International Journal of Education, Information Technology and Others (IJEIT), December 2025, 8 (4), 54-62
DOI: https://jurnal.peneliti.net/index.php/IJEIT/article/view/12911
p-ISSN: 2654-2528 e-ISSN: 2623-2324
Accredited by Directorate General of Strengthening for Research and Development
Available online at https://jurnal.peneliti.net/index.php/IJEIT

Effectiveness of Multirepresentation-Based E-Modules to Improve Scientific Reasoning Ability on Temperature, Heat, and Expansion Materials for Junior High School Students

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Received: 5 November 2025
Revised: 10 November 2025
Accepted: 13 November 2025

Abstract

Scientific reasoning is a fundamental ability that students need to develop to face the challenges of the 21st century. This ability plays an important role in understanding science concepts, solving problems, and linking knowledge with everyday life through a systematic scientific process. However, science learning in schools has not had a significant impact on improving these abilities. A number of studies have shown that students' scientific reasoning in Indonesia is still low, hindering a deep understanding of science concepts and their application in real contexts. This condition requires innovative teaching materials that can facilitate students' active involvement, one of which is through multirepresentation-based e-modules. This research aims to develop multirepresentation-based e-modules and assess their effectiveness in improving the scientific reasoning skills of junior high school students. The research method used is Research and Development (R\&D) with the ADDIE model. The research subjects were students of class VII F SMP Negeri 7 Jember. The research instruments were pretest and posttest tests to measure scientific reasoning ability. The results showed that the use of multirepresentation-based e-modules was effective in improving students' scientific reasoning skills, indicated by the N-Gain value which was in the high category. Thus, multirepresentation-based e-modules are feasible to use as innovative teaching materials in learning temperature, heat, and expansion.

Keywords: Multirepresentation, Scientific Reasoning Abilities, Science Learning, E-Module, Temperature, Heat, Expansion

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How to Cite: Arifiana, A., Mahardika, I. K., & Wicaksono, I. (2025). Effectiveness of Multirepresentation-Based E-Modules to Improve Scientific Reasoning Ability on Temperature, Heat, and Expansion Materials for Junior High School Students. *International Journal of Education, Information Technology, and Others, 8*(4), 54-62. Retrieved from https://jurnal.peneliti.net/index.php/IJEIT/article/view/12911

INTRODUCTION

21st century learning requires students to master critical thinking, problem solving, creativity, collaboration, and communication skills (Mardhiyah et al., 2021). In the context of science learning, these skills can be trained through scientific reasoning, which is the cognitive ability to think critically, provide reasons, evaluate evidence, and draw conclusions through a scientific approach (Wardani et al., 2022). Scientific reasoning is considered essential in the Merdeka Curriculum because it supports systematic and data-based complex problem solving (Hadi et al., 2021).

However, various studies show that the scientific reasoning of junior high school students in Indonesia is still low. Yusa et al. (2022) found that only 32.28% of students demonstrated this ability, while Utami et al. (2020) reported 39.0% and Taek et al. (2023) at 48.58%. This low achievement is influenced by the limitations of innovative teaching materials, the lack of discussion of abstract ideas, and the lack of scientific reasoning exercises in science learning (Erlina et al.,

2018). The need assessment results also show that most teachers still use a single representation and have not explicitly practiced scientific reasoning.

One approach that has the potential to overcome this problem is multirepresentation. Multirepresentation allows students to understand concepts through various forms of representation such as verbal, visual, mathematical, and graphic, making it easier to understand abstract concepts (Mahardika et al., 2020; Pratiwi, 2022). A number of studies have shown that multirepresentation effectively improves understanding of science concepts and scientific reasoning (Putri et al., 2020; Nikat et al., 2021). The development of educational technology also supports the use of interactive e-modules that allow the integration of multirepresentations through text, images, graphics, simulations, and videos (Saputra et al., 2020). E-modules are considered efficient because they can be accessed online or offline and support two-way interactions that encourage students to learn actively, independently, and creatively (Ramadayanty et al., 2021).

The material of temperature, heat, and expansion was chosen because it often causes misconceptions and difficulties in understanding due to its abstract nature and the relationship between physical variables that are not directly visible (Iswanto et al., 2022; Cahyaningtyas et al., 2023). The need assessment results show that most students have difficulty understanding this material and want interactive learning media based on e-modules with a variety of representations.

Based on these conditions, this study aims to analyze the effectiveness of multirepresentation-based e-modules in improving junior high school students' scientific reasoning abilities on temperature, heat, and expansion materials. This research is expected to contribute theoretically in strengthening the study of the role of multirepresentation in science learning, and practically provide solutions in the form of innovative teaching materials that support teachers to train scientific reasoning according to the demands of the Merdeka Curriculum.

RESEARCH METHOD

This research is a type of Research and Development (R&D) that aims to develop and assess the effectiveness of a product in the form of an e-module. The development model used is ADDIE, which consists of five stages: Analyze, Design, Develop, Implement, and Evaluate. The stages of e-module development in this study were carried out as follows:

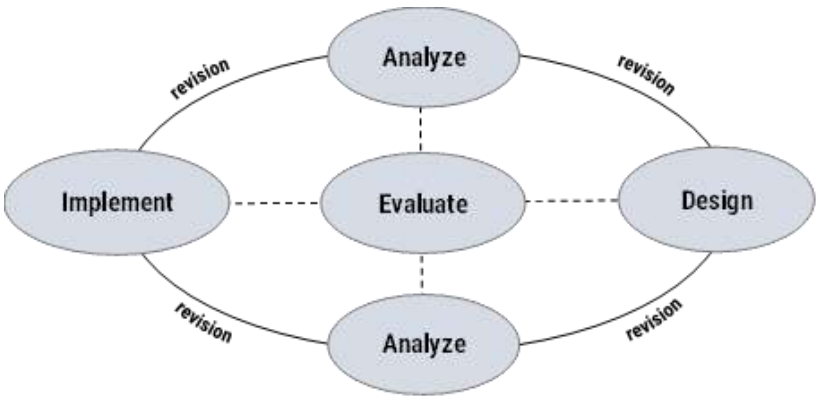

Figure 1. Research Flow Chart

a. Analyze
   Material analysis was conducted to adjust to the curriculum, analysis of student characteristics to determine needs and identify problems during the learning process, and environmental analysis to identify the learning environment and learning strategies.
b. Design
   Performed by selecting the appropriate media and format, drafting the e-module content design, multirepresentation form, and scientific reasoning activities based on the specified indicators.
c. Develop
   Conducted by developing digital e-modules using software that has been selected according to the design that has been designed. Then it is validated to assess the feasibility before it is implemented.
d. Implement
   E-modules were tested on students of class VII F SMP Negeri 7 Jember to assess the practicality and effectiveness of using multirepresentation-based e-modules in learning.
e. Evaluate
   Formative evaluation was conducted through analysis of practicality and student responses, as well as summative evaluation with pretests and posttests.

This research was conducted at SMP Negeri 7 Jember, Jember Regency, East Java Province. The research was conducted in the odd semester of the 2024/2025 academic year. The research subjects were students of class VII F SMP Negeri 7 Jember. The sample amounted to 35 students who were selected using purposive sampling technique based on the consideration of ATP, teaching modules, and learning resources.

The primary data is the effectiveness of the e-module which is assessed from the comparison of the pre-test and post-test results and through the student response questionnaire after using the e-module. While secondary data is a questionnaire in the form of a need assessment questionnaire to obtain information on problems and needs needed in learning and documentation in the form of photos and videos during the implementation of research and other supporting documentation needed.

The N-gain formula according to Hake is as follows:

$$N - Gain = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

Table 1. N-Gain Category

No.	N-Gain Criteria	Criteria
1.	g ≥ 0,7	High

2.	$0,3 \leq g < 0,7$	Medium
3.	$g < 0,3$	Low

(Hake, 1998).

RESEARCH RESULTS AND DISCUSSION

The effectiveness of the multirepresentation-based e-module was analyzed through comparison of pretest and posttest results of students' scientific reasoning ability. The test instrument was developed based on six scientific reasoning indicators with reference to a validated assessment rubric. The improvement analysis was carried out using the average score and Normalized Gain (N-Gain) calculation. This analysis aims to measure the extent of improvement in scientific reasoning skills and to be the basis for developing more optimal e-modules in the future. The average scores of students' pretest and posttest are presented in Table 2 below:

Table 2. Results of Pretest and Posttest Scores

Student Count	Pre-Test	Post-Test	N-Gain	Criteria
35	39,05	85,87	0,77	High

Table 2 shows that the average pretest score of 39.05 increased to 85.87 on the posttest. The N-Gain value of 0.77 is in the high category, which indicates a significant increase in scientific reasoning ability after the use of multirepresentation-based e-modules. The visualization in Figure 2 further strengthens this finding, by showing the striking difference in pretest and posttest scores.

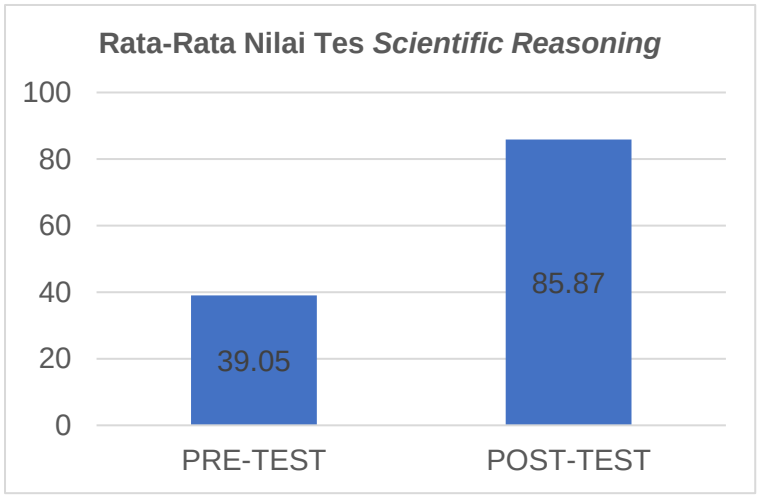

Figure 2. Graph of Average Scientific Reasoning Test Score

Furthermore, the effectiveness of multirepresentation-based e-modules is proven through the analysis of N-Gain calculations on six scientific reasoning indicators. The analyzed scientific reasoning indicators include conservation reasoning, proportional reasoning, correlation reasoning, probabilistic reasoning, variable control, and deductive hypothesis reasoning. The results of the N-Gain analysis per indicator are presented in Table 3 below:

Table 3. N-Gain of Scientific Reasoning Indicators

Scientific Reasoning Ability Indicators	Activities	N	Mean	N-Gain	N-Gain Category
Conservation Reasoning	Pretest	35	7	0,74	High
	Posttest		13		
Proportional Reasoning	Pretest		8	0,87	High
	Posttest		14		
Correlation Reasoning	Pretest		6	0,90	High
	Posttest		13		
Probability Reasoning	Pretest		4	0,80	High
	Posttest		13		
Control of Variable	Pretest		7	0,67	Medium
	Posttest		12		
Hypothetical Deductive Reasoning	Pretest		4	0,65	Medium
	Posttest		11		

Based on Table 3, four indicators are in the high category: correlational reasoning (0.90), proportional reasoning (0.87), probabilistic reasoning (0.80), and conservation reasoning (0.74). Meanwhile, the other two indicators, namely control of variables (0.67) and hypothetico-deductive reasoning (0.65), are in the medium category. Thus, most indicators experienced high improvement, while two indicators require further strengthening in order to improve more optimally.

The findings of this study indicate that multirepresentation-based e-modules are effective in improving the scientific reasoning skills of junior high school students. The significant increase from pretest to posttest confirms that presenting concepts through various forms of representation can facilitate students' understanding of abstract material. This result is in line with the findings of Mahardika et al. (2020) which states that multirepresentation supports concept understanding and scientific reasoning, and Pratiwi (2022) which shows its effectiveness in strengthening mastery of science concepts.

This effectiveness is also supported by the learning design in the e-module which involves various activities, ranging from exploration of phenomena through illustrations and videos, simple experiments, graph and table-based exercises, to contextual discussions. These activities require students to make observations, identify variables, interpret data, and draw conclusions. This is in accordance with the opinion of Erlina et al. (2018) that contextual investigative activities strengthen the connection between theory and students' real experiences, resulting in meaningful learning.

The high achievement on the correlation reasoning indicator (0.90) indicates that multiple representations are able to assist students in logically reasoning the relationship between variables. Experimental activities on changes in the form of substances, for example, allow students to observe the relationship between temperature and changes in form through verbal, visual, graphic and tabular representations. This kind of presentation encourages students to find patterns of cause-and-effect relationships systematically, thus strengthening

correlation reasoning. This finding is consistent with Wulandari et al. (2024) who emphasized that multirepresentation presentation makes it easier for students to identify the relationship between variables rationally.

In contrast, the lowest achievement on the deductive hypothesis indicator (0.65) indicates that this ability still requires strengthening. The activities in the e-module have indeed involved students to develop hypotheses based on initial data, but have not fully emphasized the stage of systematic hypothesis testing. This is in line with Yusa *et al*. (2022) who stated that deductive hypothesis ability requires repeated practice and high-level thinking. The difference in findings with the research of Utami *et al*. (2020) and Wulandari et al. (2024), which reported significant improvements in all scientific reasoning indicators, may be due to the activity design in the e-module which is still limited to the hypothesis formulation stage, not yet covering hypothesis-based experimental design in depth.

Meanwhile, the control variable indicator, which is also in the medium category, shows similar challenges. The identification of independent, dependent and control variables requires a systematic understanding that is often difficult for junior high school students to achieve without explicit practice. Therefore, further development of e-modules should add simulation features or interactive exercises that specifically train variable control in experiments.

Overall, the results of this study confirm that multirepresentation-based e-modules are effective in improving scientific reasoning, especially in the aspects of correlation, proportional, probabilistic, and conservation reasoning. However, the indicators of deductive hypothesis and variable control still require additional intervention. The main contribution of this research lies in providing empirical evidence that the integration of multirepresentations in e-modules can be an innovative solution to overcome the low scientific reasoning skills of junior high school students in temperature, heat and expansion.

CONCLUSION

This study shows that multirepresentation-based e-modules are effective in improving junior high school students' scientific reasoning skills on temperature, heat, and expansion materials. Conservation, proportional, correlation, and probabilistic indicators have increased in the high category, while variable control and deductive hypothesis are in the medium category. This confirms that multirepresentation can enrich students' concept understanding and scientific thinking process.

The practical implication is that this e-module can be utilized by teachers not only to support concept mastery, but also to train scientific thinking skills. In addition, this e-module can be an effective alternative in designing science learning that is more meaningful and student-centered, while increasing their motivation and engagement. However, this research is still limited to the number of subjects and coverage of certain indicators.

Future research is recommended to develop e-modules with interactive features that emphasize more on variable control exercises and hypothesis formulation, and test them on a wider population with various levels of education and characteristics of students. The findings are expected to be the basis for developing technology-based learning models that are more adaptive and

effective in improving students' scientific competence in the era of digital transformation, while strengthening the role of the multirepresentation approach as the foundation of reasoning-based science learning.

BIBLIOGRAPHY

Cahyaningtyas, C. D., Fatma, E., Rianto, P. A. M., Nuha, U., Wahyuni, S., & Yusmar, F. (2023). Analisis Miskonsepsi Siswa SMP pada Materi Suhu dan Kalor. Jurnal Ilmiah Wahana Pendidikan, Agustus 2023, (15), 71-75.

Erlina, N., Susantini, E., Wasis, Wicaksono, I., & Pandiangan, P. (2018). The effectiveness of evidence-based reasoning in inquiry-based physics teaching to increase students' scientific reasoning. Journal of Baltic Science Education, 17(6), 972–985. https://doi.org/10.33225/jbse/18.17.972

Hadi, W. P., Muharrami, L. K., & Utami, D. S. (2021). Identifikasi kemampuan penalaran ilmiah berdasarkan gender. Wahana Matematika Dan Sains: Jurnal Matematika, Sains, Dan Pembelajarannya, 15(2), 133–142. https://ejournal.undiksha.ac.id/index.php/JPM/article/view/34047

Hake, R. R. (1998). Interactive-Engagement Versus Traditional Methods: A SixThousand-Student Survey Of Mechanics Text Data Seductory Physica Courses. American Journal of Physics. 66(1): 65-74.

Iswanto, I. H., Wulandari, A. Y. R., Putera, D. B. R. A., Sutarja, M. C., & Huzairi, H. (2022). Identifikasi Pemahaman Konsep Siswa pada Materi Suhu dan Kalor di MTS Agung Mulia. *Jurnal Natural Science Educational Research (NSER)*, *5*(2), 129–137. https://journal.trunojoyo.ac.id/nser/article/view/17588

Mahardika, I. K., Astutik, S., Zakaria, A. F., Doyan, A., & Susilawati, S. (2020). Pengembangan Model Pembelajaran Meaningful Investigation Laboratory (MIL) untuk Meningkatkan Keterampilan Representasi Verbal, Grafik, dan Matematis (R-VGM) pada Pembelajaran Fisika SMA Di Jawa Timur. Jurnal Pendidikan Sains Indonesia, 8(2), 280–291. https://doi.org/10.24815/jpsi.v8i2.17386

Mardhiyah, R. H., Aldriana, S. N. F., Chitta, F., & Zulfikar, M. R. (2021). Pentingnya Keterampilan Belajar di Abad 21 sebagai Tuntutan dalam Pengembangan Sumber Daya Manusia. Lectura: Jurnal Pendidikan. 12(1), 29–40. https://doi.org/10.31849/lectura.v12i1.5813

Nikat, R. F., Loupatty, M., & Zahroh, S. H. (2021). Kajian Pendekatan Multirepresentasi dalam Konteks Pembelajaran Fisika. Jurnal Pendidikan Dan Ilmu Fisika, 1(2), 45. https://doi.org/10.52434/jpif.v1i2.1449

Pratiwi, N. K. R. (2022). The Pengembangan Bahan Ajar IPA Berbasis Multirepresentasi terhadap Pemahaman Konsep Siswa SMP: Sebuah Tinjauan Studi. Jurnal Pendidikan Mipa, 12(2), 359–366. https://doi.org/10.37630/jpm.v12i2.614

Putri, A. H., Sutrisno, S., & Chandra, D. T. (2020). Efektivitas Pendekatan Multirepresentasi dalam Pembelajaran Berbasis Masalah untuk Meningkatkan Pemahaman Konsep Siswa SMA pada Materi Gaya dan Gerak. Journal of Natural Science and Integration, 3(2), 205. https://doi.org/10.24014/jnsi.v3i2.9400

Ramadayanty, M., Sutarno, S., & Risdianto, E. (2021). Pengembangan E-Modul Fisika Berbasis Multiple Reprsentation Untuk Melatihkan Keterampilan Pemecahan Masalah Siswa. Jurnal Kumparan Fisika, 4(1), 17–24. https://doi.org/10.33369/jkf.4.1.17-24

Saputra, B. E., Pathoni, H., & Kurniawan, D. A. (2020). Pengembangan E-Modul Fisika Berbasis Multirepresentasi Pada Materi Gerak Lurus. EduFisika, 5(01), 39–44. https://doi.org/10.22437/edufisika.v5i01.8843

Taek, J. K. M., Mardiyyaningsih, A. N., & Wahyuni, E. S. (2023). Analisis Kemampuan Scientific Reasioning Siswa SMP dan SMA Yayasan Badan Karya Keuskupan Sanggau. EduNaturalia: Jurnal Biologi dan Kependidikan Biologi, 4(2), 50-58. http://jurnal.untan.ac.id/pkp/indeks/EduNaturalia

Utami, D. S., Muharrami, L. K., Hadi, W. P., & Ahied, M. (2020). Profil Scientific Reasoning Ability Siswa Pada Materi Gerak Benda. Quantum: Jurnal Inovasi Pendidikan Sains, 11(2), 93. https://doi.org/10.20527/quantum.v11i2.8570

Wardani et. al., I. U. (2022). Penerapan Model PBL Dalam Upaya Meningkatkan Kemampuan Scientific Reasoning Siswa Sekolah Dasar. Kappa Journal, 6(2), 432–438. https://doi.org/10.29408/kpj.v4i2.7640

Wulandari, T., Supeno, S., & Wahyuni, D. (2024). Pengaruh Model Learning Cycle 5E Disertai LKPD Berbasis Diagram Berpikir Multidimensi Terhadap Kemampuan Scientific Reasoning Siswa SMP. Jurnal Sains Dan Edukasi Sains, 7(1), 1–11. https://doi.org/10.24246/juses.v7i1p1-11

Yusa, I. W., Hadi, W. P., & Suwandi, S. (2022). Analisis Profil Scientific Reasoning Ability dan Korelasi terhadap Hasil Penilaian Akhir Semester Peserta Didik pada Pembelajaran IPA. Jurnal Pendidikan Mipa, 12(3), 902–911. https://doi.org/10.37630/jpm.v12i3.689

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