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Understanding the Concepts of Energy, Change, and Utilization: Exploring Learning Challenges and Strategies for Junior High School Students

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Abstract

This study analyzes the relationship between students' understanding of energy, energy change, and energy utilization concepts. Junior high school students learn about energy change and use through everyday activities like drying clothes, pushing objects, and studying. Contextual learning and practical experiences also affect their capacity to relate energy concepts to noticeable changes in their surroundings. A non-experimental quantitative method with a correlational approach was used in this study, involving 168 junior high school students as a sample using convenience sampling. Data was collected through a questionnaire containing three open-ended questions about energy concepts, changes, and utilization. The results showed that 56.55% of students could understand the concept of energy correctly, but their understanding of energy changes and energy utilization was still low; namely, only 12.50% of students could explain energy utilization well. Correlational analysis showed a positive but weak relationship between the concept of energy and energy change, while the relationship with energy utilization was not significant. The implication of this study is to support the development of more effective teaching strategies about energy, including its changes and utilization. This research can also be the foundation for further research, such as identifying factors that affect students' understanding of energy topics.

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INTRODUCTION

Energy is one of the most important concepts in science (Wernecke et al., 2018). Most activities involve energy use (Giancoli, 2005; Halliday et al., 2014; Tipler & Mosca, 2008). Everything from development and reproduction to tenancy and movement requires energy (Pontzer et al., 2021). Therefore, a strong understanding of energy is essential in a scientific context, and a practical understanding of everyday life (Sri, 2023).

However, research shows that students' understanding of energy concepts is often inadequate (Franco et al., 2022; Opitz et al., 2014). The 2022 PISA (Programme for International Student Assessment) results show that Indonesia only scored 359 for reading, 366 for mathematics, and 383 for science. This score has decreased compared to Indonesia's PISA score in the previous two PISA tests in 2018 and 2015 (Romli et al., 2024). Various factors contribute to this decline, including the abstract nature of scientific concepts, the

lack of connection between science and everyday experience, and ineffective learning methods.

Previous research on energy has generally focused on understanding the concept of energy separately, such as the definition of energy, forms of energy, and the law of conservation of energy (Rokmana, 2024). Some studies also examine students' misconceptions about energy (Jatmika et al., 2021; Maison et al., 2020). However, few studies have examined the interconnected understanding of energy concepts, changes, and utilization. These three aspects are essential for a comprehensive grasp of energy.

For example, an understanding of the law of conservation of energy (the concept of energy) will be more meaningful if students also understand how energy changes from one form to another in various phenomena (energy changes), such as the change of electrical energy into light energy in lamps or the change of chemical energy into motion energy in vehicles. This understanding will be even more relevant if students can relate it to the benefits of energy in daily life, such as using solar energy as an alternative energy source or energy use efficiency to reduce environmental impacts.

This research is important to ensure that students do not merely understand energy concepts in theory but can also apply them in real-life contexts. Previous studies tended to examine only one or two aspects of energy understanding separately, whereas this study aims to analyze all three aspects simultaneously. By doing so, this study seeks to bridge the existing research gap and explore whether a strong grasp of one aspect will enhance the understanding of the others.

By adopting a correlational approach to evaluating the relationship between these aspects and collecting data from junior high school students in Cimahi City, this research is expected to provide new insights into how the understanding of energy is formed holistically. The implication of this study is to support the development of more effective teaching strategies about energy, including its changes and utilization. This research can also be the foundation for further research, such as identifying factors that affect students' understanding of energy topics.

METHODS

This study uses a non-experimental quantitative research method with a correlational approach. One useful technique for examining links between variables is correlational research. Although it cannot establish cause and effect, it offers information that can direct future studies and forecasts. Reliable findings depend on appropriate analysis and precise data collection (Creswell, 2012). This approach allows researchers to analyze the relationship between students' understanding of energy concepts, energy changes, and energy utilization. This is in line with the view of Rezigalla (2020), who stated that a correlational approach can compare two or more relevant variables and report the relationship between them without controlling for variables.

Data collection was conducted using a questionnaire consisting of three open-ended questions about the concept of energy, energy change, and energy utilization. These questions were adapted from previous research by Rusyati et al. (2021), which utilized a single open-ended question to analyze conceptions about soil.

This study included two additional questions to expand the analysis by exploring aspects of energy change and energy utilization. These questions were reviewed in consultation with previous researchers and deemed appropriate for use.

The questionnaire was administered to junior high school students, who were instructed to respond independently without assistance from external sources. Additionally, participants were required to provide their identity for data classification purposes.

The qualitative data collected is assessed based on the rubric, which has been determined and classified into 6 assessment categories, from 100 to 0. Researchers also look for words that appear frequently in students’ answers to map students' understanding of energy.

The research population includes all State Junior High School students in Cimahi City in the 2024/2025 school year. One hundred sixty-eight students from grades 7, 8, and 9 at one of the State Junior High Schools in Cimahi City were selected as samples using convenience sampling. Convenience sampling is a quantitative sampling technique in which the researcher chooses participants based on their availability and willingness to participate in the study (Creswell, 2012).

Convenience sampling is one type of non-probability sampling. Convenience sampling is an opportunistic sample that draws from whoever is available at the time. Convenience sampling, also known as accidental sampling or opportunity sampling, entails selecting respondents who are nearby and continuing the procedure until the needed sample size is reached, or those who are conveniently available and reachable at the time (Cohen et al., 2007). The details of the samples are presented in Table 1.

Table 1 Number of samples per level

No	Grade	Sum
1	Grade 7	91
2	Grade 8	41
3	Grade 9	36

RESULTS AND DISCUSSION

Based on the analysis results, 56.55% of students could explain the concept of energy correctly. This can be seen from their answers, which almost meet the specified criteria. However, none of the students in the sample could explain the energy change process according to the specified criteria. However, 12.50% of students managed to provide the right explanation regarding the utilization of energy. Details of the results of the percentage of student scores related to the concept of energy are presented in Table 2.

Table 2 Percentage of student scores in question 1

Scores	Sum	Percentage (%)
100	32	19.05
80	63	37.50
60	2	1.19
40	11	6.55
20	4	2.38
0	56	33.33

Based on the data presented in Table 2, out of 168 students, 32 students, or 19.05%, could explain the concept of energy very precisely, so they got a maximum score of 100 in question 1. These students consisted of 17 grade 7 students, 3 grade 8 students, and 12 grade 9 students. This shows that 32 students have a very good understanding of the concept of energy according to the references used in the study, namely references from Tipler(2008), Halliday (2014), and Giancoli (2005).

63 students (37.50%) demonstrated the ability to explain the concept of energy correctly, so they obtained a score of 80 in question 1. This group consisted of 27 grade 7 students, 23 grade 8 students, and 13 grade 9 students, which showed that the students' understanding was close to the reference standards used.

In addition, two students (1.19%) provided a moderately precise explanation of the energy concept, scoring 60 on the same question. These two students consisted of one grade 8 student and one grade 9 student, which showed an understanding that was quite close to the reference.

Eleven other students (6.55%) also showed a lack of ability to explain the concept of energy, so they scored 40 in question 1. These students consisted of eight students from the 7th grade, two from the 8th grade, and one from the 9th grade, reflecting a suboptimal understanding according to the reference.

Furthermore, four students (2.38%) could not properly explain the concept of energy, so only a score of 20 was obtained on the same question. This group consists of two 7th-grade students and two 8th-grade students.

Lastly, 56 students (33.33%) could not explain the concept of energy, scoring 0 on question 1. This group consists of 37 students in the 7th grade, eight in the 10th grade, and 9 in the 9th grade. These findings indicate a significant gap in understanding the concept of energy between classes, which may be due to interrelated conceptual errors or misconceptions (Latif et al., 2021; Putri et al., 2023;Ustari et al., 2024).

In addition, the analysis of the answers also showed that none of the students were able to explain the process of energy change well. This can be seen from the answers of students who do not meet the specified criteria. Further details regarding the percentage of student scores related to energy changes are presented in Table 3.

Table 3 Percentage of student scores in question 2

Scores	Sum	Percentage (%)
100	0	0.00
80	0	0.00
60	0	0.00
40	0	0.00
20	80	47.62
0	88	52.38

Based on Table 3, as many as 80 students (47.62%) could not explain the energy change process properly, so they only got a score of 20 in question 2. These consisted of 49 7th-grade students, 11 8th-grade students, and 20 9th-grade students. This data shows that most students in this group have difficulty accurately understanding energy changes. In addition, 88 students (52.38%) were completely unable to explain energy changes adequately, so they obtained a score of 0 on the same question. This group consisted of 42 grade 7 students, 30 grade 8 students, and 16 grade 9 students, which showed that most students' understanding of energy change was still very low.

This is supported by a research study conducted by Septyana et al. (2024), who stated that most students find it difficult to understand the material taught and find it difficult to do the problems correctly because their understanding of concepts tends to be low. This is especially true for energy change material, which is often considered abstract and difficult for students to understand (Liu & McKeough, 2005).

Meanwhile, the analysis of the answers also showed that as many as 12.50% of students could explain energy utilization well. This is marked by their answers, which almost meet the criteria that have been determined. The percentage of students' scores related to utilization of energy is explained in more detail in Table 4.

Table 4 Percentage of student scores in question 3

Scores	Sum	Percentage (%)
100	0	2.98
80	0	9.52
60	0	10.71
40	0	8.93
20	80	13.10
0	88	54.76

Based on Table 4, out of a total of 168 students, as many as five students (2.98%) could explain energy utilization very precisely, so they obtained a 100 on question 3. This group consists of 3 7th-grade students, 1 8th-grade student, and 1 9th-grade student. Sixteen students (9.52%) explained energy utilization correctly and obtained an 80 on the same question. This group consists of 7 students from the 7th grade, six from the 8th grade, and three from the 9th grade.

Furthermore, 18 students (10.71%) could precisely explain energy utilization, so they scored 60. These consisted of 8 7th-grade students, 2 8th-grade students, and 8 9th-grade students. In addition, as many as 15 students (8.93%) showed a lack of ability to explain energy utilization, so they scored 40. This group consisted of 13 students from grade 7, 1 from grade 8, and 1 from grade 9.

Twenty-two students (13.10%) could not properly explain energy utilization, so they only scored 20. These consisted of 11 7th-grade students, 8 8th-grade students, and 3 9th-grade students. Lastly, 92 students (54.76%) could not explain energy utilization, so they obtained a 0 in question 3. This group consisted of 49 students in the 7th grade, 23 in the 8th grade, and 20 in the 9th-grade students, who showed a very low understanding of energy utilization.

In addition to this analysis, a correlation test was carried out using the Spearman method to evaluate the relationship between question 1 and other questions. The Spearman method is used because the data obtained does not meet the normality assumption. The results of the correlation test are presented in Table 5.

Table 5 Spearman correlation test

			Energy Change	**Energy Utilization**	**Energy Concept**	**Description**
Spearman's rho	**Energy Change**	Correlation Coefficient	1.000	.119	.282**	-Energy Concept vs. Energy Change There is a significant but weak positive correlation (r = 0.282).
		Sig. (2-tailed)	.	.123	<,001	
		N	168	168	168	
	Energy Utilization	Correlation Coefficient	.119	1.000	.036	-Energy Concept vs. Energy Utilization There is no significant correlation.
		Sig. (2-tailed)	.123	.	.644	
		N	168	168	168	
	Energy Concept	Correlation Coefficient	.282**	.036	1.000	
		Sig. (2-tailed)	<,001	.644	.	
		N	168	168	168	

The results of the Spearman correlation test showed that the significance value (sig. (2-tailed)) between question 1 (energy concept) and question 2 (energy change) is <0.001. This indicates that there is a significant correlation between the two questions. In addition, a correlation coefficient of 0.282 indicates a positive relationship between the two, although the strength of the relationship is relatively weak. In other words, if the score obtained by students in question 2 increases, the score in question 1 tends to increase. On the contrary, no significant correlation was found between question 1 and question 3 (energy utilization), which can be seen from the significance value of 0.644.

To strengthen these findings, the frequency of word occurrence in students' answers was analyzed. This analysis method is recognized for understanding the connections between concepts, ideas, and problems (Roodbandi et al., 2021). The frequency of word occurrence in students' answers for question 1 (energy concept) is shown in Figure 1.

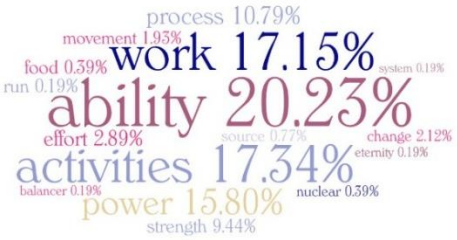

Figure 1 Frequency of word occurrence in question 1 "What do you know about energy?"

The results of the analysis of junior high school students' conceptions showed that concepts such as "ability," "activities," and "work" appeared in over 17% of student responses, indicating a similar initial understanding of these terms in the context of energy. From these responses, 16 key concepts related to energy were identified. Statistically, students who gave these responses achieved an average score of 124.84 (out of a maximum of 300), with individual scores ranging from 80 (lowest) to 220 (highest).

In grades 7 and 9, the concepts of "ability," "work," "activities," and "power" occupy the top four positions in the frequency of occurrence. Meanwhile, in grade 8, the concept of "power" became the most dominant, followed by "activities," "ability," and "work." In the 7th grade, unique concepts such as "nuclear," "balancer," and "system" emerged, which were not found in the 8th and 9th grades. More variation of concepts in grade 7 is likely to reflect the understanding of students still in the early stages of exploration.

In grade 8, only the concept of "run" does not appear in grades 7 and 9. Meanwhile, in grade 9, the concepts of "food" and "eternity" were found that were not found in the previous class. In grades 8 and 9, although there is less variation in the concept, new concepts such as "source" appear. The concept of "eternity" found in grade 9 can also reflect students' thinking about energy in an infinite context, such as energy on a cosmic scale.

Students' understanding of the concepts of "ability," "activities," and "work" shows that they associate energy with human and object activities. In physics, the concepts of "power" and "work" describe energy use to move objects. Meanwhile, in biology, this concept represents the energy used in the body's metabolic processes.

The key concepts that emerged are quite in accordance with the definition of energy according to Giancoli (2005), i.e. the ability to do work. However, there are inconsistencies related to the concept of "power". Referring to a more comprehensive definition of energy as presented by Halliday et al. (2014) and Tipler & Mosca (2008), the concept of "power" is not part of the definition of energy. This finding indicates a misunderstanding of the concept in students related to the meaning of energy.

The finding is supported by Antink-Meyer and Aldeman (2020), who reveal that one of the most common conceptual errors in understanding energy is considering power as a certain amount of energy, whereas power refers to the rate at which work is performed. Additionally, existing beliefs influence students' understanding, making it more challenging to develop correct comprehension, particularly for complex concepts such as energy in everyday life (Dewi et al., 2024).

Other than that, Figure 2 shows the frequency of word occurrence in students' answers for question 2 (energy change).

Figure 2 Frequency of word occurrence in question 2 "How does energy change occurs?"

The results of the conception of junior high school students showed that the word "energy changes" occupied the top position with a percentage of more than 40% of the total responses given. This section also revealed 19 key concepts linked to energy change. However, students who responded to "energy changes" had a low average score of 113.75, with individual scores ranging from 20 to 220.

In 7th grade, some unique concepts are found that are not found in 8th and 9th grades, such as "energy difference," "converting energy," "expansion," "heat transfer," "combustion reaction," "after sport," and "overactivity." This diversity of concepts reflects that grade 7 students' understanding is still in the initial exploration stage and has not been focused on a deeper understanding.

In the eighth grade, concepts such as "carbohydrate breakdown," "ATP formation," "metabolic molecules," and "turbine rotation" emerged, which were not found in other classes. These concepts are closely related to metabolic processes. This shows the influence of interdisciplinary materials in energy learning in grade 8. Meanwhile, in the 9th grade, there were concepts such as "shape transformation," "energy interaction," "nuclear process," and "eternity," which did not appear in the previous class.

Based on the key concepts that emerged and the results of the previous analysis in question 2, the concept of energy change is still difficult for students to understand. This is in line with a research study by Pramanda and Arianto (2016), who stated that students have difficulty learning and understanding some forms of energy and the change of energy from one form to another. Therefore, the concept of energy change can be one of the ideas teachers can emphasize when teaching (Chabalengula et al., 2012).

In addition, Figure 3 shows the frequency of word occurrence in students' answers to question 3 (energy utilization).

Figure 3 Frequency of word occurrence in question 3 "What are energy utilization in daily life?"

An analysis of junior high school students' conceptions indicates that the "do activities" concept is the most frequently mentioned, accounting for over 25% of total responses across all grade levels. Moreover, the study identified 44 key concepts related to energy utilization. Overall, 25% of the students who mentioned the "do activities" concept achieved these top average scores of 172.39, with individual scores ranging from 100 to 220.

In the 7th grade, some unique concepts are not found in the 8th and 9th grades, such as "maintaining bodily functions," "measuring the depth of the sea," and "training muscles." In the 8th grade, unique concepts such as "make the body fit," "repair damage," "metabolic molecules," and "turbine rotation" are not found in other classes. Meanwhile, 9th-grade students showed a more complex understanding with the emergence of concepts such as "rotating turbine" and "detecting metal cracks," reflecting energy use in modern industrial technology.

Overall, the research findings revealed that students' understanding progressed from general concepts in grade 7, such as “do activities,” to more specific concepts in grade 9,

such as “rotating turbines” and “detecting metal cracks.” This increase is in line with Fadlilah and Setiani's (2021) conclusion that students' understanding tends to increase as their grades increase.

In addition, the total score analysis showed differences in understanding between grades, with an average score of 80 in grade 7, 83.90 in grade 8, and 101.67 in grade 9 out of a total score of 300. This indicates a significant increase in concept understanding according to grade level. Although the students' academic background is not detailed, these findings imply that individual intelligence also plays a role in conceptual comprehension, as noted by Kurniawan et al., (2023). Such differences should be considered when developing an adaptive and responsive instructional approach.

A problem-based learning (PBL) approach is considered the most effective method for enhancing students’ understanding of the relationship between energy concepts, energy change, and energy utilization. This method can encourage students to actively identify, analyze, and solve problems within real-world contexts, thereby strengthening their conceptual understanding and critical thinking skills (Groenewald et al., 2023; Minarti et al., 2023; Triyadi & Utami, 2024).

In addition to PBL, other learning models such as project-based learning (PjBL) have been shown to improve student's learning outcomes, academic achievement, and thinking skills (Zhang & Ma, 2023), while its integration with STEM approaches (PjBL-STEM) strengthens systems thinking skills through students' active involvement in learning (Habibah et al., 2024). Interdisciplinary approaches such as STEAM (Science, Technology, Engineering, Arts, and Mathematics) have been proven to strengthen students' conceptual understanding while reducing misconceptions (Ozkan & Topsakal, 2020). These findings confirm that combining innovative approaches—such as PBL, PjBL, and STEAM—can create holistic learning.

In addition, the relationship between energy and its application in daily life is reflected in how students associate energy with "work" or "do activities". For example, middle school students learn about change and energy utilization through concrete activities such as "drying clothes," "pushing objects," or "studying," where contextual learning and practical experience affect their ability to relate energy concepts to observed changes in the environment. However, even though most students understand the basic concepts of energy, their practical applications in real life still need to be strengthened. The implementation of innovative approaches can bridge the theory-practice gap. Through these approaches, students understand energy in the abstract and explore its relevance in real contexts.

CONCLUSION

This study examines the relationship between students' understanding of energy, energy change, and energy utilization. The results show that although some students are able to understand the concept of energy, their understanding of energy changes and utilization is still low. Correlational analysis found a significant but weak relationship between understanding the concept of energy and energy change, while the relationship with energy utilization was not significant.

This study makes an important contribution to uncovering the understanding gap between aspects of energy that should support each other. Based on these findings, further research is suggested to explore an integrated learning approach that connects the three aspects of energy understanding. In addition, a more comprehensive evaluation tool is needed to support a holistic analysis of students' understanding.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

HN: Data Collection, Formal Analysis, Writing-Original Draft, Writing-Review & Editing. NYR: Supervision, Validation, Writing-Review & Editing. LR: Validation, Methodology, Formal Analysis, Writing-Review & Editing. RRA: Formal Analysis, Writing-Review & Editing.

REFERENCES

Antink-Meyer, A., & Aldeman, M. (2020). Middle grades teachers' content knowledge for renewable energy instruction design. *Research in Science and Technological Education*, *39*(4), 421–440. https://doi.org/10.1080/02635143.2020.1767048

Chabalengula, V. M., Sanders, M., & Mumba, F. (2012). Diagnosing students' understanding of energy and its related concepts in biological context. *International Journal of Science and Mathematics Education*, *10*(2), 241–266. https://doi.org/10.1007/s10763-011-9291-2

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (six). Routledge. https://doi.org/10.4324/9781315158501-17

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (four). Pearson Education, Inc.

Dewi, S. P., Saparini, S., Destiansari, E., Anjelina, E. L., & Setiani, L. (2024). Students' alternative concept on the topic of energy in life. *Jurnal Inovasi Pendidikan IPA*, *10*(1), 98–110. https://doi.org/10.21831/jipi.v10i1.71417

Fadlilah, U., & Setiani, V. (2021). Analisis pemahaman tentang pengelolaan sampah komunitas bank sampah induk surabaya (bsis) melalui transfer knowledge. *JST (Jurnal Sains Terapan)*, *7*(1), 49–56. https://doi.org/10.32487/jst.v7i1.1131

Franco, D., Macke, J., Cotton, D., Paço, A., Segers, J. P., & Franco, L. (2022). Student energy-saving in higher education tackling the challenge of decarbonisation. *International Journal of Sustainability in Higher Education*, *23*(7), 1648–1666. https://doi.org/10.1108/IJSHE-10-2021-0432

Giancoli, D. C. (2005). *Physics: Principles with applications* (6th ed.). Pearson Education, Inc.

Groenewald, E. S., Kilag, O. K. T., Unabia, R. P., Manubag, M. V, Zamora, M. B., & Repuela, D. F. (2023). The dynamics of problem-based learning: a study on its impact on social science learning outcomes and student interest. *Excellencia: International Multi-Disciplinary Journal of Education*, *1*(6), 2994–9521. https://orcid.org/0000-0002-4416-9989

Habibah, H., Lidya, N., & Suryadi, A. (2024). The effect of pjbl stem learning on students' systems thinking skills on alternative energy materials. *Berkala Ilmiah Pendidikan Fisika*, *12*(3), 371–382. https://doi.org/10.20527/bipf.v12i3.18968

Halliday, D., Resnick, R., & Walker, J. (2014). *Fundamentals of physics halliday & resnick* (10th ed.). John Wiley & Sons, Inc.

Jatmika, S., Jumadi, Pujianto, & Rahmatullah. (2021). Analisis penyebab kesalahan pemahaman peserta didik pada materi usaha dan energi. *Indonesian Journal of Applied Science and Technology*, *2*(3), 97–105.

Kurniawan, B., Dwikoranto, D., & Marsini, M. (2023). Implementasi problem based learning untuk meningkatkan pemahaman konsep siswa: Studi pustaka. *Practice of The Science of Teaching Journal: Jurnal Praktisi Pendidikan*, *2*(1), 27–36. https://doi.org/10.58362/hafecspost.v2i1.28

Latif, F. H., Mursalin, Buhungo, T. J., & Odja, A. H. (2021). Analysis of students' misconceptions using the certainty of response index (cri) on the concept of work and energy in sma negeri 1 gorontalo utara after online learning. *Advances in Social Science, Education and Humanities Research*, *528*, 511–515. https://doi.org/10.2991/assehr.k.210305.075

Liu, X., & McKeough, A. (2005). Developmental growth in students' concept of energy: analysis of selected items from the timss database. *Journal of Research in Science Teaching*, *42*(5), 493–517. https://doi.org/10.1002/tea.20060

Maison, M., Lestari, N., & Widaningtyas, A. (2020). Identifikasi miskonsepsi siswa pada materi usaha dan energi. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 32–39. https://doi.org/10.29303/jppipa.v6i1.314

Minarti, I. B., Nurwahyunani, A., Fajriyah, S. A., Sholekhah, S. D., Ardian, V. V. K., Lestari, S. A., & Firdaus, D. H. (2023). Integrasi model problem based learning (pbl) dalam meningkatkan hasil belajar dan motivasi siswa di indonesia. *Jurnal Pendidikan Matematika Dan Ilmu Pengetahuan Alam*, *1*(2), 44–54.

Opitz, S. T., Harms, U., Neumann, K., Kowalzik, K., & Frank, A. (2014). Students' energy concepts at the transition between primary and secondary school. *Research in Science Education*, *45*(5), 691–715. https://doi.org/10.1007/s11165-014-9444-8

Ozkan, G., & Topsakal, U. U. (2020). Investigating the effectiveness of STEAM education on students' conceptual understanding of force and energy topics. *Research in Science and Technological Education*, *39*(4), 441–460. https://doi.org/10.1080/02635143.2020.1769586

Pontzer, H., Yamada, Y., Sagayama, H., Ainslie, P. N., Andersen, L. F., Anderson, L. J., Arab, L., Baddou, I., Bedu-addo, K., Blaak, E. E., Lambert, E. V, Leonard, W. R., Lessan, N., Martin, C., & Medin, A. C. (2021). Daily energy expenditure through the human life course. *Science*, *373*(6556), 808–812. https://doi.org/https://doi.org/10.1126/science.abe5017

Pramanda, F., & Arianto, F. (2016). Pengaruh penggunaan media simulasi phet terhadap prestasi belajar materi pokok energi dalam sistem kehidupan bagi peserta didik kelas vii smp negeri 16 surabaya. *Jurnal Mahasiswa Teknologi Pendidikan*, *7*(1), 1–10.

Putri, M. K., Parno, P., Munfaridah, N., & Ali, M. (2023). Exploring high school students' concept mastery of work and energy topics: a quantitative descriptive study with insights for stem learning. *Jurnal Pendidikan Sains*, *11*(2), 56–64. https://doi.org/10.17977/jps.v11i22023p056

Rezigalla, A. A. (2020). Observational study designs: Synopsis for selecting an appropriate study design. *Cureus*, *12*(1), 1–8. https://doi.org/10.7759/cureus.6692

Rokmana, A. W. (2024). Analisis pemahaman konsep hukum kekekalan energi mekanik mahasiswa tadris ipa pada mata kuliah energi dalam sistem kehidupan. *AL MIKRAJ: Jurnal Studi Islam Dan Humaniora*, *5*(1), 1310–1323. https://doi.org/https://doi.org/10.37680/almikraj.v5i01.6242

Romli, S., Suhandi, A., Muslim, M., & Kaniawati, I. (2024). Research trends in the development of learning models oriented to increasing scientific literacy: A systematic literature review. *Indonesian Journal of Science and Mathematics Education*, *7*(1), 66–79. https://doi.org/10.24042/ijsme.v7i1.20517

Roodbandi, A. S. J., Choobineh, A., Barahmand, N., & Sadeghi, M. (2021). Research outputs in ergonomics and human factors engineering: A bibliometric and co-word analysis of content and contributions. *International Journal of Occupational Safety and Ergonomics*, *28*(4), 2010–2021. https://doi.org/10.1080/10803548.2021.1955495

Rusyati, L., Rustaman, N. Y., Widodo, A., & Ha, M. (2021). The conception of soils: a cross-sectional study based on the school's perspective. *Journal of Engineering Science and Technology*, *16*(3), 34–41.

Septyana, N. W., Sukawati, I., & WH, N. (2024). Penerapan model problem based learning untuk meningkatkan hasil belajar ipa materi usaha dan energi kelas viii f smp negeri 34 semarang. *Seminar Nasional Pendidikan Dan Penelitian Tindakan Kelas*, 1261–1272.

Sri, W. I. W. (2023). Implementasi model problem based learning dalam meningkatkan minat dan hasil belajar siswa kelas iv pada materi mengubah bentuk energi. *Jurnal Ilmiah Mandalika Education (MADU)*, *1*(2), 161–167.

Tipler, P. A., & Mosca, G. (2008). *Physics for scientists and engineers* (6th ed.). W. H. Freeman and Company.

Triyadi, D., & Utami, C. (2024). The Influence of a problem-based learning model assisted by spin wheel media on the conceptual understanding ability of class iv primary students in the energy sources material. *JPPIPA (Jurnal Penelitian Pendidikan IPA)*, *9*(1), 1–7.

Ustari, A. A., Palloan, P., & Dahlan, A. (2024). Analisis miskonsepsi fisika materi usaha dan energi di sma hasanuddin gowa. *Jurnal Sains Dan Pendidikan Fisika (JSPF)*, *20*(1), 65–76.

Wernecke, U., Schütte, K., Schwanewedel, J., & Harms, U. (2018). Enhancing conceptual knowledge of energy in biology with incorrect representations. *CBE Life Sciences Education*, *17*(1), 1–11. https://doi.org/10.1187/cbe.17-07-0133

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: a meta-analysis study. *Frontiers in Psychology*, *14*, 1–14. https://doi.org/10.3389/fpsyg.2023.1202728

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