

DEVELOPMENT OF A VIRTUAL REALITY-BASED DISVIR MEDIUM TO IMPROVE HIGH SCHOOL STUDENTS' NATURAL DISASTER COGNITION

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ABSTRACT

Earthquake disasters pose a serious threat to school communities, yet conventional instructional media, being abstract and two-dimensional, fail to build strong disaster-related knowledge and risk awareness among students, particularly in high-risk locations such as MA MILBoS, a boarding school situated along the active Citarik fault line. This study aimed to develop Media Disvir, a Virtual Reality-based Geography learning medium for earthquake disaster material, and to test its feasibility, practicality, and effectiveness in improving students' disaster-related knowledge and risk awareness. This study adopts a research and development (R&D) approach using the ADDIE model, with the product built through MilleaLab software and trialed on students through a one-group pretest-posttest design across limited (small-scale), broad (large-scale), and treatment (effectiveness testing) classes at MA MILBoS. Data were collected through observations and questionnaires aimed at assessing cognitive learning outcomes, then analyzed using expert validation percentages, practicality scoring, paired-sample t-tests, N-Gain analysis, and Cohen's D effect size. The results show that medium was rated highly suitable by both content and media experts (98.3% and 90%), practical according to teachers and students (75%–86.78%), and highly effective in improving learning outcomes, with a high N-Gain (0.78) and a large effect size (-1.76). These findings indicate that Media Disvir successfully improved students' disaster-related knowledge identified at the outset, offering a safe and immersive learning experience that may complement, rather than replace, direct disaster experience.

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INTRODUCTION

MA MILBoS (Maghfirah Islamic Leadership Boarding School) operates as a boarding school where students reside within the school environment for twenty-four hours a day, throughout the entire academic year. Geographically, the school area is traversed by the active Citarik fault line (Kementerian ESDM RI, 2020), placing the institution within a high-category

earthquake threat zone, particularly given West Java's high frequency of natural disasters (Sucipto, 2024; Sumariyadi, 2024). Because students spend nearly all their time inside the dormitory and classroom complex rather than commuting from external homes, any seismic event occurring on campus places the entire student population at simultaneous risk, with virtually no buffer time or external evacuation support to rely on (Masrizal & Iqbal, 2022).

Within the geography classroom itself, teachers deliver disaster-related material largely through conventional instructional tools such as printed textbooks, static two-dimensional images, and verbal explanation (Shoffa, 2023). Classroom observation shows that students are exposed to disaster content mainly as descriptive information to be memorized rather than as an experience to be internalized (Fitriana, 2021). As a result of relying on this conventional, one-dimensional approach, students' cognitive grasp of disaster-related material remains low, which is a common factor contributing to the public's broader weakness in facing disaster threats (Andwitasari & Handayani, 2022). Because a major earthquake is an infrequent event, students lack any lived reference point that would make the danger feel real or urgent, and this absence of concrete experience (Kolb & Kolb, 2009) is compounded by instructional media that cannot simulate the sensation of an actual seismic event (Passarelli & Kolb, 2012). The gap between the disaster risk MA MILBoS students actually face and their level of readiness to understand and respond to that risk highlights a clear shortfall in the school's current instructional approach to disaster education.

Edgar Dale's Cone of Experience is often cited to suggest that abstract, symbolic media such as textbooks and static images produce comparatively low retention, while direct, purposeful experience produces substantially higher retention (Pagarra et al., 2022). It should be noted that the specific percentage figures frequently attached to this model are widely circulated in popular and applied literature but lack a robust, independently replicated empirical basis, and should therefore be treated as an illustrative heuristic rather than a precise measurement. What the theory does support more cautiously is the general principle that media offering closer approximations to direct experience tend to support deeper and more durable learning than purely abstract representations. Because directly exposing students to a real earthquake is neither feasible nor safe, this principle points toward the need for a medium capable of approximating that experience artificially. Virtual Reality has been proposed as one such medium, as it can simulate elements of direct experience in a manner that is comparatively safe and interactive (Wijayanto et al., 2023). Rather than assuming VR produces cognitive mastery equivalent to genuine lived experience, this study treats that possibility more moderately, as a hypothesis to be tested empirically rather than a guaranteed outcome, consistent with prior findings that VR-based instruction can meaningfully improve learning outcomes relative to conventional media without necessarily replicating the full impact of real-world experience.

A gap therefore exists between what disaster education theory suggests is desirable and what is actually available to students at MA MILBoS. Ideally, given the severity of the seismic risk the school faces, students should be equipped with more immersive, experience-oriented instructional media than the abstract, symbol-based materials currently in use, so that a greater share of the curriculum's competency demands, namely the ability to identify, understand, process, analyze, and evaluate disaster phenomena spatially as required by the Kurikulum Merdeka's *Capaian Pembelajaran*, can be met. In practice, however, the school continues to rely on the latter, leaving this competency gap largely unaddressed. This mismatch is further intensified by the fact that immersive VR-based media for disaster education remains scarce and largely unavailable in schools despite its promising potential. This condition raises a central research problem: how can an instructional medium be developed that is simultaneously feasible, practical, and effective in closing the gap between the low cognitive outcomes currently observed and the higher cognitive potential associated with more experiential learning approaches, within a high-risk disaster zone such as MA MILBoS?

Prior studies have explored various facets of virtual reality as an instructional medium, though each carries limitations that leave room for the present study. Development research on VR-based geography learning media has demonstrated that such media can be produced and validated for classroom use, yet this work has largely centered on general geography competencies rather than disaster-specific cognitive outcomes (Saurik et al., 2019; Saparuddin et al., 2024). Separately, studies examining VR-based media effectiveness for improving students' comprehension have shown promising results, but have been conducted primarily at the elementary level, leaving the applicability of such media to senior-secondary disaster curricula largely untested (Attalina et al., 2024). More directly relevant, recent work applying VR specifically to disaster-preparedness education has reported gains in students' knowledge and self-efficacy when simulated hazard scenarios

are used in place of static instruction, supporting the premise that VR's value lies specifically in its capacity to simulate hazard-specific experience rather than in immersion alone (Zhang et al., 2024; Fauzi et al., 2025).

On the disaster-education side, instruments designed to measure adolescents' resilience toward disaster situations have been developed and validated, confirming that disaster-related psychological and cognitive constructs among adolescents can be systematically measured (Mohammadinia et al., 2019; Suryani & Uningowati, 2020). However, none of these studies combine VR-based media development with a direct measurement of cognitive improvement specifically tied to earthquake material within a boarding-school population situated on an active fault line, nor do they simultaneously test feasibility, practicality, and effectiveness within a single ADDIE-based development framework. This unaddressed intersection constitutes the specific gap the present study seeks to fill.

The novelty of this study lies in three specific contributions. First, it develops a VR earthquake scenario deliberately constructed to reflect the actual geographic and seismic context of the school site along the Citarik fault, rather than a generic hazard simulation. Second, it operationalizes disaster cognition through specific, curriculum-aligned indicators tied to the *Kurikulum Merdeka's Capaian Pembelajaran* for spatial disaster analysis, rather than relying on general comprehension measures. Third, it integrates expert validation, practicality testing, and effectiveness testing within a single ADDIE-based development cycle, providing an evidence trail from product design through to measured cognitive impact. Together, these contributions target SDG 4 (Quality Education) through an immersive instructional medium, while simultaneously advancing SDG 11 (Sustainable Cities and Communities) through strengthened disaster-risk knowledge among a genuinely at-risk student population (Aminah, 2022; Maharani, 2023).

The urgency of this study stems directly from the compounded vulnerability MA MILBoS students face: their twenty-four-hour residency on campus, the school's location astride an active fault line, and their currently low level of disaster cognition together mean that any delay in providing adequate instructional intervention carries direct safety consequences rather than merely academic ones. Left unaddressed, this gap directly undermines progress toward SDG 4's call for inclusive, effective learning environments and SDG 11's mandate for resilient, disaster-prepared communities, making the timely development and validation of Media Disvir not simply a pedagogical improvement but a preventive safety measure for a genuinely at-risk student population (Tae et al., 2024).

Based on the gaps outlined above, this study seeks to answer two central questions. First, the study examines the feasibility of Media Disvir as a developed product, assessed through the validation process by content and media experts, together with its level of practicality when used directly in the classroom, based on responses from geography teachers and students at MA MILBoS. Second, the study examines the extent to which the use of Media Disvir improves students' disaster-related cognition, measured through a comparison of learning outcomes before and after use of the medium, in order to determine whether this Virtual Reality-based medium is genuinely effective in closing the disaster-cognition gap identified at MA MILBoS.

METHOD

This study employed a Research and Development (R&D) approach using the ADDIE model (Analyze, Design, Develop, Implement, Evaluate) to produce Media Disvir, a Virtual Reality-based Geography learning medium built using MilleaLab software. The Analyze stage was carried out through classroom observation, an assessment of students' learning styles (22% auditory, 46% visual, 32% kinesthetic), and an interview with the school principal regarding facilities and infrastructure, ensuring that the developed product genuinely matched the real needs of MA MILBoS. The Design stage produced a storyboard, storyline, and a 360-degree virtual space containing earthquake disaster material, while the Develop stage translated this design into a functioning product that was then submitted for validation by a content expert and a media expert before proceeding further.

Product testing was conducted through a validity test and a practicality test. The validity test was performed by the content and media experts to assess the appropriateness of the material, design, display, and functionality of the medium; only a product rated "highly suitable" proceeded to field trials. These trials were then implemented in stages at MA MILBoS: a limited trial involving 16 eleventh-grade Geography-track students, a broad trial involving 26 tenth-grade students, and a

treatment/sample class of 18 twelfth-grade Geography-track students. Data were collected through observation and questionnaires (using validation sheets for experts and feasibility assessment sheets for teachers and students), and analyzed quantitatively, with learning outcomes further evaluated through a paired-sample t-test, N-Gain analysis, and Cohen's D effect size to determine the medium's actual impact on students' disaster-related cognition.

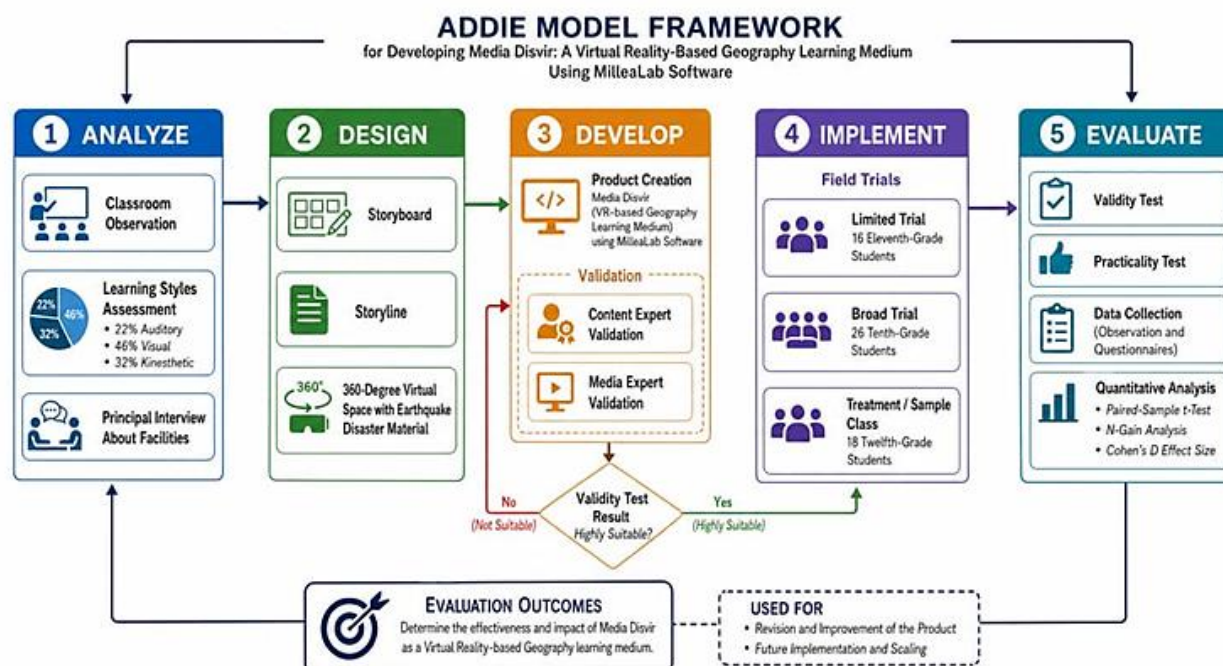


Figure 1. Research Methodology Framework
Source: AI Visualization

RESULT AND DISCUSSION

Feasibility of Media Disvir Based on Content and Media Expert Validation

The feasibility test results show that Media Disvir was rated highly suitable by both validators. The content expert, evaluating material accuracy, alignment with the earthquake disaster learning objectives, and the fit between the virtual environment and the material presented, gave a score corresponding to a feasibility percentage of 98.3%, placing the medium within the "highly suitable" category. The media expert, assessing the virtual world's realism, immersion, sensory feedback, interactivity, latency, and device comfort, gave a score equivalent to 90%, again falling into the "highly suitable" category.

Both validators offered minor revisions rather than raising fundamental objections: the content expert suggested adding a bibliography and correcting typographical errors, while the media expert recommended inserting short quizzes after each scene so comprehension could be checked progressively rather than only at the end. These revisions were incorporated before field testing began, further strengthening the product.

Taken together, the two validation results indicate that Media Disvir met the conceptual and technical standards required before being introduced into an actual classroom, answering the first research question with clear evidence that the developed medium is both materially and technically sound.

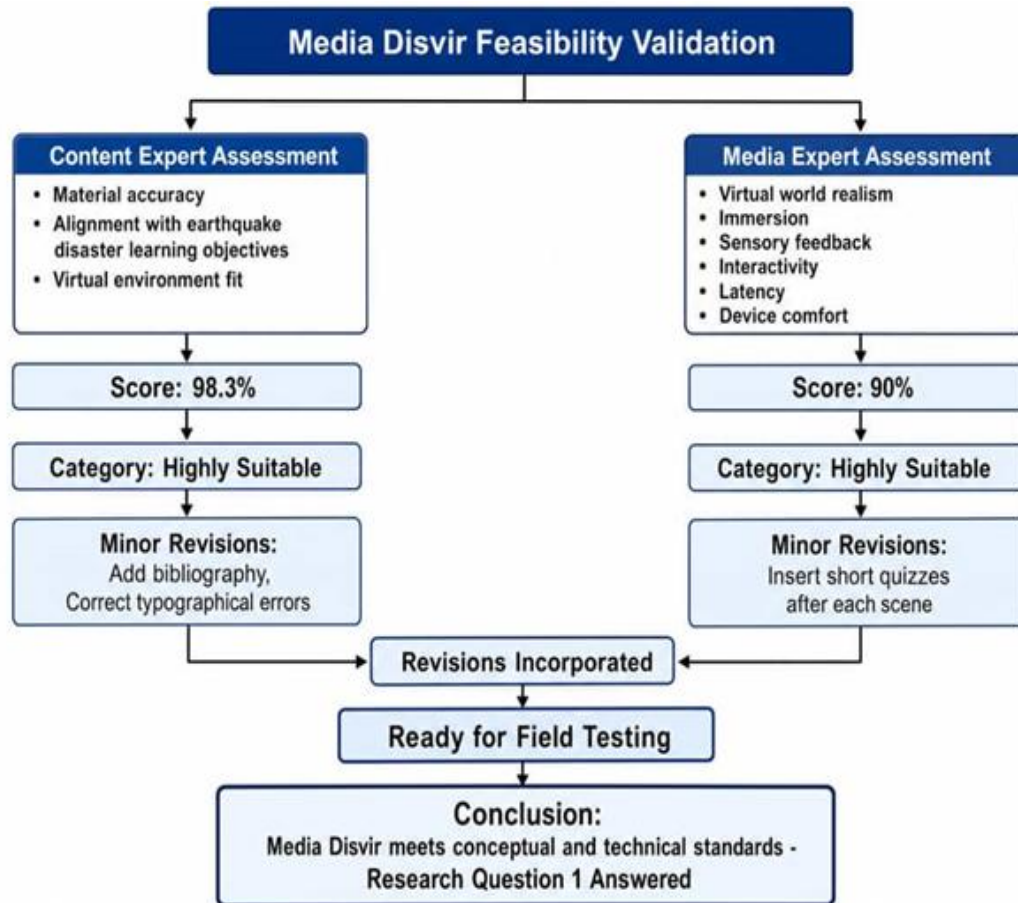


Figure 2. Feasibility of Media Disvir Based on Content and Media Expert Validation
Source: AI Visualization

Effectiveness Based on Teacher and Student Practicality Responses

The practicality test, administered across the limited trial, broad trial, and treatment class, produced consistently favorable results from students, averaging 86.78%, 85.2%, and 83.35% respectively, all within the "practical" category. Teachers' assessment was more moderate at 75%, still practical but noticeably lower than student scores. The range of 75%–86.78% reported here corresponds to the range stated in the abstract, with 75% representing the lowest teacher score and 86.78% representing the highest student score across the three trial stages.

This gap is worth noting: students, who directly operated the VR headset, experienced the medium as intuitive and engaging, while teachers' more moderate score likely reflects operational concerns such as classroom management, device readiness, and internet dependency that do not weigh as heavily in students' immediate experience. Even so, both stakeholder groups ultimately rated Media Disvir as practical, answering the second research question by showing that the medium functions effectively not only in controlled testing but within the everyday realities of the MA MILBoS classroom.

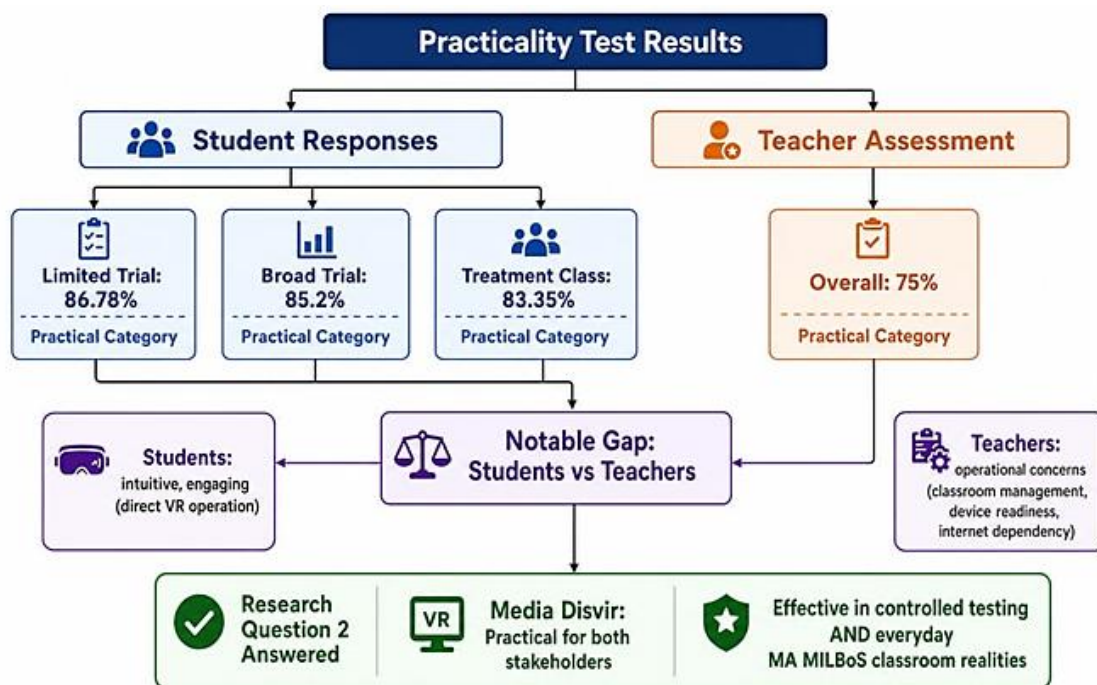


Figure 3. Effectiveness Based on Teacher and Student Practicality Responses

Source: AI Visualization

Improvement in Students' Disaster Cognition

The effectiveness test showed a clear, statistically significant increase in students' disaster-related cognition after using Media Disvir. Paired-sample t-test results across the three trial groups produced t-values of -5.684, -6.747, and -7.447, all significant at $p < 0.05$, indicating a consistent rise in knowledge scores from pretest to posttest. The Cohen's D effect size for the treatment class reached -1.76, categorized as high, meaning the intervention produced a substantively large, not merely detectable, change.

This was corroborated by an N-Gain score of 0.78, falling into the high-effectiveness category, confirming genuine and meaningful improvement rather than marginal gain. This N-Gain result is broadly comparable to, and in some cases higher than, the gains reported in prior studies applying VR to secondary-level science and social studies content, where N-Gain scores in the moderate-to-high range (approximately 0.4–0.7) have typically been reported (Attalina et al., 2024; Saparuddin et al., 2024), the comparatively higher figure obtained here may be attributable to the disaster-specific, geographically contextualized scenario used in Media Disvir, rather than a generic simulation.

Several factors plausibly explain why VR produced this improvement in cognition. First, the immersive, 360-degree environment likely supported stronger spatial visualization of disaster phenomena than static two-dimensional media allows, which is directly relevant to the spatial-analysis competencies emphasized in the Kurikulum Merdeka. Second, the interactivity of the medium, including the scenario-based earthquake simulation, may have encouraged more active cognitive processing than passive reading or listening. Third, situating the simulation within a scenario resembling the school's actual seismic context may have increased the personal relevance of the material, a factor that prior disaster-education research associates with stronger retention (Mohammadinia et al., 2019; Suryani & Uningowati, 2020). These explanations are consistent with, though not definitively isolated by, the present findings, and disentangling the relative contribution of immersion, interactivity, and contextual relevance would require further study designed specifically for that purpose.

This finding directly answers the third research question, indicating that Media Disvir was associated with a meaningful improvement in students' cognitive understanding of earthquake disaster material. However, this claim should be interpreted with appropriate caution. Because the study did not employ a control group, the pretest-posttest gains cannot be attributed solely and conclusively to Media Disvir, other factors, including the teacher's accompanying instruction, test repetition effects, and general learning experience accrued during the research period, may also have contributed to the observed improvement. This limitation must be taken into account when interpreting the magnitude of the intervention effect., and future research incorporating a control group is recommended to more rigorously isolate the specific contribution of the VR medium itself.

CONCLUSION

Successful development was achieved during this Media Disvir study, a Virtual Reality-based Geography learning medium for earthquake disaster material, and demonstrated that it is highly feasible, practical, and effective for use at MA MILBoS. Validation by content and media experts placed the medium in the "highly suitable" category, while practicality testing among teachers and students confirmed its usability in real classroom conditions. Most significantly, statistical analysis showed a substantively large effect size and a high N-Gain score, confirming that Media Disvir meaningfully closed the cognitive gap identified at the outset of this research, moving students' understanding of disaster material much closer to the level associated with direct, experiential learning.

Beyond its pedagogical contribution, this research carries direct relevance to sustainable development. By strengthening inclusive, immersive, and learning-style-responsive instruction, Media Disvir advances SDG 4 (Quality Education), while its role in equipping a genuinely at-risk student population with practical earthquake preparedness knowledge directly supports SDG 11 (Sustainable Cities and Communities). Given that MA MILBoS sits on an active fault line and houses students around the clock, the improved disaster cognition demonstrated here is not merely an academic gain but a tangible contribution to student safety and long-term community resilience.

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