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Improvement of Eighth Grade Students' Scientific Thinking Skills Using Multirepresentation-Based E-Module in Science Subjects: Vibrations, Waves, and Light

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Abstract

This study aims to explore Improvement of Eighth Grade Students' Scientific Thinking Skills Using Multirepresentation-Based E-Module in Science Subjects: Vibrations, Waves, and Light. *The research design employed was the ADDIE model with five stages: analysis, design, development, implementation, and evaluation. The study sample consisted of one class, specifically Grade VIII D, which utilized multirepresentation-based e-modules in IPA, comprising 34 students (18 females and 16 males). Data collection included pre- and post-treatment assessments of conceptual mastery and application abilities using tests. Data analysis utilized the N-Gain test to compare the average score improvements before and after employing multirepresentation-based e-modules in IPA. The results indicate that the use of multirepresentation-based e-modules significantly enhances students' scientific thinking abilities in understanding concepts related to vibrations, waves, and light. These findings suggest that employing multirepresentation approaches within e-module technology can effectively enhance science learning at the middle school level.*

Keywords: *IPA e-modules, multirepresentation, scientific thinking abilities, vibrations, waves, light, middle school students*.

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INTRODUCTION

Education serves as the foundation to create skilled human resources required by a nation to face global competition (Anjasti et al., 2024). Efforts can be made through enhancing the quality of education in Indonesia. Improving educational quality is the responsibility of educators through the implementation of high-quality learning processes (Safitri et al., 2022). The learning process involves various interconnected components such as learning objectives, educators and learners, learning materials, methods, media, and assessment (). The achievement of quality learning can be determined by the implementation of learning processes that align with the learning objectives. This involves the use of engaging learning media to enhance learning outcomes. Engaging learning media can be created through the utilization of modern technology and incorporating components such as videos, images, sound, and others.

The use of technology is rapidly evolving, especially in supporting the learning process. Various technologies play a role in creating an engaging

atmosphere to make learners more interactive in the learning process, such as digital devices, the internet, and learning applications (Laili et al., 2022). Utilizing technology in learning ensures that the learning process is not solely reliant on textbooks and educators (Mahardika et al., 2023). This highlights the importance of technology-based learning media as a necessity for educators and learners. However, challenges in implementing technology-based learning media are often encountered due to insufficient technological proficiency and innovation among educators, as well as limitations in educational institution facilities (Rahma et al., 2023). Innovation in the learning process is necessary to address educational issues and create effective and efficient learning environments. One step towards achieving this is through using more interactive and innovative technology-based media in teaching and learning (Febrianty et al., 2023).

Science education (IPA) focuses on understanding and investigating natural phenomena using scientific methods (Sari & Sutihat, 2022). In an educational context, IPA is a subject taught in schools with the goal of enabling students to understand scientific fundamentals and develop comprehension, knowledge, and skills to tackle challenges (Fadila et al., 2023). IPA learning is associated with various student abilities, including scientific thinking skills, which are critical skills allowing students to observe, formulate questions, gather data, develop hypotheses, test ideas, and systematically interpret data (Afifah & Faizah, 2023).

According to a survey conducted among eighth-grade students, difficulties were reported in the IPA learning process, especially in understanding light as a wave, resulting in low mastery of concepts (Fitriyanti et al., 2020). This aligns with interviews conducted with teachers at SMP N 1 Rogojampi. Based on interviews conducted, students demonstrated relatively low scientific thinking abilities, managing to address issues but not in a scientific, systematic, and meticulous manner. Teachers indicated that the learning process relied on conventional methods supported by printed books, digital materials, and some teaching aids (Utami et al., 2023). The school's learning facilities were adequate, allowing students to access electronic devices during learning sessions. However, current media usage is limited to platforms such as WhatsApp, PowerPoint, and e-learning.

Observations revealed that the printed books distributed by schools lacked comprehensive material coverage, leading to passive student involvement in the learning process due to inadequate information provided and relying solely on what educators imparted. Science education at the junior high school level (SMP) plays a crucial role in establishing a foundation for understanding scientific concepts and scientific thinking skills among students. Therefore, an effective learning approach is needed to enhance understanding of IPA and students' scientific thinking abilities (Fitriyanti et al., 2020).

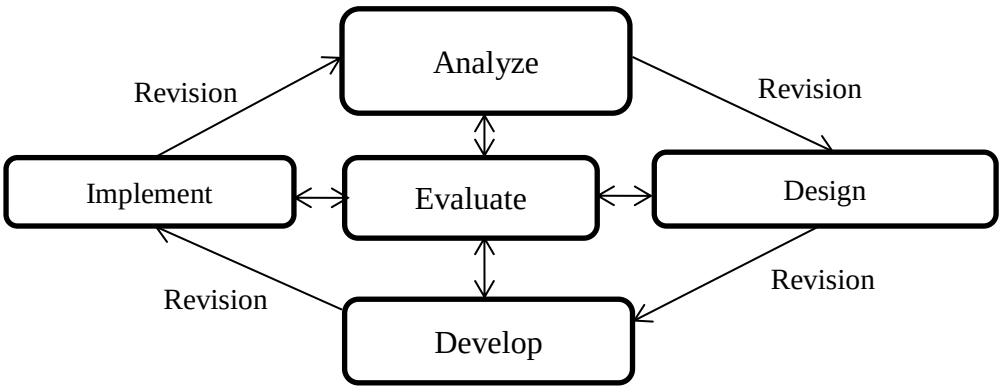
With the rapid advancement of technology, students find it more comfortable accessing simulations, videos, images, and graphics related to learning materials (Ilmiani et al., 2020). The use of digital technology in the

learning process can capture students' interest. Furthermore, students find it easier to understand material concepts through direct interaction based on available features (Nasir et al., 2022). One digital learning medium that can be used in the learning process is e-modules (Fitria et al., 2023). In the context of IPA learning, using more than one representation is essential to avoid misunderstandings of abstract IPA concepts. Therefore, appropriate learning media such as multirepresentation-based e-modules utilizing more than one representation are necessary (Yuliana et al., 2017). Additionally, e-modules serve as technology-based learning resources that students can use independently (Ulfa et al., 2023).

The researcher conducted observations and considerations, concluding that the development of multirepresentation-based e-modules for IPA as an alternative learning medium on vibrations, waves, and light is necessary (Arifin et al., 2024) . This development includes five representations: verbal representation, graphic representation, image representation, formula representation, and video representation. Research on learning media in the form of e-modules has not been conducted previously. Through this media development, it is expected to assist learners and educators in the learning process, particularly in enhancing learners' concept comprehension, and facilitating flexible and independent learning anywhere. This approach aims to increase students' motivation and enthusiasm in learning IPA.

RESEARCH METHOD

The research was conducted using Research and Development (R&D) with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. The flow of the development model can be seen in the following diagram.



Experimental Subjects

The product development's feasibility will be assessed by 3 expert validators. Once the development product has been deemed feasible, it will then be tested on 34 eighth-grade students of SMPN 1 Rogojampi.

Data Collection Instruments

The data collection instruments include validation sheets for the e-module, learning resources validation sheets, practicality sheets, and N-Gain analysis from

pre-test and post-test assessments.

Data Analysis Methods

The data analysis technique related to the validation sheets of e-modules and learning tools was conducted using Akbar's formula (2013).

$$V = \frac{T_{SE}}{T_{SM}} X\ 100\%$$

Ex: V : presentase validitas
T_{SE} : total score
T_{SM} : total score maximum

The average can be calculated using the following formula:

$$Va = \frac{V_1 + V_2 + V_3}{3}$$

The scores obtained from calculations using the Akbar formula are then interpreted based on criteria outlined in Table 1 below:

Table 1. Validity Criteria

Presentase	Level of Validity
86% - 100%	Very Valuable
71% - 85%	Valid
56% - 70%	Quite Valid
41% - 55%	Less Valid
25% - 40%	Not Valid

(Akbar, 2013)

The data analysis technique related to the practicality sheet is conducted using the formula from Arikunto (2014), as follows:

$$Sk = \frac{St}{Sm}\ x\ 100\%$$

Ex: Sk : Percentage of practicality
St : Total score of observations
Sm : Maximum possible score

The results of the percentage score on the practicality of the product are then interpreted into qualitative descriptive categories based on the reference criteria in the following table 2:

Table 2. Practicality Criteria

Presentase	Level of Practicality
81% - 100%	Very Practical
61% - 80%	Practical
41% - 60%	Less Practical
33% - 40%	Unpractical

(Arikunto, 2014)

The data analysis technique related to effectiveness testing is conducted using the N-gain test with the formula from (Hake in Rachmawati et al., 2020) below:

$$(g) = \frac{\boldsymbol{S_{Post} - S_{pre}}}{\boldsymbol{S_{max} - S_{pre}}}$$

Ex: (g) : Average gain score
S_{max}: Maximum average score

S_{post}: Average posttest score

S_{pre}: Average pretest score

The results of the scores on the effectiveness test of the product are interpreted into qualitative descriptive categories based on the reference criteria in the following table:

Table 3. N-gain Criteria

N-gain	Kriteria
$(\langle g \rangle) \geq 0{,}7$	High
$0{,}7 > (\langle g \rangle) \geq 0{,}3$	Currently
$(\langle g \rangle) < 0{,}3$	Low

(Hake dalam Rachmawati *et al*., 2020)

RESULTS AND DISCUSSION

The IPA E-Module based on multirepresentation is a digital module that incorporates more than one representation, such as verbal representation, image representation, audio representation, formula representation, graphic representation, and audiovisual representation. Development research resulted in a product in the form of an IPA E-Module based on multirepresentation to enhance students' scientific thinking skills. This research utilized the ADDIE design framework, consisting of 5 stages as follows:

Analysis Stage

This stage is conducted to identify the problems that occur during the science learning process at SMPN 1 Rogojampi and to obtain an initial overview before the research implementation. The analysis process begins with direct observation in classrooms where students tend to be more interested in materials accompanied by pictures and animations. Additionally, interviews with science teachers are conducted to determine the curriculum type and classroom conditions. Several analyses are performed, including student analysis, curriculum analysis, situational analysis, and technology analysis.

Design Stage

The activities carried out in the design stage begin with data collection, drafting of the Analysis of Training Needs (ATP) and teaching modules, selection of module content components, and choosing supporting implementation applications. The products designed in this stage are also based on field constraints and the data obtained from interviews. At this stage, the researcher also designs materials aligned with the curriculum used by the school, focusing on topics such as vibrations, waves, and light. Supporting applications chosen for designing the product include Microsoft Word, Canva.com, and Fliphtml5. The media design developed in the researcher's learning materials at this design stage remains conceptual and forms the basis for further development processes (Winarni, 2018).

Development Stage

The develop stage in the ADDIE development process is the realization phase of the product design from the previous stage. The product design at this stage is developed into a complete product. Research instruments are also developed in this stage to test the feasibility, practicality, and effectiveness of the

product. The research instruments are considered good if they can accurately and appropriately measure what should be measured (Muntazhimah et al., 2020).

The outcome of the development stage is a tangible product, an IPA e-module based on multirepresentation using Fliphtml5 to enhance students' scientific thinking skills in topics such as vibrations, waves, and light. Below are examples of the cover design, scientific thinking indicators, and the interface within the Fliphtml5 application.

Picture 1. The cover design of the development product

Picture 2. The display of scientific thinking indicators

Picture 3. The display of scientific thinking indicators

Picture 4. The display of scientific thinking indicators

The aspects of scientific thinking skills include inquiry, analysis, inference, and argumentation. The designed e-module product will be converted into PDF format and subsequently transformed into a web format using Fliphtml5.

Picture 5. The display on Fliphtml5 web platform

Picture 6. The barcode of the e-module on the Fliphtml5 web platform

The validation of the multi-representation-based IPA e-module product was conducted by three experts, comprising 2 lecturers and 1 science teacher. Each validator assessed the developed product by completing a provided validation questionnaire. The critiques and suggestions from the validators served as guidance for the researcher to revise the developed product (Depiani et al., 2019). The assessment scores given by the three validators can be viewed in the following table:

Table 4. Validator assessment results for the IPA e-module

No	Assessment aspects	Presentase Validator (%)			Presentase (%)	Categories
		V1	V2	V3		
1	Content	87	87	93	89	Very Valuable
2	Subject matter	83	93	87	88	Very Valuable
3	Presentation suitability	93	87	93	91	Very Valuable
4	Language	85	95	90	90	Very Valuable
5	Design	92	96	96	95	Very Valuable
Average Percentage (%)		**88**	**92**	**92**	**90**	Very Valuable

Table 5. Validator assessment results on the research instrument

No	Learning tools	Presentase Validator (%)			Average Percentage (%)	Categories
		V1	V2	V3		
1	Modul ajar	88%	92%	92%	91%	Very Valuable
2	Soal *pre-test* dan *post-test*	87%	84%	84%	85%	Valid

Based on the above assessment results, it is evident that the multi-representation-based IPA e-module using Fliphtml5 falls into the highly valid category, with an average percentage score of 90%. As for the research instrument, it received average percentage scores of 91% and 85%. These findings indicate that the developed products are suitable and can be tested in the school learning process (Nurhasanah, 2024).

***Impelementation* Stage**

The implementation phase is conducted to field-test the product that has been deemed suitable through field trials. The product is a multi-representation-based IPA e-module using Fliphtml5. Implementation was carried out with 34

eighth-grade students in class VIII D. The results of the practicality test are presented in the following table:

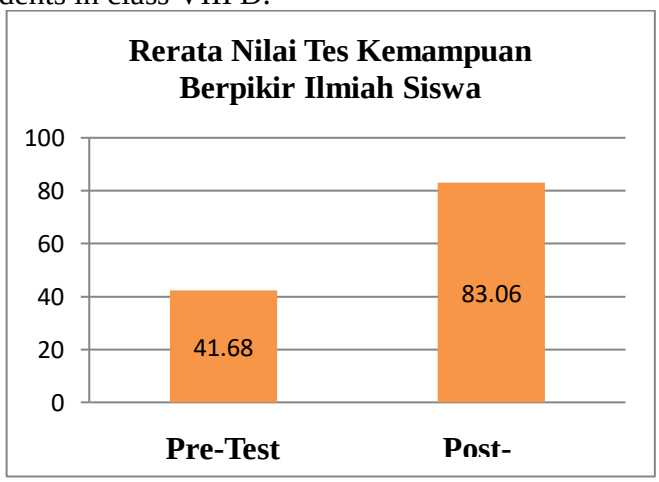
Table 6. Practicality test results

No	Observed aspects	Percentage of implementation per session (%)						Presentase (%)
		P1	P2	P3	P4	P5	P6	
1	Introduction	90	100	97	97	95	97	96
2	Core activities	90	86	93	92	93	94	91
3	Classroom atmosphere	92	97	94	97	97	89	94
4	Conclusion	92	96	98	96	100	96	96
Average Percentage(%)		**91**	**96**	**95**	**95**	**96**	**94**	**94**

Based on the observer's assessment results above, it can be determined that the practicality score averages 94%, indicating it falls under the category of highly practical. Therefore, the multi-representation-based IPA e-module using Fliphtml5 that was developed is highly practical and suitable for use in the learning process.

Evaluate Stage

This stage is intended to evaluate the effectiveness of the developed product by assessing the improvement in students' scientific thinking abilities after using the multi-representation-based IPA e-module using Fliphtml5 in the learning process. The effectiveness can be determined through the N-gain test using pre-test and post-test scores, which include indicators of scientific thinking ability consisting of 7 questions. Here are the average pre-test and post-test scores obtained by students in class VIII D.



Picture 7. The average scores of the pre-test and post-test

The results of the N-gain test will be displayed in the following table:

Table 7. N-gain test results

Components	Class VIII D		*N-gain* (g)	Category
	Pre-test	*Post-test*		
Number of students	34			
Minimum Score	14	54	0,74	High
Maximum Score	54	96		

The data analysis of the N-gain test in Table 4.6 shows a score of 0.74, indicating a significant improvement in students' scientific thinking abilities after using the multi-representation-based IPA e-module in the lessons covering Vibrations, Waves, and Light.

CONCLUSION

Based on the research findings, the multi-representation-based IPA e-module using Fliphtml5 is considered suitable with a validity score of 90% (highly valid). According to the practicality test results, the e-module is rated as highly practical by observers with a percentage of 94%. Furthermore, based on the effectiveness test results, the multi-representation-based IPA e-module using Fliphtml5 has shown a significant impact on enhancing students' scientific thinking abilities. This is evidenced by the N-gain test result of 0.74, indicating a high category of improvement. Therefore, efforts to enhance students' scientific thinking abilities can be effectively pursued through the development and implementation of the multi-representation-based IPA e-module using Fliphtml5 in science education.

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