JPPIPA 11(2) (2025)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Analysis of STEM Components and Scientific Literacy in the 8th Grade Science Book on Energy Material

Intan Indiati[1*], Siti Patonah[1], Harto Nuroso[2], Ummi Kaltsum[2]

[1] Pendidikan IPA S2, Universitas PGRI Semarang, Semarang, Indonesia.
[2] Pendidikan Fisika, Universitas PGRI Semarang, Semarang, Indonesia.

Received: November 18, 2024
Revised: January 27, 2025
Accepted: February 25, 2025
Published: February 28, 2025

Corresponding Author:
Intan Indiati
intanindiati@upgris.ac.id

DOI: 10.29303/jppipa.v11i2.9763

Abstract: This research lays the groundwork for developing an integrated STEM-based science e-module on energy material for Grade VIII students. The study aims to analyze the presence of STEM components—science, technology, engineering, and mathematics—and scientific literacy in Grade VIII science textbooks covering energy topics. Using a qualitative case study approach, the research examines the energy material presented in the Grade VIII science textbook published by the Center for Books, Ministry of Education, Culture, Research, and Technology. The analysis reveals that the science component dominates the discussion, while technology, engineering, and mathematics are largely absent. Regarding scientific literacy, the textbook presents energy concepts primarily by explaining science as knowledge and its applications in society. However, elements related to scientific inquiry, historical contributions, and science as a way of thinking are not integrated into the material.

Keywords: Energy; Science; Scientific Literacy; STEM

Introduction

In the 21st century, six basic literacies need to be mastered by students, one of which is scientific literacy (S. N. Pratiwi , C Cari, 2019). Scientific literacy refers to the ability to apply knowledge to identify questions, generate new understanding, provide scientific explanations, draw conclusions based on evidence, and cultivate a reflective mindset for engaging in science-related issues. It plays a crucial role in accurately interpreting and explaining phenomena using scientific principles (Wulandari & Sholihin, 2016). Moreover, it motivates students to design the procedures based on their investigations (Lestari & Siskandar, 2020). Furthermore, scientific literacy is a central focus of 21st-century education.

Science consists of three interrelated components: the scientific process, scientific attitude, and scientific product (Rusilowati, 2018). Therefore, science education should integrate all these components. A scientifically literate individual is prepared to engage in science- and technology-related activities, possessing the skills to explain phenomena scientifically, evaluate and design scientific investigations, and interpret data through scientific methods (OECD, 2017). Therefore, educational reforms are essential to strengthen students' scientific literacy and prepare them for 21st-century challenges. One effective approach is incorporating scientific literacy into teaching materials. To fully grasp the nature of science, students must actively develop scientific skills, which in turn enhances their awareness of the natural environment (Septiani & Rustaman, 2017).

Practically, enhancing scientific literacy is essential for helping students grasp scientific concepts. However, many junior high school students in Indonesia have yet to recognize its importance (Pertiwi et al., 2018). As a consequence, a learning approach that embeds scientific literacy is necessary to equip students with scientific knowledge, technological awareness, critical thinking skills, creativity, and a scientific perspective (Rakhmawan et al., 2015).

One of the learning approaches is STEM which facilitates learning by bringing real-world experiences

How to Cite:
Indiati, I., Patonah, S., Nuroso, H., & Kaltsum, U. (2025). Analysis of STEM Components and Scientific Literacy in the 8th Grade Science Book on Energy Material. *Jurnal Penelitian Pendidikan IPA*, *11*(2), 1207–1212. https://doi.org/10.29303/jppipa.v11i2.9763

into science education (Subramaniam et al., 2012). STEM-based learning is designed to equip students with 21st-century competencies.

On the other hand, textbooks play a vital role in education by presenting material ranging from definitions and theories to concepts, principles, and real-world applications. (Sukaesih & Kartijono, 2014). As a key learning resource, textbooks are essential for motivating, enriching, and educating students. Considering the importance of scientific literacy and the frequent reliance on textbooks in education, incorporating scientific literacy elements into science textbooks is crucial for enhancing students' understanding and skills in science.

Moreover, research findings (Listiana et al., 2023) show that implementing a STEM learning approach effectively improves scientific literacy skills. Therefore, integrating STEM into textbook content is essential. As primary learning resources for both teachers and students, textbooks play a crucial role in shaping and supporting curriculum goals (Lipovec et al., 2020). Integrating these components into textbooks is crucial for promoting scientific literacy (Darling-Hammond et al., 2020). Therefore, this study seeks to examine STEM components and the scope of scientific literacy in Grade VIII science textbooks, with a focus on energy material.

Method

This study utilizes a qualitative case study approach. Document analysis was carried out to identify STEM components and assess the extent of scientific literacy in energy material. The selection of energy material was guided by concepts from PISA and TIMSS. The research subjects were Grade VIII science textbooks based on the independent curriculum, published by the Center for Books, Agency for Standards, Curriculum, and Educational Assessment, Ministry of Education, Culture, Research, and Technology. The textbooks were selected based on recommendations from junior high school science teachers, who identified them as the primary learning resources in schools implementing the independent curriculum. Data collection was conducted through observation using document analysis instruments.

A content analysis guideline sheet was used to assess STEM components and scientific literacy, with clearly defined indicators for each category. These indicators were evaluated by validators to determine: (a) STEM components, including Science, Technology, Engineering, and Mathematics, and (b) Scientific literacy components, covering knowledge of science, the investigative nature of science, science as a way of thinking, and the interaction of science, technology, and society.

In the STEM and scientific literacy analysis sheet, validators reached agreements on the presence of these components within the analyzed textbooks. The data analysis followed these steps:

1. Marking a checklist in the score column (1 if the content matched the STEM and scientific literacy indicators, 0 if it did not).
2. Determining the analysis results using the Rater Agreement Percentage.

Result and Discussion

STEM Component Analysis in Science Textbooks

The STEM components, which include science, technology, engineering, and mathematics, are presented in Table 1 (Torlakson, 2014).

Table 1. Definition of STEM

STEM content	Definition
Science	Understanding the principles and laws that govern natural phenomena.
Technology	A set of skills or systems used to manage society, organizations, and knowledge, or to design and apply artificial tools that enhance efficiency and productivity.
Engineering	The knowledge required to implement or design procedures for problem-solving.
Mathematics	A branch of science that explores quantities, numbers, and space, relying solely on logical reasoning, with or without empirical evidence.

The science component pertains to natural phenomena, encompassing knowledge from disciplines such as biology, physics, and chemistry, and enabling direct observation. The technology component includes knowledge about technology, its applications, and its development. The engineering component involves applying conceptual understanding, fostering innovation, and designing and creating products. The mathematics component focuses on the ability to analyze, formulate, and interpret solutions to mathematical problems.

Based on these definitions, the science component in textbooks includes learning materials related to nature, visual representations such as images, graphs, or tables, explanations of complex concepts derived from facts, principles, or laws, and activities that promote student engagement, such as questioning, decision-making, and experimentation.

The technology component in textbooks is identified through the inclusion of technology use, real-life applications, software implementation, and online research. The engineering component is analyzed based on project-based assignments, opportunities for students to present creative ideas, and real-world

problem-solving tasks. The mathematics component includes the presence of formulas leading to mathematical calculations, higher-order thinking (HOTS) questions, problem-solving exercises, and data interpretation using images, tables, or graphs.

Based on these descriptions, science learning resources in STEM education must incorporate all four aspects—science, technology, engineering, and mathematics—as outlined in Table 1. The STEM components identified in the analyzed science textbooks, as evaluated by validators, are presented in Table 2.

Table 2. Analysis Results

Component	Validator		Agreement
	1	2	
Science	1	1	1
Technology	0	0	1
Engineering	0	0	1
Mathematics	1	1	1

Based on the results in Table 2, all four assessments are in agreement, yielding an inter-validator agreement percentage of 100%. These findings indicate that both validators concur that the STEM components present in the analyzed textbooks align with the indicators, specifically the Science and Mathematics components, as detailed in Table 3.

Table 3. Component of STEM

Science	Technology	Engineering	Mathematics
Factual: 1. Pushing a cart loaded with cargo over a certain distance results in physical exhaustion. 2. The faster a person pushes the cart while running, the greater their fatigue. Conceptual: 1. Definition: Potential energy (page 88) 2. Kinetic energy (page 88) 3. Mechanical energy (page 89) Procedural: Identifying objects that possess mechanical energy (page 92).	-	-	Calculation formulas: 1. Kinetic energy (page 88 2. Potential energy (page 89 3. Mechanical energy (page 90)

Based on the validator's assessment results in Table 3, the Science component is the most prominent in the analyzed eighth-grade science textbook. The introduction encourages students to examine the connection between the studied material and real-life scenarios, such as how an object's weight, travel distance, and required energy are related.

In the learning activities, the Science component is reinforced through relevant visuals and comprehensive explanations that build upon facts, concepts, principles, and laws, particularly concerning kinetic energy, potential energy, and mechanical energy. Additionally, the textbook encourages students to analyze problems critically. However, it does not include activities that actively engage students in conducting experiments, limiting the opportunity to develop investigative skills. The science component is also reflected in the "Test Your Skills" section, which guides students in identifying and answering questions related to mechanical energy.

The second STEM component, technology, is not integrated into the analyzed textbook. There are no technological tools included to support students' understanding or enhance learning effectiveness. This absence may stem from the lack of experimental activities and the omission of prompts for students to explore information online. Additionally, the textbook does not incorporate instructional videos as a learning aid. The use of technology in education is crucial for achieving learning objectives, encompassing both advanced tools and simple technological applications that facilitate the learning process.

Likewise, the engineering component is not represented in the eighth-grade science textbook. Engineering involves project-based tasks that promote problem-solving and product development, yet such assignments are not included. Incorporating project-based tasks would encourage students to take responsibility for their work and engage actively in solving real-world problems (Pratama & Prastyaningrum, 2016). Whether working individually or in groups, students should be encouraged to plan, organize, test, and present their project results.

The mathematics component appears only in the form of mathematical expressions, such as formulas for potential energy, kinetic energy, and mechanical energy. However, it is not utilized for problem-solving or real-world applications. A student demonstrates problem-solving ability when they can analyze a situation and apply their knowledge to new contexts effectively (Fitriani et al., 2022). This can be accomplished if the mathematics component in the analyzed textbook is integrated with real-life applications and problem-solving activities.

Analysis of Science Literacy Components in Science Textbooks

The analysis of scientific literacy content is based on four observed categories: knowledge of science, the investigative nature of science, science as a way of thinking, and the interaction of science, technology, and society (Chiappetta et al., 1991). The knowledge of the science category includes activities that foster discussion and actively involve students in understanding facts, concepts, principles, laws, theories, hypotheses, and models. This category represents the transfer of scientific knowledge as students acquire and process information.

The investigative nature of the science category is reflected in activities that stimulate critical thinking and engage students in conducting investigations or experiments. The science as a way of thinking category highlights how scientists approach inquiries and conduct investigations using scientific reasoning. The interaction of science, technology, and society category explores the impact and influence of scientific and technological advancements on society. Based on these categories, the scientific literacy components identified in the analyzed textbook are summarized in Table 4.

Table 4. Category of Science Literacy

Science literacy indicators	Validator 1	Validator 2	*Agreement*	Statement
The knowledge of science	1	1	1	Definition and formula of kinetic, potential, and mechanic energy.
The investigative nature of science	0	0	1	-
Science as a way of thinking	0	0	1	-
Interaction of science, technology, and society	1	1		Scientific Fact: Water as a Renewable Energy Source.

Based on the results in Table 4, all four assessments showed agreement, yielding a 100% consensus between the validators. This indicates that both validators concurred that the components aligning with scientific literacy indicators in the analyzed textbook are the knowledge of science and the interaction of science, technology, and society.

The knowledge of science category is prominently presented, particularly in the energy topic, where the textbook primarily conveys scientific knowledge through definitions and formulas related to potential, kinetic, and mechanical energy.

However, the categories of the investigative nature of science and science as a way of thinking were not identified in the textbook. The absence of investigative activities means students are not encouraged to conduct experiments or scientific inquiries. Additionally, the science as a way of thinking category is lacking, as the textbook does not include historical accounts of scientists conducting experiments, examples illustrating the empirical and objective nature of science, or applications of the scientific method for problem-solving.

Students develop strong problem-solving skills when scientific knowledge is complemented by hands-on experiences, such as investigative activities or experiments (Lailatul et al., 2015). The interaction of science, technology, and society category is reflected in the textbook through the "Scientific Facts" section, which emphasizes the role of science and technology in everyday life. A well-structured science textbook should establish clear connections between each topic and its real-world applications, illustrating the relationship between science, technology, and society (RN et al., 2016). In addition, textbooks should incorporate diverse questions, investigative activities, experiments, and discussions that actively engage students in applying scientific and technological concepts to real-world situations (Maryati, 2018). Based on the analysis of STEM components and scientific literacy, it is essential to develop an integrated STEM-based science textbook for Grade VIII, focusing on the energy topic. This development should enhance content that strengthens the interconnection between STEM components. A STEM project, such as designing and building a simple water wheel, can effectively demonstrate these connections, as outlined in Table 5.

Table 5. The Relationship Between STEM Components in Water Wheel Construction

Science	Technology
Factual: Example of an energy source (water). Conceptual: Water has potential energy due to its height, which is converted into kinetic energy as it flows and spins the blades. Procedural: - Steps to construct a simple water wheel. - Steps to test a simple water wheel.	- Internet for researching information about simple water wheel technology. - Tools and materials for constructing a simple water wheel. - Computer for creating tables, graphs, and diagrams of observation results and reporting the construction of the simple water wheel.

Metacognitive: - Designing a simple water wheel. - Building a simple water wheel. - Evaluating the water wheel design.	
Engineering - Designing a Simple Water Wheel - Building a Simple Water Wheel - Testing the Simple Water Wheel - Evaluating the Simple Water Wheel	Mathematics - Calculating potential energy - Calculating kinetic energy - Calculating mechanical energy

Conclusion

Based on the research findings and discussion, the analyzed Grade VIII science textbook on the energy topic has not yet fully integrated scientific literacy and STEM components. An effective textbook should align with students' needs and the school environment. Selecting an appropriate textbook can enhance students' understanding of science and improve their scientific literacy. Therefore, developing a STEM-integrated and science literacy-based Grade VIII science textbook on energy is essential.

Acknowledgments
This research was funded by LPPM Universitas PGRI Semarang, and the authors sincerely appreciate the support provided.

Author Contributions
Conceptualization, writing—original draft preparation, Intan Indiati; methodology, Siti Patonah; formal analysis, Harto Nuroso; writing—review and editing, Ummi Kaltsum. All authors have read and agreed to the published version of the manuscript.

Funding
This research was funded by LPPM Universitas PGRI Semarang, grant number 014/SKK-LPPM UPGRIS/REG/II/2024.

Conflicts of Interest
The authors declare no conflict of interest.

References

Chiappetta, E. L., Sethna, G. H., & Fillman, D. A. (1991). A Quantitative Analysis of High School Chemistry Textbooks for Scientific Literacy Themes and Expository Learning Aids. *Journal of Research in Science Teaching*, *28*(10), 939–951. https://doi.org/10.1002/tea.3660281005

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for Educational Practice of the Science of Learning and Development. *Applied Developmental Science*, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Fitriani, Y., Pakpahan, R., Junadi, B., & Widyastuti, H. (2022). Analisa Penerapan Literasi Digital dalam Aktivitas Pembelajaran Daring Mahasiswa. *Journal of Information System, Spplied, Management, Accounting and Research*, *6*(2), 439–448.

Lailatul, H., Rosyidatun, E. S., & Miranto, S. (2015). EDUSAINS. *Analisis Isi Buku Sekolah Elektronik (BSE) Biologi Kelas XI Semester 1 Berdasarkan Literasi Sains*, *7*(1), 1–10.

Lestari, H., & Siskandar, R. (2020). Literasi Sains Siswa Melalui Penerapan Model Pembelajaran Blended Learning dengan Blog. *Jurnal Kajian Penelitian Dan Pendidikan Dan Pembelajaran2*, *4*(2b), 597–604.

Lipovec, A., Batič, J., & Kranjec, E. (2020). New Horizons in Subject-Specific Education: Research Aspects of Subject-Specific Didactics. In *University Press* (Issue July). https://doi.org/10.18690/978-961-286-358-6

Listiana, L., Millah, F., & Suharti, P. (2023). Development and Validation of Learning Strategy for Creative Thinking Skills Empowerment: STEM-Based E-Modules. In *Jurnal Penelitian Pendidikan IPA* (Vol. 9, Issue SpecialIssue, pp. 479–486). https://doi.org/10.29303/jppipa.v9ispecialissue.6003

Maryati, I. (2018). Penerapan Model Pembelajaran Berbasis Masalah pada Materi Pola Bilangan di Kelas VII Sekolah Menengah Pertama. *Mosharofa*, *7*(1), 63–74. https://doi.org/10.26737/jipf.v3i1.335

OECD. (2017). *PISA 2015 Assessment and Analytical Framework Science, Reading, Mathematic, Financial Literacy and Collaborative Problem Solving* (revised ed, Issue 20). OECD Publishing. https://doi.org/http://dx.doi.org/10.1787/9789264281820-en

Pertiwi, U. D., Atanti, R. D., & Ismawati, R. (2018). Pentingnya Literasi Sains pada Pembelajaran IPA SMP Abad 21. *Indonesian Journal of Natural Science Education (IJNSE)*, *1*(1), 24–29.

Pratama, H., & Prastyaningrum, I. (2016). Pengaruh Model Pembelajaran Project Based Learning Berbantuan Media Pembelajaran Pembangkit Listrik tenaga Mikrohidro terhadap Kemampuan Berfikir Kritis. *Jurnal Penelitian Fisika Dan Aplikasinya*, *6*(2), 44–50.

Rakhmawan, A., Setiabudi, A., & Mudzakir, A. (2015).

Perancangan Pembelajaran Literasi Sains Berbasis Inkuiri Pada Kegiatan Laboratorium. *Jurnal Penelitian Dan Pembelajaran IPA*, *1*(1), 143–152. https://doi.org/10.30870/jppi.v1i1.331

RN, E. W., Fathurohman, A., & MS, S. (2016). Analisis Buku Siswa Mata Pelajaran IPA Kelas VIII SMP/MTs Berdasarkan Kategori Literasi Sains. *Jurnal Inovasi Dan Pembelajaran Fisika*, *3*(2), 1–10. https://doi.org/10.31332/kd.v3i2.2966

Rusilowati, A. (2018). Asesmen Literasi Sains: Analisis Karakteristik Instrumen dan Kemampuan Siswa Menggunakan Teori Tes Modern Rasch Model. *Prosiding Seminar Nasional Fisika Universitas Riau Ke-3*, 2–15.

S. N. Pratiwi , C Cari, N. S. A. (2019). Pembelajaran IPA Abad 21 dengan Literasi Sains Peserta didik. *Jurnal Materi Dan Pembelajaran Fisika (JMPF)*, *9*(1), 34–42.

Septiani, A., & Rustaman, N. Y. (2017). Implementation of Performance Assessment in STEM (Science, Technology, Engineering, Mathematics) Education to Detect Science Process Skill. *Journal of Physics: Conference Series*, *812*, 1–6. https://doi.org/10.1088/1742-6596/755/1/011001

Subramaniam, M. M., Ahn, J., Fleischmann, K. R., & Druin, A. (2012). Reimagining the Role of School Libraries in STEM Education: Creating Hybrid Spaces for Exploration. *Library Quarterly*, *82*(2), 161–182. https://doi.org/10.1086/664578

Sukaesih, S., & Kartijono, N. E. (2014). Pengembangan Buku Ajar Mikroteaching Biologi Berbasis Kompetensi dan karakter Konservasi. *Jurnal Pendidikan IPA Indonesia*, *3*(1), 79–85.

Torlakson, T. (2014). *Innovate: A Blueprint for Science, Technology, Engineering, and Mathematics in California Public Education, A Report by State Superintendent of Public Instruction Tom Torlakson's STEM Task Force* (Issue May). The Californians.

Wulandari, N., & Sholihin, H. (2016). Analisis Kemampuan Literasi Sains Pada Aspek Pengetahuan Dan Kompetensi Sains Siswa Smp Pada Materi Kalor. In *Edusains* (Vol. 8, Issue 1, pp. 66–73). https://doi.org/10.15408/es.v8i1.1762