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Development of Enrichment Science Module on Clean Water in Mining Areas Assisted by Mind Mapping to Improve Ninth Grade Students' Literacy

Pengembangan Modul Pengayaan IPA Air Bersih di Wilayah Pertambangan Berbantuan *Mind Mapping* Untuk Meningkatkan Literasi Siswa Kelas IX

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Abstract

One method that can help students understand contextual science learning is the mind mapping model, which contains material on clean water management. The objectives of this study are 1) to produce a clean water science enrichment module assisted by mind mapping to improve environmental literacy of ninth-grade students; 2) to conduct validation and limited-scale trials of the mind mapping-assisted science enrichment module for ninth-grade students. This study produced a mind mapping-assisted science enrichment module aimed at improving the environmental literacy of junior high school students. The research is a development study referring to the Thiagarajan 1974 development model, namely 4D (Define, Design, Develop, and Disseminate). The results of the study show expert validation results with high scores in content aspects at 83.17, language 85, presentation 85, and literacy potential 84. This concludes that the clean water science enrichment module in mining areas assisted by mind mapping to improve the environmental literacy of ninth-grade students is valid and feasible to use.

Article Information

Keywords:
Module; *mind mapping*; literacy, environmental issue;

Salah satu metode yang dapat membantu peserta didik dalam memahami pembelajaran IPA yang bersifat kontesktual adalah model mind mapping yang memuat materi tentang pengelolaan air bersih. Tujuan penelitian ini adalah 1) menghasilkan modul pengayaan IPA air bersih berbantuan mind mapping untuk meningkatkan literasi lingkungan siswa kelas IX; 2) melakukan validasi dan ujicoba skala terbatas modul pengayaan IPA berbantuan mind mapping pada siswa kelas IX. Penelitian ini menghasilkan modul pengayaan IPA berbantuan mind mapping untuk meningkatkan literasi lingkungan siswa SMP. Penelitian merupakan penelitian pengembangan yang mengacu pada model pengembangan Thiagarajan 1974 yaitu 4D (Define, Design, Develop, dan Disseminate). Hasil penelitian menunjukkan hasil validasi ahli dengan skor tinggi pada aspek isi dengan nilai 83,17, kebahasaan 85, penyajian 85, serta potensi literasi 84. Hal ini menyimpulkan bahwa modul pengayaan IPA air bersih di wilayah pertambangan berbantuan mind mapping untuk meningkatkan literasi lingkungan siswa kelas IX valid dan layak digunakan.

Kata kunci:
Modul; *mind mapping*; literasi; isu lingkungan;

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A. INTRODUCTION

Education plays an important role in shaping a generation that is intelligent, creative, and environmentally conscious. According to Zuhdy (2024), education not only serves to transfer knowledge but also develops attitudes and skills relevant to the needs of the 21st century. One important competency is scientific and environmental literacy. Scientific literacy is crucial to equip the younger generation to face global environmental issues, including clean water problems. (Hollweg et al., 2011).

One of the main issues that often arises is the pollution of clean water due to mining waste, whether in the form of hazardous chemicals, heavy metals, or sedimentation. Clean water, which is a basic human need, is often threatened in quality, impacting public health and the sustainability of aquatic ecosystems. Community waste around mining sites adds other environmental problems, such as sources of disease, aesthetics, and causes of flooding. According to Siahaan (2019), improper management of mining waste has the potential to cause serious environmental damage, particularly to water and soil quality, and adversely affect the health of communities around mining areas.

Science learning is one of the subjects that can include material on clean water management. The management of clean water must be instilled in students from school age, so that they can grow into a generation that cares about and is able to protect the environment around them. Science learning in schools still largely uses conventional teacher-centered methods. Arends (2012) stating that learning that is only oriented towards delivering material makes students passive and less trained in critical and creative thinking. As a result, important concepts such as the water cycle, clean water treatment, and the impact of water pollution are not deeply understood by students, even though this topic is very relevant to their daily lives. One of the main problems in science learning at school is the lack of contextual material, so students often have difficulty understanding the connection between the theory taught and its application in everyday life. This was also conveyed by Mulyasa (2015), who stated that learning that is not contextual can hinder the development of students' skills in relating theory to real-life practice.

One of the methods that can be used to help students understand contextual science learning is through the use of mind mapping. Mind mapping can significantly enhance contextual learning by providing a visual representation that facilitates understanding and information retention. This approach allows students to connect concepts across different contexts, thereby improving problem-solving skills and cognitive outcomes (Jahring et al., 2020). Mind mapping fosters visual and associative thinking, which is very important. This method helps in organizing complex information and enhancing memory retention (Murugova & Verbovataya, 2022). Mind mapping promotes the development of cognitive abilities by encouraging students to create connections between concepts, thereby enhancing understanding and information retention (Arulselvi, 2017) (Tehnic & Cotea, 2024).

Based on observations conducted by the researcher at schools in the mining area, namely SMP Negeri 4, SMP Negeri 9, SMP Negeri 13, and SMPN Satap Gemaf in Central Halmahera Regency, North Maluku Province, on October 2, 2023, it was found that the science (IPA) material designed by teachers still focused on the textbook and lacked enrichment based on the surrounding environment. The learning process was still not optimal, resulting in students' understanding and environmental literacy being categorized as low, particularly regarding behavior and attitudes towards the environment. To address this issue, one strategy implemented was developing a clean water science enrichment module in the mining area with the aid of mind mapping to improve the literacy of ninth-grade students.

B. METHOD

Research Design

This research falls under the category of Research and Development (R&D), using a development model by Sivasailam Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel, which consists of four development stages: Define, Design, Develop, and Disseminate. This study was conducted only up to the development stage, considering that a small-scale test had already been carried out in the third stage.

Define

Definition is carried out to identify needs in the learning process. This stage is conducted through a preliminary study by interviewing teachers at the school. The definition stage carried out includes curriculum analysis, which serves to determine the competencies in the integrated science module. Needs analysis aims to find out whether it is necessary to develop mind mapping-based teaching materials through interviews with science teachers. Concept analysis is carried out to identify the main concepts to be presented according to the learning outcomes. A mind mapping-assisted module will be developed based on Learning Outcomes (LO), specifically on content related to environmental issues on clean water topics.

Design

The design begins by determining the material or content, estimating the size and number of pages, and designing a mind map. The design stage includes the initial phase in designing a science module assisted by mind mapping by determining the material to be included in the module; creating a design draft as a reference for the process of developing the science module; designing clean water material; and creating the closing section of the science module.

Development

This stage involves a small-scale test of the mind mapping-based module that was developed. The small-scale test during the development stage includes the validity and feasibility of the developed mind mapping-based module. Validity is carried out by validators who are experts in the design and development of learning media and have an understanding of the field of science. Practicality tests are conducted by two biology science teachers at the target school to assess the practicality of the biology science module in the teaching and learning process at the school. Student responses involve 10 students to observe their feedback on the developed module learning materials.

Research Time and Location

This research was conducted in the even semester of the 2024/2025 academic year, starting from February to May 2025. Data collection began in April 2025. This research was carried out at SMP Negeri 4, SMP Negeri 9, SMP Negeri 13, and SMP Negeri Satap Gemaf, Central Halmahera, North Maluku.

Research Subjects and Objects

The subjects in this study were students and validation was carried out by two validators, while the practicality was conducted by three science teachers. The object of this study was a science module assisted by mind mapping on the topic of clean water.

Research Instrument

The instruments in this study consist of questionnaires and interview guidelines. The questionnaires were created and validated by the supervisor. The interview guidelines are in the

form of a list of questions designed to obtain information related to issues in the school and the need for the teaching materials being developed.

Data Collection Techniques

Data collection techniques are methods of obtaining data to support research results. The data collection techniques used to gather data in this study are as follows:

Analysis of Teaching Material Validity

The results of the validity observation are then interpreted in a qualitative sense based on Table 1 below.

Table 1. Criteria for The Validity Test Results of Teaching Materials

No	Interval	Criteria
1	76% - 100%	VeryValid
2	51% - 75%	Valid
3	26% - 50%	Less valid
4	0% - 25%	Invalid

Practicality analysis of teaching materials

The results of the validity observation are then interpreted in a qualitative sense based on the following Table 2:

Table 2. Criteria for The Practicality Test Results of Teaching Materials

No	Interval	Criteria
1	76% - 100%	Very Practical
2	51% - 75%	Practical
3	26% - 50%	Less Practical
4	0% - 25%	Impractical

The results of the validity observation are then interpreted in a qualitative sense based on the following Table 3:

Table 3. Criteria for Student Response Test Results

No	Interval	Criteria
1	76% - 100%	Very Good
2	51% - 75%	Good
3	26% - 50%	Not Good
4	0% - 25%	Bad

C. RESULT AND DISCUSSION

The results of the research on the development of a science enrichment module product assisted by mind mapping, focusing on clean water material in mining areas, were carried out through several stages, namely: identification of the needs for the enrichment module (Analysis), design of the enrichment module product (Design), validation and refinement of the module design (Development), limited-scale trials (Implementation), and revision of the enrichment module product (Evaluation).

Analysis

At the analysis stage, an initial study was conducted to obtain information related to the science enrichment module in the target schools through biology teachers using questionnaires and interviews. Based on the results of interviews at SMP Negeri 4 and SMP Negeri 9, Central Halmahera, it was found that science learning, especially on the topic of clean water, still uses

lecture and assignment methods. This causes students to be less active in exploring concepts and tends to have difficulty connecting the material to everyday life. Students are more interested in learning that presents pictures, diagrams, or concept maps. Therefore, the use of mind mapping is considered appropriate to help students organize knowledge. This is in accordance with what was stated by Rai et al (2025); Tehnic & Cotea (2024) that the use of images, colors, and symbols in mind mapping aids visual learning, making complex information more accessible and easier to understand. According to Tehnic & Cotea (2024), the interactive nature of using mind mapping keeps students engaged, making learning more enjoyable and effective. Moreover, limited time and learning resources are major obstacles, as the existing modules are not integrated with teaching strategies that demand higher-order thinking skills, making it difficult for students to develop their analytical and creative abilities. Arulselvi (2017); (Rai et al., 2025), state that mind mapping stimulates creativity by allowing students to express their thoughts in a dynamic format, which can lead to more innovative ideas and solutions. As for the data obtained based on the questionnaire given to science teachers at SMP Negeri 13 Halmahera Tengah, most teachers stated that enrichment modules that are practical and innovative are still limited.

Design

The activities carried out in the design stage are more focused on the results obtained in the analysis stage. Based on the analysis conducted, the module title was determined as Enrichment Module on Clean Water Science in Mining Areas Assisted by Mind Mapping to Improve the Literacy of 9th Grade Students. Developing a mind mapping-based module can help students construct knowledge by connecting the concept of clean water with real environmental issues. According to Ausubel's theory (Advance Organizer), mind mapping functions as a link to prior knowledge so that students can more easily understand the concept of water pollution in mining areas and how to manage it. The use of text and images in mind mapping makes it easier to process information, thereby strengthening students' memory. Contextual Teaching and Learning (CTL) in the developed module can relate science concepts to everyday life, particularly the issue of providing clean water in mining areas. Thus, students not only master the concepts but are also able to apply them in real life. This is in line with what was stated by (Murugova & Verbovataya, 2022), that mind mapping can enhance contextual learning by visualizing information, promoting associative thinking, and facilitating understanding. This approach encourages learners to connect concepts, thereby improving comprehension and retention, making it an effective tool in learning. In addition to what has been previously explained, there are several aspects that need to be considered in this design stage, including aspects of material/content, screens/media, and writing/language. The science enrichment module on clean water in mining areas includes several topics, namely: 1) the concept of clean water, 2) clean water and mining, 3) water treatment and quality testing, 4) efforts to preserve clean water, 5) mind mapping as a learning strategy.

Development

The validation data in the development of science enrichment include information obtained from content expert validation and the effectiveness results of the module in improving environmental literacy. The learning module developed in this study has undergone a validation process by experts to ensure its quality and feasibility before being used in learning. Validation was conducted by assessing several key aspects, including content feasibility, language, presentation or learning media, as well as usability and literacy potential. Each aspect was

evaluated using standardized assessment instruments, so the results can provide an objective overview of strengths and aspects that still need improvement.

Figure 1 below presents the results of the validation in the form of percentages or scores, which serve as a reference for assessing the extent to which this module meets the criteria as contextual enrichment teaching material and is feasible for use in the field.

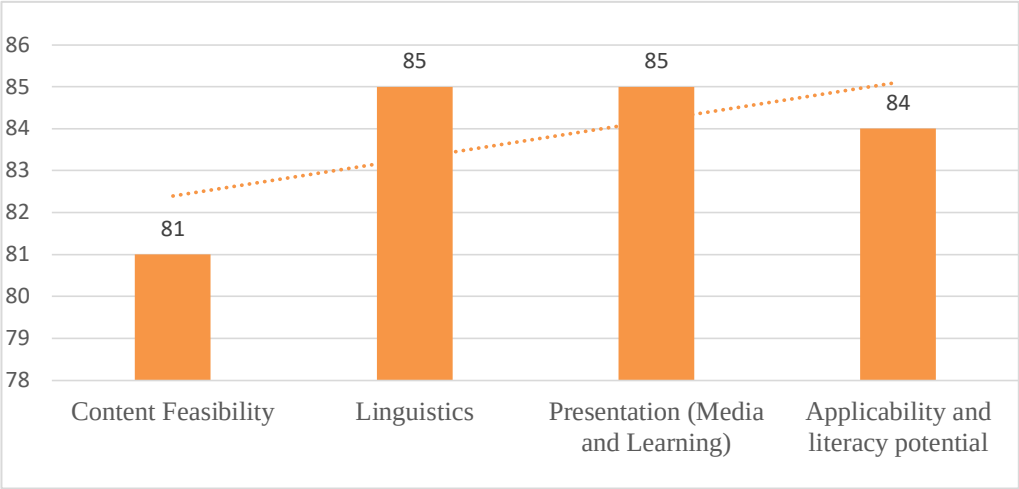

Figure 1. Module validation results

Based on Graph 1, it can be seen that all aspects of the teaching module assessment received high scores, ranging from 78 to 86. Content feasibility received a score of 81, indicating that the material presented is already in line with the learning objectives and relevant to students' needs. The language aspect received a score of 85, showing that the language used meets proper language standards, is easy to understand, and communicative for readers. The presentation or learning media also achieved a score of 85, meaning that the appearance, layout, and completeness of the media are effective in supporting the learning process.

Meanwhile, usability and literacy potential are in the range of 84–86, indicating that this teaching material has a high capability for practical use and promoting students' literacy skills. The relatively even scores across each aspect show that there are no significant weaknesses. Both language and presentation aspects, which each scored 85, indicate the main strengths of this teaching material, where information is delivered clearly, systematically, and engagingly. Content feasibility with a score of 81 falls into the good category, although there is still room for development to enrich the material, add contextual examples, or present deeper new facts.

The applicability and high literacy potential affirm that this material can be used not only in a formal classroom context but also to support self-directed learning for students in mining areas. This also indicates that the enrichment teaching module developed is relevant to the real-life experiences of students in mining regions, reinforcing the contextual aspect, which is one of the important indicators in developing enrichment teaching materials. The high literacy potential also shows that this teaching module is capable of developing students' reading, writing, and critical thinking skills, making learning more meaningful.

Based on the overall validation scores, according to the material validators, the developed teaching materials fall into the category of "highly feasible" for use in learning. Thus, this IPA (science) enrichment module assisted by mind mapping with clean water material is suitable for implementation in the learning process, particularly to enhance environmental literacy for ninth-grade junior high school students in mining areas. Mind mapping can improve memory,

creativity, as well as students' understanding of complex materials. This module can be used both in face-to-face learning and self-study at home, and teachers can also utilize it as enrichment material for students with higher abilities (Buzan & Griffiths, 2013). Mind mapping promotes the development of metacognitive skills by requiring students to engage in self-regulation and reflection during the learning process (Ding, 2023).

Implementation

A limited-scale trial of the science enrichment module product was conducted in the ninth grade of SMP Negeri Satap Halmahera Tengah with 31 students in the 2024/2025 academic year. A large-scale trial of the science enrichment module product was conducted in the ninth grade of SMP Negeri 4 Halmahera Tengah with 30 students, SMP Negeri 9 Halmahera Tengah with 27 students, and ninth grade of SMP Negeri 13 Halmahera Tengah with 29 students.

The mind mapping-based teaching module that was developed has been trialed on a limited basis to measure its effectiveness and ease of use in junior high school science learning, particularly on the topic of clean water in mining area regions. The trial results showed an increase in scores experienced by students after being given the learning module in class. This is reflected in the students' pretest score of 45.71, which increased to 84.87 on the posttest, resulting in an improvement difference of 39.16 points, which falls into the high category. This indicates that the module is effective in enhancing students' understanding. This improvement demonstrates that the mind mapping approach facilitates students in organizing concepts visually, makes memorization easier, and systematically connects information across topics.

Mind mapping significantly improves learning outcomes across various subjects. In a conducted study, students showed marked improvements in the cognitive, affective, and psychomotor domains after applying mind mapping, with scores increasing from poor to very good across all these domains (Sari & Romadhon, 2024). It is further explained that, in science education, mind mapping has been proven to improve students' academic performance, indicating that it can be a powerful tool to enhance learning outcomes in subjects (Ahmed et al., 2022).

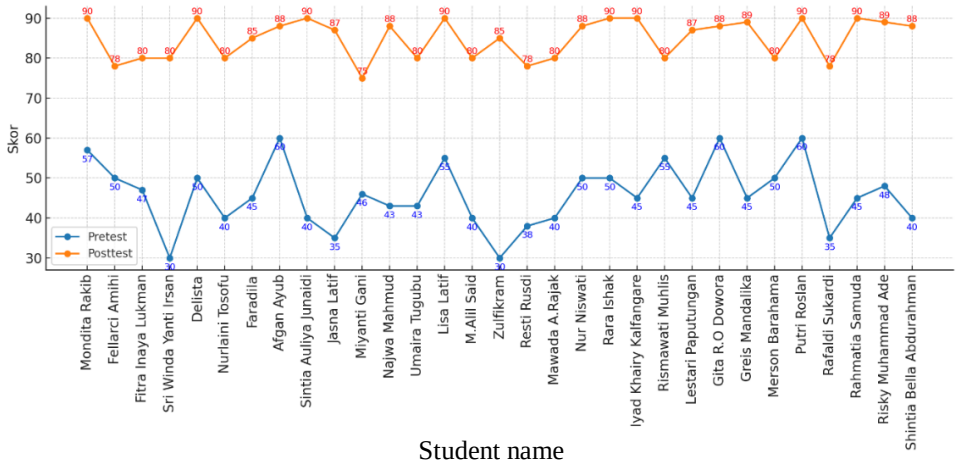

Figure 2. Student Scores

Its effectiveness is evident not only from the increase in average scores but also from the consistency of results among almost all participants, indicating that mind mapping functions as a visual strategy to enhance cognition, thereby aiding in understanding complex material such as the clean water treatment process and environmental issues around mining areas..

In addition, this research is supported by studies showing that STEM learning models assisted by mind-mapping enhance students' science literacy. Since environmental science literacy includes the ability to evaluate evidence, understand cause-and-effect relationships, and consider solutions, these findings support the claim that mind-mapping can strengthen critical understanding in an environmental context (Hariyadi et al., 2023).

Evaluation

Revision of the science enrichment module product is carried out after the validator completes the validation stage of all instruments related to the development of the research product. The validation results, in the form of evaluations, as well as comments and suggestions from the validator, are then used in the review of product development.

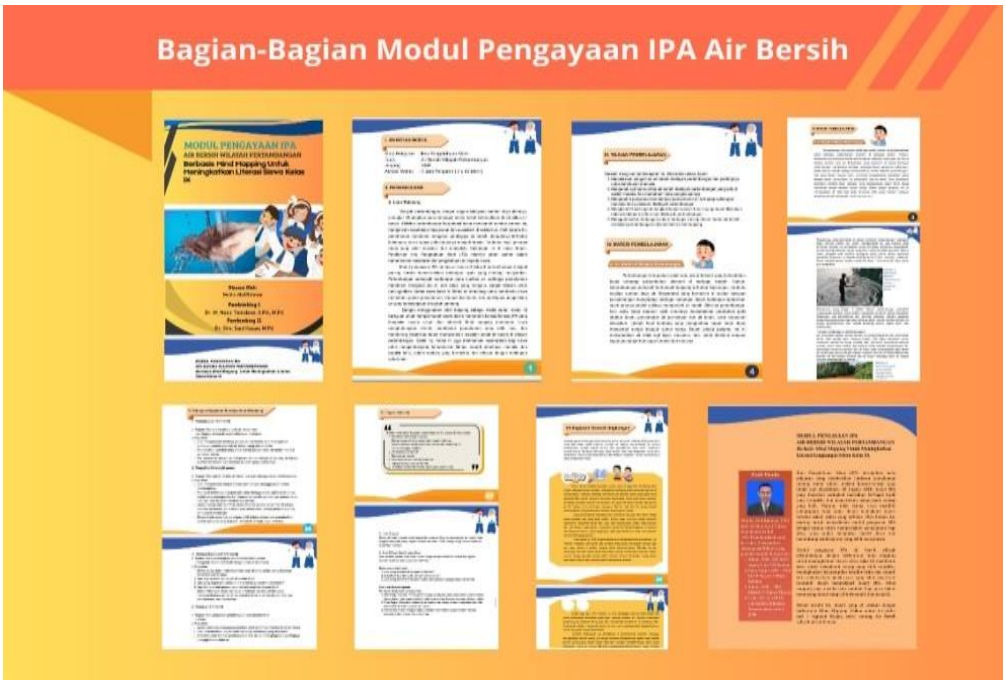

Figure 3. Components of The Developed Module

D. CONCLUSION

Based on the results of the research and development of the science enrichment module assisted by mind mapping on the topic of clean water in mining areas for ninth-grade students, it can be concluded that the research and development results show that the science enrichment module assisted by mind mapping on the topic of clean water in mining areas for ninth-grade students is feasible, effective, and beneficial. The module is considered very feasible based on expert validation with high scores in content aspects with an average score of 83.17, language 85, presentation 85, and literacy potential 84. Limited and field trials proved that this module improves students' cognitive learning outcomes as well as environmental literacy through concept visualization strategies using mind mapping. Furthermore, the module serves as a learning enrichment tool that can be used in class or independently to encourage students' creativity, critical thinking, and concern for environmental issues..

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