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Integration of WE-ARe Approach in Flood Mitigation Modules: Transforming Student Scientific Literacy

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Abstract

Recent declines in Indonesian students' scientific literacy, exacerbated by the post-pandemic learning loss and inadequate teaching materials, necessitate innovative instructional solutions. While contextual learning improves student engagement, the integration of the WE-ARe (Warm-up, Exploring, Argumentation, Resume) approach specifically into flood disaster mitigation modules remains underexplored in current literature. Therefore, this study aims to develop and evaluate the feasibility, instructional implementation, and effectiveness of a WE-ARe-based teaching module on students' scientific literacy. This Research and Development (R&D) study adopted the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The researchers selected 26 eighth-grade students at MTs Maslakul Huda as the research sample using a purposive sampling technique. Furthermore, the researchers collected data through expert validation questionnaires, instructional observation sheets, and scientific literacy tests. The results demonstrated high product feasibility, with validation scores from material (83.33%), media (75.00%), and language experts (85.71%) indicating strong validity. During the intervention, the instructional implementation achieved an excellent category average of 92.00%. Finally, the paired sample t-test revealed a significant improvement in students' scientific literacy ($p = 0.001 < 0.05$). In conclusion, the WE-ARe-based flood mitigation module provides a valid, highly implementable, and effective pedagogical tool to elevate students' scientific literacy, offering a scalable framework for disaster-resilient science education.

Key words: Flood Disaster, Mitigation Scientific Literacy, Teaching Module, WE-ARe Approach..

INTRODUCTION

The rapid evolution of global scientific developments transforms the primary focus of 21st-century education onto scientific literacy mastery at the international level (Yusmar & Fadilah, 2023). Modern educational standards demand the acquisition of this comprehensive scientific literacy within contemporary curricula (AT Hidayat & Hidayati, 2024). Forward-thinking educators integrate essential components of scientific literacy throughout their daily instructional processes (OCDE, 2024). Ideal pedagogical frameworks facilitate the optimal development of these analytical skills inside dynamic academic environments (Chiu et al., 2024; Kadıoğlu-Akbulut et al., 2023). However, recent global disruptions like the pandemic present unprecedented challenges against the achievement of these ideal educational conditions (Deshmukh, 2024). Innovative instructional interventions offer potential solutions to bridge this critical gap in science education.

The WE-ARe (Warm-up, Exploring, Argumentation, Resume) approach introduces a structured

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pedagogical mechanism into modern science education practices (Adiansyah, Asmah, et al., 2023; Amin et al., 2024; Tjereni et al., 2024). Recent international studies demonstrate the fundamental effectiveness of the WE-ARe model across various scientific disciplines (Adiansyah, Muliana, et al., 2023). The collaborative features of WE-ARe elevate student cognitive engagement during active learning interventions (Amin et al., 2024). Educational developers formulate diverse adaptations of WE-ARe for specific instructional needs. The systematic application of WE-ARe mitigates conventional passive learning constraints significantly (Adiansyah, Muliana, et al., 2023). This interactive methodology supports the transformation of conceptual learning in a highly systematic manner.

Recent bibliometric analyses of global literature reveal an exponential increase in publications regarding interactive learning modules and scientific literacy (Arroyo-Barrigüete et al., 2023; Saragi & Wulan, 2025; Sengul, 2023; Zillich et al., 2024). The majority of international researchers investigate the utilization of instructional modules within general science contexts (Putri et al., 2023; Sharma et al., 2020). The global scientific community employs robust experimental methodologies to validate their educational findings (Sheptian et al., 2024; Wusqo et al., 2021). Leading scholars acknowledge the profound importance of interactive modules for the continuous improvement of educational quality (Ismaniati & Iskhamdhanah, 2023; Simbolon et al., 2024; Trinoviorar, 2024). Current research trends explore the technological dimensions of modern teaching modules comprehensively (Hartini et al., 2024; Sanjaya et al., 2022; Sary et al., 2023). Nevertheless, this extensive literature map leaves a prominent void regarding specific contextual integrations.

Eighth-grade students at MTs Maslakul Huda experience severe difficulties in mastering scientific literacy on contextual environmental topics. This conceptual limitation decreases the quality of their overall learning achievements during formative academic evaluations. Science educators at this institution lack appropriate teaching media and contextual materials inside their classrooms. Furthermore, the school's geographical location near flood-prone areas necessitates the immediate integration of disaster mitigation topics into the science curriculum. A preliminary observational study records the complete absence of flood mitigation instruction at the research site. Therefore, this educational institution requires a comprehensive learning intervention to address this critical academic crisis urgently.

Local educational practitioners utilize conventional instructional solutions to mitigate these academic deficiencies. These traditional learning modules fail to resolve the root causes of low scientific proficiency completely. Several neighboring schools adopt generic disaster education materials without adequate local contextual adaptation. This partial instructional approach hinders the continuous evaluation process of disaster preparedness in the field. Previous module development studies separate the vital elements of active learning and

environmental contexts within their intervention designs. This collective methodological limitation generates suboptimal cognitive impacts for the development of the target subjects.

Current educational literature neglects the explicit development of WE-ARe-based modules specifically to address flood disaster mitigation awareness. Previous academic studies have not tested the influence of the WE-ARe approach on this specific contextual environmental curriculum (Tjereni et al., 2024). Science education researchers rarely integrate comprehensive disaster mitigation frameworks into this specific active learning model (Funfuengfu, 2022; Rholl et al., 2023; Sadik & Abdulmonem, 2021). Prior instructional investigations exclude junior high school demographics in disaster-prone areas from their primary research samples. This glaring gap in the literature restricts the ultimate optimization of pedagogical solutions within this critical scientific domain. Future scientific inquiries must bridge this empirical and theoretical divide immediately.

This current study proposes the systematic development of a WE-ARe-based teaching module as a strategic educational solution. The proposed instructional intervention combines the pedagogical phases of WE-ARe with the contextual urgency of flood mitigation. The dynamic mechanism of the WE-ARe approach processes the complex components of scientific literacy highly systematically. The design of this learning solution translates essential scientific competence indicators into a series of measurable instructional steps. The newly designed teaching module accommodates the specific contextual needs of MTs Maslakul Huda students in accordance with the Independent Curriculum framework. This holistic module solution is projected to overcome the conventional pedagogical limitations of the past effectively.

This particular research presents a novel instructional module architecture that has never been comprehensively explored before. In contrast to previous studies, this academic investigation produces a brand-new contextual synthesis based on specific local geographical characteristics. The core design of this research applies a unique combination of active learning stages throughout its analytical developmental phases. This specific product development utilizes the constructivist theoretical framework of scientific literacy holistically. The proposed educational approach redefines the interactive relationship between disaster mitigation and the WE-ARe model in a completely new instructional dimension. These groundbreaking empirical findings will enrich the global scientific education discourse significantly.

This developmental research aims to develop and validate the WE-ARe-based teaching module for scientific literacy on the eighth-grade target population. The initial phase of this study examines the fundamental validity of the module through rigorous expert judgment procedures. The subsequent implementation phase measures the practical effectiveness of the module during the actual classroom learning intervention. The final evaluation phase analyzes the cognitive impact on scientific literacy via a Paired Sample T-

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Test statistical mechanism. The specific focus of this research restricts the scope of the material evaluation strictly to flood disaster mitigation concepts. This structured developmental process will generate robust empirical answers systematically.

The final results of this study expand the theoretical understanding of disaster-based education within the broader science literature. The practical findings of this research facilitate the instructional performance of local science educators in real-world academic environments. Educational policymakers can utilize these evidence-based recommendations to design future disaster-resilient curricula guidelines. The upcoming methods section will outline the R&D design and validation instruments thoroughly in the next academic segment. The subsequent results section will present the expert validation scores and the t-test data findings highly systematically. Finally, the discussion section will deliberate the profound implications of these findings against the wider framework of global science education.

METHOD

This study applied a Research and Development (R&D) approach to evaluate the effectiveness of the flood mitigation teaching module (Irawan & Hakim, 2023; Torang Siregar, 2023). The specific ADDIE instructional design model facilitated the impact measurement of the WE-ARe approach systematically shows at Figure 1 (Dwita Dana Pradipta et al., 2021; Septaria et al., 2025; Sunedi & Syaflin, 2024). The researchers adopted the five sequential phases of Analysis, Design, Development, Implementation, and Evaluation as the primary developmental framework (Almelhi, 2021; Rahmawati et al., 2021; Septaria, 2023). This operational framework guided every developmental stage from the initial needs analysis to the final product evaluation. The selection of this design considered the complex characteristics of scientific literacy problems in actual field conditions. This methodological approach guaranteed a high level of research precision for the final conclusion drawing process.

The research population encompassed all 106 eighth-grade students at MTs Maslakul Huda Dengok Paciran Lamongan. The research team selected 26 participants from class VIII BCP3 through a purposive sampling technique (Wardah et al., 2022). The inclusion criteria required a homogeneous baseline of environmental understanding and specific science curriculum alignment as the primary participation requirement. The selection process excluded potential sample candidates from other parallel classes that did not meet this specific academic parameter. The demographic distribution of this sample represented the diversity of gender and cognitive abilities proportionally. All participants and their guardians signed ethical informed consent forms before the data collection process commenced.

The primary data collection utilized validation questionnaires, observation sheets, and scientific literacy tests during the measurement phase. The test instrument measured the students' scientific literacy indicators based on

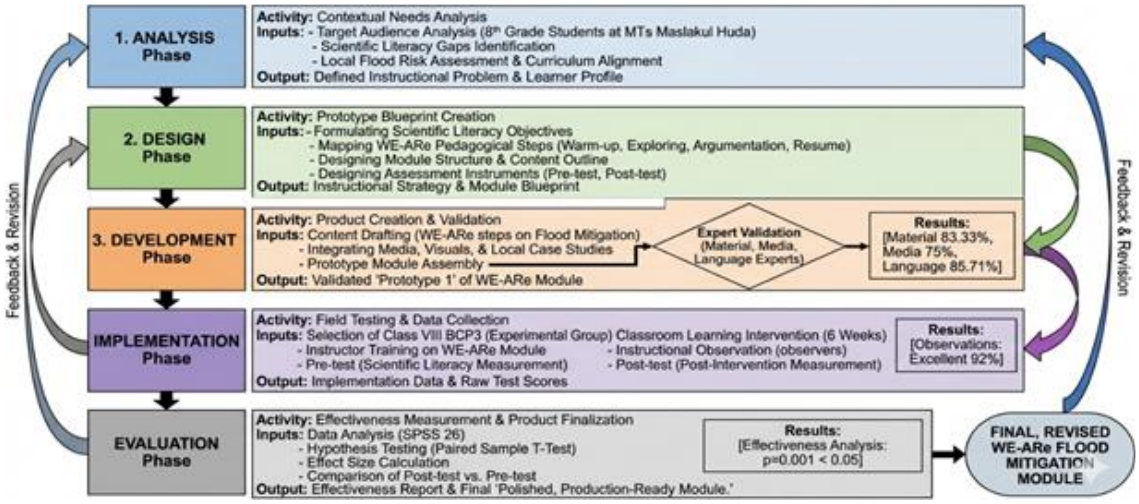


Figure 1. Flowchart of the ADDIE Model Research and Development (R&D) Process for the WE-ARe Based Flood Mitigation Module.

internationally recognized science taxonomies (Georgiou, 2023; Mujtahid & Radeswandri, 2025; Sotério et al., 2023; Zarestky & Vilen, 2023) shows in Table 1. Three expert lecturers validated the constructs of the instructional module drafts through a rigorous expert judgment process. A preliminary limited trial produced excellent Cronbach's Alpha reliability data for the test items during the pre-measurement stage. This meticulous calibration process eliminated ambiguous or biased question items from the final version of the instrument. The finalized assessment tools met international psychometric standards convincingly for academic publication.

The implementation phase involved the entire research sample within a single experimental testing group. This experimental group received the WE-ARe module intervention treatment during the allocated science learning period. Two independent observers recorded the implementation of the learning process using structured instructional observation sheets (Adamskiy & Kolachev, 2024; Jatmiko et al., 2024). The researchers administered an initial test (pre-test) and a final test (post-test) to this specific subject group. The field supervisors monitored the intervention implementation to minimize instructional biases dynamically. The entire series of processes documented the subjects' cognitive responses into a secure digital database.

The computational stage processed the raw measurement data using the latest version of SPSS statistical software. The prerequisite tests evaluated the normality of data distribution and the homogeneity of variance before the main hypothesis analysis occurred. The researchers applied the Paired Sample T-Test statistical method to compare the achievement scores before and after the intervention (Badeo & Koc, 2021; Rasyid et al., 2023; Samsudin et al., 2023; Wardah et al., 2022). Additional metric analyses measured the instrument validity criteria more specifically using

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Table 1. Matrix of Data Collection Instruments and Measured Indicators

No	Data Collection Instrument	Target Respondent / Source	Measured Variables & Indicators	Administration Phase
1	Expert Validation Questionnaires	Material, Media, and Language Experts	Feasibility, content validity, instructional design construct, and linguistic clarity of the WE-ARe module.	Development Phase (Pre-Implementation)
2	Instructional Observation Sheets	Independent Observers	The practicality and systematic execution of the WE-ARe pedagogical steps (Warm-up, Exploring, Argumentation, Resume) in the classroom.	Implementation Phase (During Intervention)
3	Scientific Literacy Tests (Multiple Choice/Essay)	8th-Grade Students (Experimental Group)	Cognitive mastery and contextual problem-solving skills regarding flood disaster mitigation based on scientific literacy taxonomies.	Implementation Phase (Pre-test and Post-test)

expert feasibility percentages (Djatmiko et al., 2020; Subari & Mercuriani, 2024; Wulandari et al., 2022). This inferential statistical test determined the practical impact magnitude of the WE-ARe module on the research sample. All hypothesis testing established the significance level (alpha = 0.05) as the absolute boundary for statistical acceptance.

RESULT AND DISCISSION

The research team executed the Analysis, Design, and Development phases to create a contextually relevant instructional tool. The initial needs analysis at MTs Maslakul Huda identified a critical shortage of interactive media for environmental science. Educators reported that students struggled to connect abstract scientific concepts with local flood phenomena. The researchers subsequently designed the module blueprint by integrating the WE-ARe pedagogical stages with disaster mitigation materials. This instructional design prioritized the development of scientific literacy indicators through structured exploration and argumentation. The development phase culminated in the production of a prototype module ready for professional expert evaluation.

Three independent experts evaluated the module prototype to ensure its pedagogical, linguistic, and technical quality. The material expert focused on the accuracy of flood mitigation concepts and scientific literacy alignment. The media expert assessed the visual appeal, layout consistency, and interactive elements of the module. Simultaneously, the language expert reviewed the grammatical precision and the readability of the instructional instructions. These validators utilized standardized rubrics to provide quantitative scores and qualitative constructive feedback. Table 2 presents the detailed validation results and the

Table 2. Detailed Expert Validation Results and Product Refinements

Validation Domain	Score (%)	Category	Expert Feedback and Revision Implementation
Material & Content	83.33%	Very Valid	Advice: Strengthen the connection between flood causes and mitigation. Revision: Added local flood history and comparative analysis tasks.
Media & Design	75.00%	Valid	Advice: Enhance the clarity of infographics and cover aesthetics. Revision: Replaced low-resolution images with high-definition local disaster maps.
Language & Literacy	85.71%	Very Valid	Advice: Simplify complex scientific jargon for 8th-grade readability. Revision: Refined the glossary and simplified technical argumentation prompts.
Overall Average	81.35%	Very Valid	The module is statistically and pedagogically ready for field testing.

subsequent architectural refinements of the module.

The implementation phase involved 26 eighth-grade students from class VIII BCP3 during a designated six-week period. Two independent observers monitored the classroom activities to measure the consistency of the WE-ARe syntax application. The observation data recorded a high implementation average of 92.00% across all instructional sessions. This metric proves that the "Warm-up" and "Exploring" stages effectively stimulated student curiosity. The students participated actively in the "Argumentation" phase by discussing flood prevention strategies. These results demonstrate that the module is highly implementable within the actual constraints of a junior high school environment.

The research team conducted a rigorous cognitive assessment to evaluate the effectiveness of the intervention. The participants completed a pre-test to establish their baseline scientific literacy before using the module. After the six-week intervention, the researchers administered a post-test using identical scientific literacy indicators. The pre-test data showed a



Figure 2. teaching module cover

modest initial average score of 64.00 among the participants. However, the post-test results exhibited a significant upward trajectory with an average score of 80.00. This numerical progression indicates a substantial enhancement in student comprehension following the module integration (Ahmed et al., 2024; Orkodashvili, 2021; Syawaludin et al., 2024).

The statistical analysis utilized a Paired Sample T-Test to confirm the significance of the observed score

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increase. The computational output yielded a significance value of p=0.001, which is lower than the alpha threshold of 0.05. This result confirms that the WE-ARe-based module exerted a positive and significant influence on scientific literacy. The subsequent N-Gain calculation provided a deeper insight into the specific indicator improvements. Content knowledge and procedural knowledge achieved moderate gain scores of 0.68 and 0.47, respectively. Nevertheless, epistemic knowledge and information interpretation recorded lower gains, indicating areas for future pedagogical refinement.

The significant improvement in scientific literacy scores originates from the structured nature of the WE-ARe approach. The "Warm-up" phase successfully activated the students' prior knowledge regarding local environmental issues. The "Exploring" stage allowed students to investigate the scientific mechanisms behind flood disasters independently. Through "Argumentation," students developed critical thinking skills by defending their proposed mitigation solutions (Casey, 2019; Shahin et al., 2025; Ummah, 2022). The "Resume" phase solidified their conceptual understanding by synthesizing the explored information. Consequently, this systematic pedagogical sequence transformed passive learning into an active cognitive experience (Ayers, 2024).

The high implementation score of 92.00% reflects the synergy between technology and pedagogy in the module. The integration of local disaster contexts made the science lessons more relevant to the students' daily lives (Budi et al., 2023; Ridha et al., 2025; Sutopo, 2022). Students felt more motivated to learn when they analyzed flood risks surrounding their own school environment (Ma'dan et al., 2020; Nurhasnah et al., 2022; Puspitasari et al., 2023). The interactive nature of the module reduced the cognitive load associated with complex scientific terminology (Buljung et al., 2023). This instructional environment fostered a sense of urgency and responsibility toward environmental preservation (Fauzian, 2021). Thus, the module served as both a cognitive tool and a motivational catalyst.

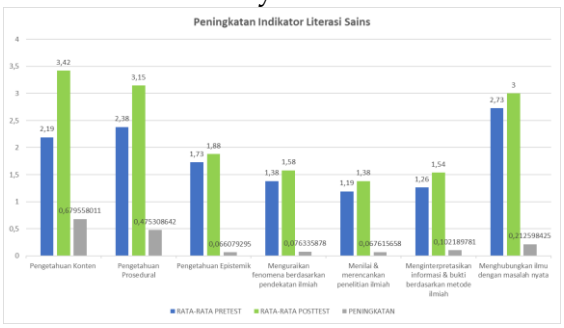


Figure 3. Scientific literacy indicator values

The moderate N-Gain results in content and procedural knowledge suggest a successful foundational mastery. However, the stagnation in epistemic knowledge indicates that students still struggle with the nature of scientific inquiry (Elhai, 2023; Fatmaryanti et al., 2022; Kurup et al., 2021; Nasir et al., 2022; Şensoy & Güneş, 2023). This phenomenon suggests that eight-grade students require more time to master higher-order thinking skills (Atmojo et al., 2024; Hursen, 2021; Luzyawati et al., 2025). Developing the ability to connect scientific knowledge with real-world problems remains a significant pedagogical challenge (Bakar,

2021; Morgacheva et al., 2023; Qolbyatin et al., 2023). Future instructional designs should incorporate more complex, open-ended investigative tasks to stimulate epistemic growth. A more longitudinal approach might be necessary to achieve balanced development across all literacy indicators.

These findings strongly support the theoretical framework of constructivist learning in science education (Göschlberger et al., 2022; Kussmaul & Pirmann, 2021; Nurhidayati, 2017). The success of the WE-ARe module aligns with Rahmi's (2021) emphasis on the importance of contextual exploration. By addressing local flood issues, this research fulfills the requirements of the Sustainable Development Goals (SDGs) for quality education (Hafshah & Nugraheni, 2024; Rilianti & Huda, 2023; Saengkaew et al., 2024). This study proves that innovative, localized teaching materials can bridge the gap between theory and practice. The module provides a scalable model for other disaster-prone regions in Indonesia. Ultimately, this research offers a robust contribution to the global discourse on disaster-resilient science education.

CONCLUSION

This study confirms that the WE-ARe-based flood mitigation module significantly enhances junior high school students' scientific literacy. The systematic integration of the WE-ARe approach facilitates a structured transition from conceptual science understanding to contextual disaster preparedness in the classroom. Science educators can adopt this innovative module as a practical instructional tool to bridge the gap between abstract concepts and real-world environmental challenges. Furthermore, school administrators and curriculum planners should incorporate such adaptive modules to strengthen the national disaster-resilient education framework effectively. However, the localized scope of this implementation limits the absolute generalization of these findings to diverse or non-flood-prone demographics. Therefore, future researchers must execute longitudinal studies involving larger samples and various grade levels to refine the module's universal applicability across different scientific topics. Ultimately, this pedagogical innovation drives the transformation of science education toward a more inclusive and disaster-resilient learning ecosystem.

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