments. The developed products are then used in the implementation stage, which involves applying the learning to real-life classroom situations or learning environments. To determine the level of achievement of learning objectives, continuous evaluation is conducted, both during and after the learning process. The results of this evaluation are used as a basis for improvement and refinement, allowing the learning development process to continuously improve its quality.

1. Needs Analysis

Needs analysis is used to analyze students' needs using a survey questionnaire to determine students' needs for Augmented Reality technology-based learning media and their understanding of disaster material. Needs analysis was conducted on 63 students of class XII IPS SMA Negeri 1 Kerjo. In measuring Needs Analysis using indicators such as knowledge of Augmented Reality media, the use of 3D media based on Augmented Reality, the use of 3D media based on AR is it fun?, Ease in understanding disaster mitigation material, difficulty in understanding geography material with media used by

teachers, enthusiasm when participating in geography learning, participating in disaster mitigation activities at school, use of teaching materials (videos, technology-based media, teaching aids) by Geography Teachers, understanding of disaster sub-chapter material when presented using 3D animation learning media based on Augmented Reality, Support if necessary to develop teaching materials such as Augmented Reality-based books for disaster mitigation learning, so that it is easier to understand. Based on these indicators, it can be seen that the results of filling in the needs analysis by 60 class XII IPS students at State University 1 Kerjo are as follows:

Table 3. Needs Analysis Results

Indicator	Yes	No	% Needs
Have you ever heard of Augmented Reality media?	30	33	47.619%
Have you ever used 3D Augmented Reality media?	17	46	26.984%
Do you think learning using 3D AR media would be more enjoyable?	52	11	82.540%
Do you find the geography material on disaster mitigation difficult to understand?	26	37	41.270%
Do you have difficulty understanding geography material with the media used by teachers?	16	47	25.397%
Are you enthusiastic about participating in geography lessons?	58	5	92.063%
Have you ever participated in disaster mitigation activities at school?	6	57	9.524%
Do geography teachers use teaching materials (videos, technology-based media, props)?	53	10	84.127%
Would you enjoy and understand the disaster sub-chapter material if presented using 3D animated Augmented Reality learning media?	54	9	85.714%
Do you agree that teaching materials such as Augmented Reality-based books should be developed for disaster mitigation learning to make it easier to understand?	53	10	84.127%

Source: Researcher analysis with modified Laswili indicators 2024

Based on **Table 3** it can be seen that the use of AR, 3D AR, difficulty in understanding disaster mitigation material, difficulty in understanding geography material with media used by teachers, school disaster mitigation activities are still below 50%. Meanwhile, based on the data in Table 2, it can be seen that students' opinions on the use of AR-based 3D media will be more enjoyable getting a score of 82.540%, enthusiasm in following geography lessons 92.063%, use of media by teachers 84.127%, children's comfort when the material is presented in AR 85.714%, and agreement on the development of AR-based books 84.127%.

Based on the needs analysis, students found moderate to high demand for

Augmented Reality (AR)-based learning media. AR-based learning media is needed to create a more engaging learning process and provide interactive visualizations that can enhance students' understanding of disaster preparedness material, considering their level of understanding of the material.

2. Media Design

This research aims to design and develop an Augmented Reality (AR)-based learning media book titled "The Earth Is No Longer Silent" to represent the importance of awareness of the dynamics of the geosphere and the potential for natural disasters. This media design is an innovative effort to increase student engagement, motivation, and understanding of disaster concepts through interactive and contextual three-dimensional visualizations. The augmented reality media is visualized in **Figure 2**.

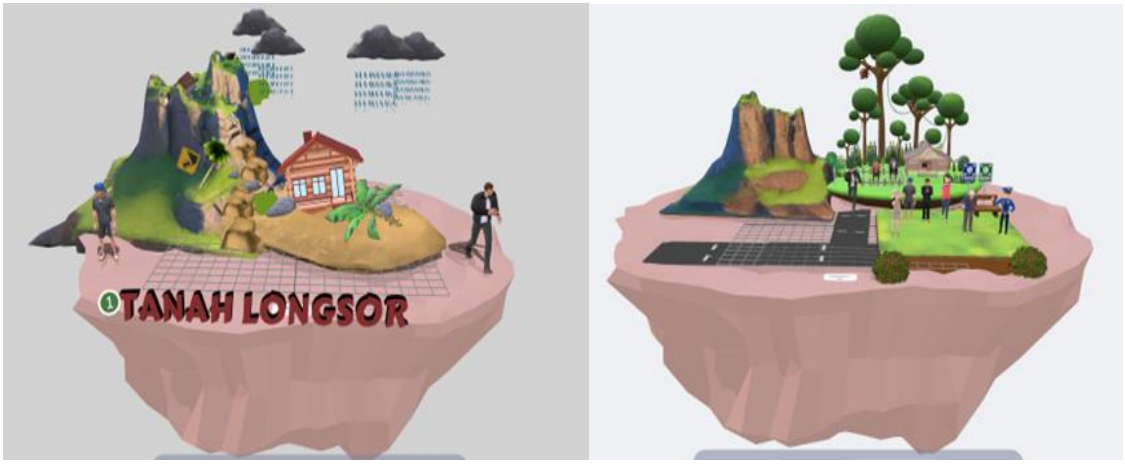

Figure 2. Augmented Reality Media

Source: Researcher's Design Results, 2025

This media was developed using the Assemblr EDU application. Assemblr EDU is an Augmented Reality (AR)-based learning medium developed to support the role of teachers and parents in providing a more interactive learning process. Through the use of three-dimensional object visualization, this platform helps explain abstract material to be more concrete and easier to understand, without requiring users to have special skills in the fields of programming or design. Assemblr EDU is equipped with various supporting features, such as Edu Kits, Topics, Editor, and Visual Code, which make it easier to design AR-based learning activities. In addition, there are various

ready-to-use 3D assets, coverage of learning materials from kindergarten to high school levels, and online class facilities that allow teachers to create and manage AR learning projects more effectively and interestingly.

This AR-visualized book is designed by integrating disaster concepts and interactive digital elements, allowing students not only to obtain textual information but also to observe virtual disaster simulations and mitigation steps. Thus, the learning media for "Ketika Bumi Tak Lagi Diam" is expected to create an engaging, meaningful, and immersive learning experience, as well as increase students' preparedness and awareness of the importance of disaster mitigation in everyday life.

3. Media Development

Validation was conducted by two experts: a material expert and a media expert. The validation of both materials and media involved 25 questions. The validation results from the material experts' interviews indicated that the book's content aligns with core competencies in the curriculum and disaster risk reduction principles.

Table 4. Eligibility results

Validation	Skor	Category
Content expert validation	79.2	Eligible
Media expert validation	80	Eligible

Source: Researcher Analysis, 2025

Based on **Table 4**, the average score from the material expert validation was in the "adequate" category with a score of 79.2 for content and a score of 80 for media, with an emphasis on content accuracy, relevance to the local context, and clarity of information delivery. The expert recommended adjustments to some technical terms to make them more easily understood by high school students.

Meanwhile, validation results from media experts indicated that the media fell into the "adequate" category, with the integration of AR technology into the book providing significant added value. The AR feature, which displays visual simulations of landslides, evacuation routes, and mitigation measures, was deemed effective in enhancing conceptual understanding. Scores for the app's visual appearance, interactivity, and ease of access were in the "good" to "very good" category. Several technical inputs from media experts were followed

up with improvements to the interface design to make it more user-friendly.

4. Implementation

This large-scale trial involved 32 students in grade XII.F7 of SMA Negeri 1 Kerjo. The trial phase aimed to determine the effectiveness of the textbook on a larger class scale. Analysis showed that the use of the SPAB-AR-based textbook had a positive impact on improving student readiness.

Table 5. N-Gain Score Analysis Results

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	32	-33	83	5628	.22965
Ngain_Persen	32	-33.33	83.33	56.2780	22.96481

Source: Researcher Analysis, 2025

Pretest results showed that most students had low initial understanding, especially regarding the natural causes and human activities that trigger landslides, as well as emergency evacuation procedures. After using the AR-based learning book, posttest scores improved significantly. The average score increased from 56.2 to 83 (see **Table 5**). Data analysis showed that the use of interactive visual media helped students understand complex concepts more easily. The results of the N-Gain Score analysis were used to determine the effectiveness of the applied media. Based on the results of the study, the N-Gain Score was 56%, categorized as "quite effective," meaning the media used was quite effective when used in learning. Furthermore, through the evaluation results, students gave high ratings to the practicality of the book. They stated that the book was easy to use independently and helped them understand concrete mitigation steps. Teachers involved in the trial also stated that the material in the book aligned with the principles of context-based learning and was able to foster a responsive attitude towards disasters. Teachers felt helped by the AR-based supporting media because it could increase students' focus and interest in learning.

5. Evaluation

The results of this study reinforce previous research findings showing that the use of innovative technology-based learning media can improve the quality of disaster management education. In the context of landslide preparedness, AR visualization can overcome the limitations of conventional learning,

which tends to be narrative and lacks context. AR technology provides a more immersive learning experience, making it easier for students to understand geological processes, risks, and actions to take in the event of a disaster.

From a pedagogical perspective, the development of SPAB-AR-based textbooks also aligns with problem-based and project-based learning approaches, as they encourage students to explore information, analyze risks, and design solutions in real-world contexts (Wardhani et al., 2024). These textbooks not only convey facts but also encourage students to think critically and reflectively about the conditions of their living environment. This aligns with Tyas et al (2025) study, which showed that the integration of AR technology in DRR education increases student engagement through visual exploration, going beyond the delivery of facts to critical thinking about their living environment.

Furthermore, students' active engagement in the learning process through interaction with AR features fosters meaningful learning experiences. This experience strengthens the development of disaster preparedness and response, a key goal of disaster education in schools. This research also demonstrates the importance of collaboration between media developers, disaster experts, and teachers in creating learning resources that are responsive to local needs and technological developments.

However, several significant obstacles emerged during the development and implementation process. First, the availability of AR-compatible devices is a challenge, especially in schools with limited resources. Second, teacher training is needed to optimize the use of this medium in learning. Third, curriculum integration is also crucial to ensure that disaster material is not incidental but becomes an integral part of the educational process.

The implications of these findings suggest that the development of SPAB-based learning media and AR technology could be a viable model for replication in other disaster-related topics, such as earthquakes, floods, or forest fires. Furthermore, this approach has the potential to be further developed into interactive e-books, digital modules, or online learning platforms with broader reach.

CONCLUSIONS

Based on the research results, the development of a Disaster Safe Education Unit (SPAB)-based learning book enriched with Augmented Reality (AR) technology through the ADDIE model resulted in a product suitable for use in learning. Validation results showed that the developed book received a score of 79.2 from material experts and 80 from media experts, both of which are in the suitable category. These findings indicate that the material content, suitability with the curriculum, accuracy of disaster concepts, as well as the display and interactivity of the media have met the standards of suitability as teaching materials. The integration of AR visualizations in the learning book can strengthen the presentation of disaster mitigation material in a contextual manner and support students' understanding of the phenomenon of landslides.

Furthermore, the results of the effectiveness test on 32 students showed a significant increase in learning outcomes after using the SPAB-AR-based book. The average student score increased from 56.2 in the pretest to 83 in the posttest. The effectiveness analysis using N-Gain produced an average score of 56%, which is included in the moderately effective category. These results indicate that the developed learning media can significantly improve students' preparedness and understanding of landslide disaster mitigation. Student and teacher support for the practicality of using the book and the ease of understanding the material confirms that AR-based learning media has great potential for wider application in disaster education and development on other disaster topics.

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