ISSN (PRINT) : 2549-9955 ISSN (ONLINE): 2549-9963
JURNAL ILMIAH PENDIDIKAN FISIKA
https://ppjp.ulm.ac.id/journals/index.php/jipf/index

The Effectiveness of STEM Integrated Problem-Based Learning in Enhancing Student Science Literacy on Temperature and Heat Materials

Annisa Sholihah[1], Syahmani[1,2], dan Suyidno[1,2*]
[1]Graduate Program, Lambung Mangkurat University, Banjarmasin, Indonesia
[2]Faculty of Teacher Training and Education, Lambung Mangkurat University Banjarmasin, Indonesia
*suyidno_pfis@ulm.ac.id

Abstract

Science literacy is a key factor in overcoming real-life problems, but it needs to be adequately trained in schools. Therefore, this study aims to analyze the effectiveness of STEM-integrated problem-based learning (STEM-PBL) in enhancing students' science literacy skills. This research is part of research and development with the ADDIE model in the implementation and evaluation stages. The implementation test used a one-group pre-test and post-test design on 58 students divided into two groups. The data collection instruments were science literacy tests and an interview questionnaire. The results showed that: (1) paired t-test results showed that there was a significant increase in students' science literacy skills in both groups; (2) independent t-test results showed that there was no significant difference in the average N-gain score of science literacy in both groups; and (3) n-gain test results for science literacy showed an increase in science literacy in both groups in high criteria. Thus, STEM-PBL is effective in enhancing students' science literacy. STEM-PBL can be the leading solution to realizing the science literacy movement in schools.

Keywords: PBL; Scientific Literacy; STEM

Received : 17 June 2022
Accepted : 9 February 2023
Published : 27 February 2023
DOI : https://doi.org/10.20527/jipf.v7i1.5639

How to cite: Sholihah, A., Syahmani, S., & Suyidno, S. (2023). The Effectiveness of STEM Integrated Problem-Based Learning in Enhancing Student Science Literacy on Temperature and Heat Materials. *Jurnal Ilmiah Pendidikan Fisika*, *7*(1), 1-9.

INTRODUCTION

In the industrial era 4.0, the nation's progress in international relations is heavily influenced by science literacy, mathematics literacy, and language literacy (Puspitasari, 2015). In this case, scientific literacy requires individuals to comprehend scientific phenomena, to identify scientific questions, to draw factual conclusions, and to apply them in everyday life with regard to scientific issues and social contexts (Miller & Demtra, 2016; Nur'ain et al., 2018; Toharudin et al., 2011; Utami et al., 2016; Wulandari & Sholihin, 2016). Students can care, respond to science-related challenges and opportunities, think critically, be creative, understand and apply science to solving real-world problems (Widowati et al., 2017).

The scientific literacy level of Indonesian students remains low. Students' scientific literacy ranks 71st out of 709 countries assessed by PISA (Program for International Student Assessment) in 2018 (Hewi & Shaleh, 2020; Ibrohim et al., 2022). Andriani et al's (2018) and Noviana & Julianto's (2017) research results demonstrate that the scientific literacy ability of a junior high school student in Banjarmasin based on the PISA framework is 47.1 in the low criteria. This low level of scientific literacy indicates that only a small percentage of students are able to apply their scientific knowledge to explain the surrounding natural phenomena, utilize technology, and try to solve real-life problems (Choirunnisa et al ., 2017; Effendi, 2016; Kurnia et al ., 2014; Nadia et al ., 2019). Thus, students' low scientific literacy is a major problem that must be addressed.

Students' inadequate scientific literacy is influenced by a number of variables, including teachers' inability to construct instructional materials based on scientific literacy (Fakhriyah et al., 2022; Pujawan et al., 2022; Teresia et al., 2022; Wahyudi, 2022). The instructional materials, such as textbooks and worksheets, have not been designed to train students to discover and apply their own ideas. Some teachers have not developed their own teaching materials (Aria, 2022; Ishasyuarna & Hafizah, 2022), opting to conduct learning using restricted teaching resources and existing infrastructure rather than providing a new, more innovative learning strategy.

The development of problem-based STEM-integrated teaching materials is one of the efforts taken to overcome students' scientific literacy. Instructional materials function as a teacher's instrument for teaching, motivating, and engaging students' attention to actively engage in physics learning (Rifansyah, 2017). This is supported by the research findings of Sarwi et al., (2021) and the meta-analysis findings of Wahono et al., (2020), which demonstrated that STEM learning is an effective universal tool for preparing students from diverse national and cultural backgrounds in Asia for better learning outcomes.

The integration of the STEM approach in science learning can not only help students explore science materials that work independently, but also be applied in solving real-life problems (Kareem et al., 2022). In its implementation, STEM is often integrated in Project, Problem, Discovery, or Inquiry-based Learning (Casad & Jawaharla, 2012; Dewi et al., 2017; Laforce et al., 2017; Redkar, 2012). However, in this research, STEM is integrated in problem-based learning (STEM-PBL). STEM-PBL is designed to increase students' scientific literacy on temperature and heat. In line with previous research (Safitri et al., 2021; Suyidno et al., 2022; Winarni et al., 2016). STEM-PBL is believed to be able to increase student literacy through the process of solving real-life problems. Students solve problems in groups because they can work together, be responsible and independent, and manage discussion patterns that suit the circumstances of their respective groups (Farwati et al., 2017). Therefore, the purpose of this study was to analyze the effectiveness of STEM-PBL in increasing students' scientific literacy skills in science-physics learning.

METHOD

This research is part of the research and development of the ADDIE model, namely the implementation and evaluation stages. In this research; the independent variable is STEM-PBL instructional materials, while the dependent variable is students' scientific literacy abilities.

The previous stage, namely ADD (Analysis, Design, and Development), has produced a draft of STEM-PBL teaching materials and has been validated by three science learning experts with a validity value for lesson plans (97.50), *Lembar Kinerja Peserta Didik/*LKPD or students' worksheets (94.1), teaching materials (91.61); and LP Science Literacy (91.67). STEM-PBL teaching materials include valid tools to be used to enhance students' scientific literacy and are ready to be tested in real classes.

This research is in the IE (Implementation and Evaluation) stage of the ADDIE model. The implementation test used a pre-test and post-test design (O1 X O2) (Fraengkel & Wallen, 2012) in 2 groups. Both groups were given the same treatment to determine the consistency of the impact of implementing STEM-PBL. According to the KBBI, consistent means fixed, does not change, adheres to principles, or is steady. In this study, consistency will be seen if STEM-PBL can provide the same results when applied to groups 1 (30 students) and 2 (28 students) in grade VII in two schools in Banjarmasin.

The research trial started with a pre-test (O1), where students were initially asked to do a scientific literacy test. This test consists of six essay questions to measure students' ability to explain phenomena scientifically, design and evaluate scientific inquiry, and interpret data and facts scientifically. Furthermore, both groups applied STEM-PBL for four meetings, where the teacher presented motivation in the form of temperature and heat problems in the surrounding environment, and students then analyze the problem themselves and submit alternative solutions. Next, the teacher organized students to solve the problem. Students planned and built simple railroads, and solved mathematical problems, and then the results were presented in front of the class. In the end, the teacher and students tried to conclude their learning and reflected on problem solving. The research ended with a post-test, in which students worked independently on the science literacy LP independently.

The results of the students' answers were converted using a scoring rubric, and their scores were obtained using the equation: the total score obtained divided by the maximum score multiplied by 100. The value was adjusted according to the criteria: 100 ≥ very good > 80; 80 ≥ good > 65; 65 ≥ pretty good > 55; 55 ≥poor > 40; and not good ≤ 40. The level of increasing scientific literacy ability is analyzed by the n-gain equation (Hake, 1999) which is then adjusted according to 3 criteria, namely high, medium, and low. To determine whether the increase is significant and consistent (has the same impact) in both groups, the homogeneity and normality tests are started, followed by the Paired Sample t-Test (parametric) and the independent t-test on the mean n-gain value in both groups. The significance level in this study was set at = 0.05 (two-tailed).

FINDINGS AND DISCUSSION

Science learning is effective if it is able to achieve the stated learning objectives. In this study, scientific literacy ability became a learning objective as measured through a pre-test and post-test of scientific literacy. The results of the analysis of students' scientific literacy abilities are presented in Table 1.

Table 1 Scientific literacy ability

Student	**Group 1**				**Group 2**			
	Pre-test		**Post-test**		**Pre-test**		**Post-test**	
	Score	**Criteria**	**Score**	**Criteria**	**Score**	**Criteria**	**Score**	**Criteria**
S1	23.33	NG	88.33	VG	21.67	NG	71.67	G
S2	20.00	NG	85.00	VG	11.67	NG	81.67	VG
S3	8.33	NG	73.33	G	23.33	NG	85.00	VG

Student	Group 1				Group 2			
	Pre-test		Post-test		Pre-test		Post-test	
	Score	Criteria	Score	Criteria	Score	Criteria	Score	Criteria
S4	15.00	NG	85.00	VG	8.33	NG	78.33	G
S5	28.33	NG	73.33	G	15.00	NG	88.33	VG
S6	8.33	NG	71.67	G	8.33	NG	85.00	VG
S7	15.00	NG	81.67	VG	8.33	NG	73.33	G
S8	8.33	NG	76.67	G	15,00	NG	85.00	VG
S9	15.00	NG	86.67	VG	8.33	NG	90.00	VG
S10	25.00	NG	83.33	VG	15.00	NG	88.33	VG
S11	20.00	NG	81.67	VG	25.00	NG	73.33	G
S12	5.00	NG	80.00	VG	20.00	NG	85.00	VG
S13	21.67	NG	86.67	VG	5.00	NG	73.33	G
S14	11.67	NG	88.33	VG	21.67	NG	71.67	G
S15	23.33	NG	90.00	VG	11.67	NG	81.67	VG
S16	28.33	NG	88.33	VG	25.00	NG	88.33	VG
S17	10.00	NG	90.00	VG	20.00	NG	90.00	VG
S18	11.67	NG	83.33	VG	5.00	NG	88.33	VG
S19	15.00	NG	81.67	VG	21.67	NG	90.00	VG
S20	23.33	NG	80.00	VG	11.67	NG	83.33	VG
S21	8.33	NG	86.67	VG	23.33	NG	81.67	VG
S22	15.00	NG	88.33	VG	13.33	NG	80.00	VG
S23	8.33	NG	90.00	VG	13.33	NG	86.67	VG
S24	8.33	NG	88.33	VG	21.67	NG	88.33	VG
S25	15.00	NG	73.33	VG	15.00	NG	90.00	VG
S26	8.33	NG	85.00	VG	23.33	NG	88.33	VG
S27	15.00	NG	73.33	G	16.67	NG	73.33	G
S28	25.00	NG	71.67	G	23.33	NG	85.00	G
S29	20.00	NG	81.67	VG				
S30	5.00	NG	66.67	G				

Information: S = Student, NG = Not Good, G = Good, VG = Very Good

Based on Tables 1 the pre-test data showed that students' scientific literacy skills are initially still low. After applying STEM-PBL , the post-test data showed an increase in students' scientific literacy skills in the good criteria, even for the majority of students in the very good criteria. This is supported by the results of the analysis of scientific literacy indicators as presented in Table 2.

Table 2 Analysis of science literacy indicators

Indicator	Pre-test		Post-test	
	Score	Inf	Score	Inf
1	16,17	NG	80,67	VG
2	16,40	NG	80,27	VG
3	14,17	NG	72,83	G

Information: 1. Explaining scientific phenomena, 2. Designing and evaluating scientific investigations , 3. Interpreting data and facts scientifically; NG = Not Good, G = Good, VG = Very Good

Based on Table 2, the low ability of students' initial scientific literacy is because all the indicators are in bad criteria. On the contrary; after implementing STEM-PBL, all indicators of scientific literacy experienced an increase in the criteria of good/very good. This is supported by the results of the scientific literacy n-gain analysis presented in Table 3.

Table 3 N-Gain value of scientific literacy

Group	Scores		
	Pre-test	*Post-test*	*N-Gain*
1	15.5 (NG)	80.0 (G)	0.79 (High)
2	16.13 (NG)	83.04 (VG)	0.80 (High)

Table 3 depicts the n-gain achievements in the two groups of 0.79 and 0.80, respectively. There is an increase in scientific literacy before and after implementing STEM-PBL under the high criteria. Furthermore, in order to determine the significance of the impact of implementing STEM-PBL, homogeneity and normality tests are conducted with the assistance of SPSS 26. The results of the Kolmogorov-Smirnov test on the pre-test data for the scientific literacy post-test in group 1 were 0.95 and 0.49, respectively, while in group 2 they were 0.64 and 0.02, indicating that all of the data is normally distributed (p 0.05), except for the post-test data in group 2. Thus, the next test is to use the paired t-test in group 1 and the Wilcoxon test in group 2, the results are presented in Table 4.

Table 4 Paired t-test results

Group	**N**	***Sig. (2-tailed)***	
		Paired t-test	Wilcoxon test
1	30	0,00	
2	28		0,00

Table 4 shows the results of the paired t-test in group 1 and the Wilcoxon test in group 2, with a sig (two-tailed) of 0.000 <0.05. This means that there is an effect of increasing scientific literacy significantly after applying STEM-PBL to material temperature and heat. To strengthen these findings, the mean value of n-gain for groups 1 and 2 would be tested by an independent t-test. This test was chosen because the normality test results for n-gain in groups 1 and 2 were 0.20 and 0.86, and the homogeneity test results were 0.75, which means that the n-gain data is normally distributed and homogeneous. The results of the independent t-test presented in Table 5.

Table 5 Independent t-test results

Group	**N**	**Man Whitney** *Sig. (2-tailed)*
1	30	0.83
2	28	

Information: $p < 0,05$

Based on Table 5, the results of the independent t-test obtained a sig. (2-tailed) of 0.838 > 0.05. This means there is no significant difference in the mean score of N-Gain scientific literacy in the two groups.

Tables 1–3 show that students' scientific literacy skills are low at first because they have trouble explaining things in a scientific way, planning and evaluating scientific experiments, and figuring out what data and facts mean in a scientific way. The reason is the unavailability of scientific literacy packages to practice scientific literacy in schools. Students are rarely trained to practice in the laboratory, so they have less experimental skills. This is in line with some of the results of previous research showing that students are only able to remember scientific knowledge (scientific facts, principles, and laws) as well as draw simple conclusions and let alone apply them in real life (Dewi et al., 2019; Ratini et al., 2018; Utomo et al., 2018). Students can only provide simple scientific explanations and follow explicit evidence (Angraini, 2014).

After implementing STEM-PBL, however, students' scientific literacy abilities meet the good/very good criteria. In this case, the teacher facilitates students' understanding of current science issues and identification of problems (phase 1); scientific literacy learning needs (phase 2); scientific inquiry, problem-solving, and decision-making in relation to science problems (phase 3); presenting the work (stage 4); and evaluating scientific literacy outcomes and processes (phase 5). Students can use STEM to build miniature mini-fridges, railroads, hot air balloons, and solar panels. This engineering activity can assist students maximize their intellectuality (Puryadi, Sahono, & Turdjai, 2017). Students try to dare to decide how to handle cases, and consider the good and bad of every decision they make. In line with Fauziah et al. (2019); student activities in STEM-PBL are deliberately designed to train scientific attitudes through scientific inquiry, decision making, and problem solving so that they have a positive impact on students' scientific literacy abilities. This is supported by cognitive theory (Sutarto, 2017), which states that the involvement of mental activity in students is a result of a process of active interaction with other people and the environment to obtain changes in knowledge, understanding, skills, behavior, and scientific attitudes is relative.

Students' ability to explain natural phenomena improves after using STEM-PBL (Tables 1–3), as does the application of scientific conclusions in life and mathematics in science, though with less success. Due to limited time for research and students' lack of initial literacy, the process of learning scientific literacy takes a long time from lesson plans. Furthermore, some students lose focus and read less information. Remember that practical activities have characteristics that cannot be equated with theoretical learning (Sutrisno, 2016), so students are expected to be skilled at carrying out experiments and gain theoretical knowledge through reading teaching materials. However, Tables 4 to 6 prove the application of STEM-PBL was able to significantly and consistently improve students' scientific literacy in both groups according to the high criteria. Consistency means that something is fixed, does not change, adheres to principles, or is steady (KBBI, 2022). In Tables 1 to 4, the meaning of this consistency can be seen from the implementation of STEM-PBL, which has an impact on increasing scientific literacy in group 1 in the high criteria as well as in group 2. Therefore, the fundamental implication of the results of this study is that STEM-PBL can be applied on a large scale to overcome the problem of the low ability scientific literacy of students in learning physics.

CONCLUSION

The application of STEM-PBL to the temperature and heat materials has proven effective in enhancing students' scientific literacy, as this research findings demonstrates a significant and consistent increase in scientific literacy skills in both groups that meet the high criteria. Through STEM-PBL, students are accustomed to being scientific learners, participating in successful scientific inquiry, making decisions, and solving real-life problems. Further research needs to be carried out on other materials and at various levels of education.

REFERENCES

Andriani, N., Saparini, & Akhsan, H. (2018). Kemampuan literasi sains fisika siswa SMP kelas VII di Sumatera Selatan menggunakan kerangka PISA (Program for International Student Assesment). *Berkala Ilmiah Pendidikan Fisika*, *6*(3), 278-291.

Angraini, G. (2014). *Analisis kemampuan literasi sains dan kemampuan berpikir tingkat tinggi (hots – higher order thinking skills) siswa SMAN kelas X di Kota Solok pada konten biologi*. Universitas Pendidikan Indonesia.

Aria, R. (2022). Pengembangan buku ajar berbasis literasi sains pada materi ekosistem untuk meningkat-kan hasil belajar IPA di kelas V SDN 101783 Saentis Kabupaten Deli Serdang. Doctoral dissertation, UNIMED. Tidak Dipublikasikan.

Casad, B., & Jawaharla, M. (2012). Learning through guided discovery: an engaging approach to K-12 STEM education. *America Society for Engineering Education*, *6*(2), 1-10.

Choirunnisa, N., Wardani, S., & Sri, S. (2017). Keefektifan pendekatan contextual teaching learning dengan model pembelajaran inkuiri terbimbing terhadap literasi sains. *Jurnal Inovasi Pendidikan Kimia, 11*(2), 10-18.

Dewi, C. A., Khery, Y., & Erna, M. (2019). An ethnoscience study in chemistry is learning to develop scientific literacy. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 279–287.

Dewi, H. R., Mayasari, T., & Handhika, H. (2017). Peningkatan keterampilan berpikir kreatif siswa melalui penerapan inkuiri terbimbing berbasis STEM. *Prosiding Seminar Nasional Pendidikan Fisika III*, Universitas PGRI Madiun, pp. 47-53.

Effendi, R. (2016). Model pembelajaran SQ3R untuk mengembangkan kemampuan literasi matematis siswa. *Jurnal Pendidikan Matmatika, 1*(2), 1-10.

Farwati, R., Permatasari, A., & Firman, H. (2017). Integrasi problem-based learning dalam STEM education berorientasi pada aktualisasi literasi lingkungan dan kreativitas. *Prosiding Seminar Nasional Pendidikan IPA*. Universitas Sriwijaya.

Fauziah, N., Hakim, A., & Andayani, Y. (2019). Meningkatkan literasi sains peserta didik melalui pembelajaran berbasis masalah berorientasi green chemistry pada materi laju reaksi. *Jurnal Pijar MIPA, 14*(2), 31-35.

Fakhriyah, F., Masfuah, S., Hilyana, F. S., & Mamat, N. (2022). Analysis of technological pedagogical content knowledge (TPACK) ability based on science literacy for pre-service primary school teachers in learning science concepts. *Jurnal Pendidikan IPA Indonesia, 11*(3), 399-411.

Fraenkel, J. R., & Wallen N. E. (2012). *How to design and evaluate research in education.* Boston: McGraw-Hill, Higher Education.

Hewi, L., & Shaleh, M. (2020). Refleksi hasil PISA (the programme for international student assesment): Upaya perbaikan bertumpu pada pendidikan anak usia dini. *Jurnal Golden Age, 4*(01), 30-41.

Irhasyuarna, Y., & Hafizah, E. (2022). Analisis validitas terhadap pengembangan bahan ajar IPA berbasis literasi sains pada materi objek ipa dan pengamatannya. Pahlawan: *Jurnal Pendidikan-Sosial-Budaya*, *18*(1), 11-15.

Kareem, J., Thomas, R. S., & Nandini, V. S. (2022). A conceptual model of teaching efficacy and beliefs, teaching outcome expectancy, student technology use, student engagement, and 21st-century learning attitudes: A STEM education study. *Interdisciplinary Journal of Environmental and Science Education, 18*(4), e2282

Kurnia, F., Zulherman, & Fathurohman, A. (2014). Analisis bahan ajar fisika SMA kelas XI di kecamatan Indraloaya Utara berdasarkan kategori literasi sains. *Jurnal Inovasi dan Pembelajaran Fisika, 1*(1), 43-47.

Laforce, M., Nobie, E., & Blackwell, C. (2017). Problem-based learning and student interest in stem careers: The roles of motivation and ability beliefs. *Education Sciences, 92*(7), 1-22.

Miller, D. M., & Demtra, A. C. (2016). Integrating the liberal arts and chemistry: A series of general assignments to develop science literacy. *Journal of Chemical Literacy, 93*(5), 864-869.

Mullis, I. V., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in mathematics.* International Association for the Evaluation of Educational Achievement.

Nadia, Suryati, E., & Natalina, M. (2019). The implementation of the 5e learning cycle model to improve the scientific literacy skills of students in the science lessons class VIII.2 of 21 St junior high school in Pekanbaru. *JOM FKIP, 6*(1), 22-30

Nofiana, M., & Julianto, T. (2017). Profil kemampuan literasi sains siswa SMP di Kota Purwakerto ditinjau dari aspek konten, proses dan konteks ilmiah. *Jurnal Ilmiah Sosial dan Humaniora, 1*(2), 77-84.

Nur'aini, D., Rahardjo, S. B., & Susanti, E. (2018). Student's profile about science literacy in Surakarta. *Journal of Physi*cs, 1022(1), 012016.

Nur'Aini, D., Rahardjo, S. B., & Susanti, V. E. (2018). Student's profile about science literacy in Surakarta. *Journal of Physics: Conference Series,1022*(1), 012016.

Pujawan, I. G. N., Rediani, N. N., Antara, I. G. W. S., Putri, N. N. C. A., & Bayu, G. W. (2022). Revised bloom taxonomy-oriented learning activities to develop scientific literacy and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, *11*(1), 47-60.

Puryadi, P., Sahono, B., & Turdjai, T. (2017). Penerapan metode eksperimen untuk meningkatkan sikap ilmiah dan prestasi belajar siswa. *Jurnal Ilmiah Teknologi Pendidikan*, 7(2), 132–140.

Puspitasari, A. D. (2015). Efektivitas pembelajaran berbasis guided inquiry untuk meningkatkan literasi sains siswa. *OMEGA, Jurnal Fisika dan Pendidikan Fisika, 1*(2), 1-5.

Ratini, Muchtar, H., Suparman, M. A., Tamuri, A. H., & Susanto, E. (2018). The influence of learning models and learning reliance on students' scientific literacy. *Jurnal Pendidikan IPA Indonesia*, 7(4), 458–466.

Redkar, S. (2012). Teaching advanced vehicle dynamics using a project-based learning approach. *Journal of STEM Education*, *13*(3), 17-30.

Rifansyah, M. & Mastuang, M. (2017). Pengembangan perangkat IPA pada pokok bahasan tata surya. *Berkala Ilmiah Pendidikan Fisika, 5*(3), 286-296.

Safitri, R., Haryanto, H., & Harizon, H. (2021). Development of PBL-STEM-based E-LKPD to improve students' science literacy skills on reaction rate materials. *Jurnal Pendidikan Kimia*, *13*(2), 113-129.

Sarwi, S., Baihaqi, M. A., & Ellianawati, E. (2021). Implementation of Project-Based Learning Based on STEM Approach to Improve Students' Problems Solving Abilities. *Journal of Physics: Conference Series*, *1918* (5), 052049.

Soltura, R. T. (2022). Designing a constructivist learning aid module in disentangling least mastered competencies in the wave motion. *Journal of Research in Instructional*, 2(1), 1-18.

Sutarto, S. (2017). Teori kognitif dan implikasinya dalam pembelajaran. *Islamic Counceling*, *1*(2), 1–26.

Sutrisno, V. L. P. (2016). Faktor-faktor yang mempengaruhi hasil belajar siswa pada pembelajaran praktik kelistrikan otomotif SMK di kota Yogyakarta. *Jurnal Pendidikan Vokasi*, *6*(1), 111–120.

Suyidno, S., Fitriyani, F., Miriam, S., Mahtari, S., & Siswanto, J. (2022). STEM-Problem Based Learning: Pembelajaran inovatif untuk meningkatkan literasi sains siswa di era industri 4.0. *Jurnal Penelitian Pembelajaran Fisika, 13*(2), 163-170.

Teresia, W., Sahyar, S., & Sinulingga, K. (2022). Development of PISA-based questions for electricity in SMA. *Proceedings of the 7th Annual International Seminar on Transformative Education and Educational Leadership,* 20

September 2022, Medan, North Sumatera Province, Indonesia.

Toharudin, U., Sri, H., & Andrian, R. H. (2011). *Membangun literasi sains siswa*. Humaniora.

Utami, B., Saputro, S., Ashadi, & Masykuri, M. (2016). Scientific literacy in a science lesson. *Prosiding ICTTE FKIP Universitas Negeri Surakarta 2015, 1(1)*, 125-133.

Utomo, A. P., Narulita, E., Yuana, K., Fikri, K., & Wahono, B. (2018). Students' errors in solving science reasoning-domain of trends in international mathematics and science study (TIMSS). *Jurnal Pendidikan IPA Indonesia*, *7*(1), 48–53.

Wahono, B., Lin, P. L., & Chang, C. Y. (2020). Evidence of STEM enactment effectiveness in Asian student learning outcomes. *International Journal of STEM Education*, *7*, 1-18.

Wahyudi, M. (2022). Identification of science literacy ability of MAN 1 East Lombok students in learning static fluid matter physics. *KONSTAN-Jurnal Fisika Dan Pendidikan Fisika*, 7(1), 90-94.

Widowati, A., Anjarsari, P., Zuhdan, K. P., & Dita, A. (2018). Applying the innovative approach "Nature of Science (NoS) within inquiry" for developing scientific literacy in the student worksheet. *Journal of Physics: Conference Series, 983*(1), 012199.

Winarni, J., Zubaidah, S., & Koes, S. (2016). STEM: Apa, mengapa, dan bagaimana. *Prosiding Seminar Pendidikan IPA Pascasarjana Universitas Negeri Malang*, *1*, 976-984.

Wulandari, N., & Sholihin, H. (2016). Analisis kemampuan literasi sains pada aspek pengetahuan dan komptensi ilmiah siswa SMP pada materi kalor. *Edusains, 8*(1), 66-73.