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Application of STEM-PjBL Based Chemistry Module to Improve Science Literacy and Student Learning Motivation

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Abstract: The purpose of this study is to determine the application of the use of STEM-PjBl-based chemistry modules in improving science literacy and student learning motivation. The subjects of this study were 2nd semester students in the 2022/2023 academic year who attended general chemistry lectures on the topic of organic compounds. There are 92 students divided into 3 classes. The research method uses a quantitative approach with a quasi-experimental design in the form of a one group pretest and posttest design. The instruments used in the study were science literacy test and learning motivation questionnaire. The research data were analyzed statistically and descriptive statistics including the calculation of N-Gain and percentage. Based on the results of data analysis, the increase in student science literacy was 0.46 with moderate criteria. Science literacy skills that increased significantly were in the aspect of explaining scientific phenomena by 81%. The application of STEM-PjBL-based chemistry modules also increases student learning motivation with an average of 76% before learning to 87% after learning. It can be concluded that using STEM-PjBl-based chemistry modules can help students improve science literacy and learning motivation in organic compound materials.

Keywords: Learning Motivation; Module; Science Literacy; STEM-PjBL

Introduction

The advancement of science and technology has a significant impact on the field of education and is essential to surviving in the 21st century's competitive environment (Wardana et al., 2013). In order for the next generation to thrive in the twenty-first century, that is, to be high-quality, ethical, and capable of operating on a global scale from the perspectives of planning, capability, and capability, it is hoped that SDM quality will be increased (Ramdani et al., 2021). It is predicted that education for the twenty-first century will produce human resources with a variety of skills for the twenty-first century, including scientific literacy (Menggo et al., 2019; Rios et al., 2020). Learning science that can increase students' science literacy is one strategy to raise the standard of human resources. Science literacy is crucial for students to possess because it helps them comprehend and interpret scientific concepts and processes that occur in context, in addition to helping them memorize subject information (Amala et al., 2023). Science literacy not only involves knowledge of concepts and theories, but also involves knowledge of procedures linked to scientific inquiry (Putri et al., 2023).

Science literacy is the capacity to use scientific knowledge in understanding and making judgments about nature and how it has been altered by human activity. It also includes the ability to identify questions and develop conclusions based on the data at hand (Rohman et al., 2017). Using scientific knowledge to understand and make decisions about the natural world and how it is changing as a result of human activity is known as science literacy. It involves recognizing questions and reaching all conclusions based on evidence (Afni et al., 2018; Al Sultan et al., 2018; Fuadi et al., 2020; Muzijah et al., 2020). Indonesia is one of the

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countries with a low level of science literacy skills (Masithah et al., 2022; Ramdani et al., 2021). Based on student performance in the PISA (Program for International Student Assessment) science literacy test, Indonesia ranks in the bottom 10 countries, even though science literacy is a key indicator of a nation's educational system's quality (OECD, 2014).

Based on the results of observations made in the lecture process, it was found that student science literacy was still low. One of the causes is the low motivation of students to learn, this results in learning outcomes that have not been maximized. Different learning levels when learning occurs, students' attitudes such as curiosity, excitement, responsibility, enjoyment of their work, and responses to the teacher's stimulus can be used to determine whether they are motivated (Sudjana, 2013).

Improving student literacy is important in the learning process. To attract students to be interested and happy to learn can be done by facilitating teaching materials such as modules. Colligative of solutions are another topic on which STEM-based chemistry e-modules effectively improve student learning outcomes (Dalimunthe et al., 2022). A project-based learning (PjBL) or STEM-PjBL integrated teaching resource is a systematically organized resource whose content integrates chemistry, an experimental science, or PjBL by utilizing various STEM components, namely science, technology, engineering, and mathematics, where the problems being tackled are drawn from real-world situations. STEM offers a wealth of pedagogical strategies, including frameworks, methods, and existing approaches for using STEM in the classroom (Park et al., 2022).

STEM-based PjBL model in science learning affects students' science literacy (Wahyu et al., 2023). The STEM-based PjBL model can help aspiring teachers become more competent educators, reach the affective and cognitive domains in science learning, boost student interest, allow learning to occur in a stress-free environment, and help students solve problems when studying science (Christensen et al., 2015).

PjBL is an inquiry-based teaching method where students are forced to create real-world products and are given pertinent tasks to complete in order to engage in knowledge production (Brundiers et al., 2013). According to the findings of Tseng et al. (2013) study, STEM-integrated PjBL can boost students' interest in learning, make it more relevant, assist students in resolving real-world issues, and support future professions. Additionally, because it teaches students to think critically, analyze, and develop higher order thinking skills, STEM in PjBL challenges and engages pupils (Capraro, 2013). Through STEM education, students develop science and technology literacy, which can be seen in reading, writing, observing, and practicing science. As a result, they are better equipped to live in society and solve problems connected to STEM science disciplines in their daily lives (Mayasari et al., 2014). STEM learning can also improve student learning outcomes and motivation (Amdayani et al., 2022).

Student learning achievement can be affected by several factors, both internal factors such as intelligence, talent, interest, and learning motivation (Abdullah et al., 2021). One of the many elements that influences learning and the accomplishment of learning objectives is learning motivation. Motivation is the driving force within in a person who can arouse, direct and become the basis of one's behavior to achieve a goal (Glynn et al., 2009). Motivation is one of the essential factors in the learning process that could have a positive impact on student outcomes (Safitri et al., 2023). Students' abilities and skills are directly proportional to their own motivation (Taupik et al., 2023).

By considering some of the above, innovation is needed to overcome the problem by implementing a STEM-PjBl-based chemistry module to improve science literacy and student learning motivation.

Method

Quantitative research using an experimental approach is the methodology employed. The type of research used is Pre-Experimental. The One-Group Pretest Posttest Design is the kind of Pre-Experimental that is employed. The research was conducted at the Department of Chemistry, FMIPA, Universitas Negeri Medan. This design used a group of research subjects from a population that was not randomly selected (Boslaugh, 2008; Cohen et al., 2018). The sample for this study was selected using purposive sampling technique using criteria such as lecturers who teach the same and equivalent student competencies. The subjects of this study were 2nd semester students in the 2022/2023 academic year who attended general chemistry lectures on the topic of organic compounds. Students totaled 92 people who were divided into 3 classes.

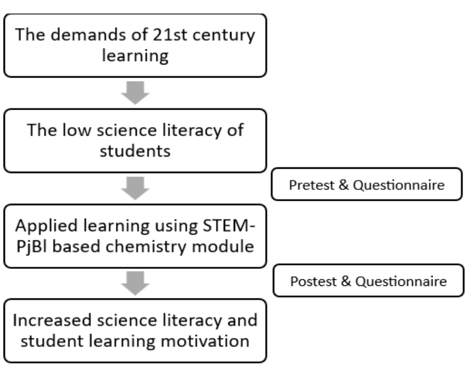


Figure 1. Research stages chart

The instruments used in this study were test and non-test instruments. The test instrument used is a science literacy question, while the non-test instrument is a learning motivation questionnaire. The criteria for science literacy scores as shown in Table 1.

Table 1.Science Literacy Score Criteria (Purwanto, 2010)

Interval (%)	Criteria
86-100	Very high
76-86	High
60-75	Medium
55-59	Low
≤54	Very Low

The science literacy test developed refers to the PISA 2012 framework which is associated with STEM aspects. The research data were analyzed statistically and descriptive statistics including the calculation of N-Gain and percentage. The increasing of students' science literacy after learning using PjBL STEM teaching materials is achieved by measuring the score of normalized gain average (N-Gain) (Hake, 1998).

$$g = \left(\frac{\%\,(S_f) - \%(S_i)}{100 - \%\,(S_f)}\right) \quad (1)$$

Where g is the normalized gain value, Sf is the mean posttest score, and Si is the mean pretest score. According to Hake (1998), the normalized gain mean value can be interpreted as follows: (g) < 0.3 for the low category; 0.3 ≤ (g) < 0.7 for the medium category; and (g) > 0.7 for the high category.

The increase in student learning motivation was analyzed by descriptive statistics using the percentage formula. The results of the analysis were then classified into very high, high, medium, low, and very low. The number of criteria scores (each item has a maximum score of 5) multiplied by the number of items (11) and the number of respondents (92 students) were used to assess the motivation questionnaire results. The percentage value can be interpreted as follows: 0–20% for very low, 21–40% for low, 41-60% for medium, 61–80% for high, and 81–100% for very high.

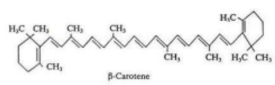
Result and Discussion

Improvement Students' Science Literacy

The science literacy questions used in this study were arranged based on aspects of context, knowledge, and competence. Overall, the organic compound material is the context aspect. For aspects of knowledge about carbon compounds, hydrocarbons and functional groups. While the competency aspects consist of explaining scientific phenomena (ESP), identifying scientific issues (ISI), and using scientific evidence (USE).

After the test is completed based on the grid, the test validation is carried out to the material expert and declared feasible to be tested. Validation is used to determine the feasibility level of a test. The test questions were tested on students who had learned organic compound material and then analyzed so that the validity, reliability, difficulty index and differential power of the test questions were obtained. The test results were analyzed using the SPSS program. Reliability and Validity Test on primary data test results obtained from 30 respondents with r table of 0.361 and sig of 5%. In the test validity test of 30 test questions that were tested, 22 questions were declared valid, so 20 questions were selected to be used as pretest and posttest questions. Furthermore, the reliability test obtained a Cronbach's Alpha value of 0.813, so it was declared reliable. For the test of the difficulty index, the average question used has a medium difficulty index. Followed by a test of differential power, all data contained in the corrected item-total correlation table in the SPSS program shows a number greater than 0.3, so that all questions can be used because they have medium and high differential power. The questions are shown as examples in Figure 2.

1. Labu kuning merupakan salah satu produk hortikultura termasuk family *Cucurbitaceae* yang mempunyai nutrisi beragam. Warna orange pada labu kuning menandakan labu mengandung antioksidan yaitu β – karoten. Bahan ini kemudian dikonversi menjadi Vitamin A didalam tubuh. Berikut struktur dari senyawa β – karoten



β-Carotene

Jumlah atom C primer dan sekunder berturut-turtu pada struktur diatas adalah……

   a. 9 dan 20
   b. 10 dan 20
   c. 20 dan 10
   d. 20 dan 9
   e. 20 dan 20

2. Indah mendapatkan tugas project dari gurunya, dia melakukan percobaan di laboratorium tentang identifikasi senyawa hidrokarbon pada suatu bahan. Setelah dianalisis menggunakan spektrofotometer UV-VIS diperoleh struktur senyawanya sebagai berikut:

$$\begin{array}{l} CH_3 - C \equiv C - \underset{|}{CH} - CH_3 \\ \qquad\qquad\; CH_3 - CH - CH_3 \end{array}$$

Nama senyawa di atas yang tepat adalah ….

   a. 4-isopropill-2-pentuna
   b. 2-isopropil-3-pentuna
   c. 4,5-dimetil-2-heksuna
   d. 4,5,5-trimetil-2-pentuna
   e. 4,5,5-trimetil-2-pentuna

3. Pengelasan (welding) adalah salah salah satu teknik penyambungan logam dengan cara mencairkan sebagian logam induk dan logam pengisi dengan atau tanpa tekanan dan dengan atau tanpa logam penambah dan menghasilkan sambungan yang kontinyu. Proses pengelasan berkaitan dengan lempengan baja yang dibuat dari kristal besi dan karbon sesuai struktur mikronya, dengan bentuk dan arah tertentu. Tukang las menyambung batang besi dengan api yang berasal dari gas asetilena. Gas asetilena ternyata menghasilkan energi panas yang sangat besar sehingga dapat melelehkan logam. Reaksi yang terjadi untuk menghasilkan gas asetilena adalah….
   a. Reaksi senyawa CaC_2 dengan air
   b. Reaksi senyawa CaC_2 dengan oksigen
   c. Reaksi senyawa C_2H_2 dengan hidrogen
   d. Reaksi senyawa C_2H_2 dengan nitrogen
   e. Reaksi senyawa CaC_2 dengan nitrogen

Figure 2. Example of pretest-posttest question

After it was declared that the test questions were suitable for use, then the pretest was carried out on the three research sample classes, namely classes A, B and C. After that, learning is given using STEM-PjBl integrated teaching materials. Then a posttest was conducted to find out how students' science literacy improved after using STEM-PjBl integrated teaching materials. The average results of student pretests and posttests on organic compound material can be seen in Figure 3.

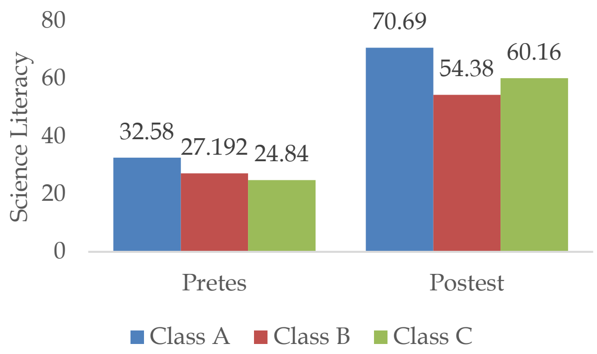


Figure 3. Average result of student pretest and posttest

Figure 3 shows that there is a change in the average score from the pretest and posttest. Overall, the posttest scores were higher than the pretest scores. Class A has a higher average of achievement and posttest results compared to other classes. Meanwhile, the lowest average pretest score is in class C, and the lowest average posttest score is in class B. Furthermore, the values obtained were analyzed to see the improvement of science literacy assisted by STEM-PjBl integrated teaching materials using the N-gain formula. The N-gain results of the research sample can be seen in Figure 4.

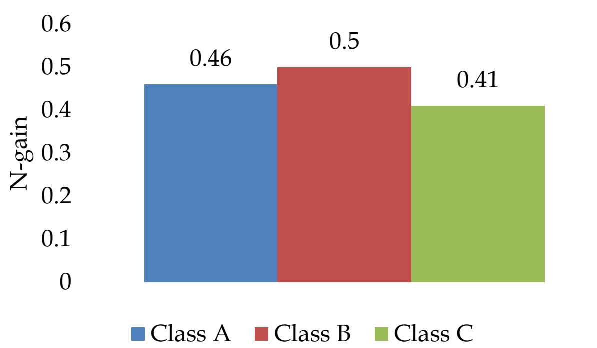


Figure 4. N-gain of science literacy

Figure 4 shows that the average N-gain value obtained is 0.46 with moderate criteria. Class B has the highest n-gain compared to class A and Class C, which is 0.5. It can be concluded that STEM-PjBl integrated teaching materials are effective for improving students' science literacy skills with moderate criteria. In accordance with the results of research (Dianti et al., 2023), the application of project-based learning with a STEM approach has good effectiveness in improving students' science literacy. Similar research also obtained the same results that PjBL STEM learning had an effect on science literacy (Afriana, 2022). In line with research Nilyani et al. (2023) that STEM-integrated science learning has a very high influence on students' science literacy and critical thinking skills. In line with Asri et al. (2021) research, which found that there was an increase in post-test results compared to pretests after the application of PjBl learning with the STEM approach. Accordingly, it demonstrates how STEM can enhance the quality of the learning process, which will affect the caliber of graduates (Zamista, 2018).

Science Literacy on Competency Aspects

Science literacy is a learning outcome obtained by students as a form of knowledge they have and used to solve real problems in life. Aspects of science literacy competencies are explaining scientific phenomena (ESP), identifying scientific issues (ISI), and using scientific evidence (USE). The average proportion of students' science literacy success in the competency element, as shown in Table 2, yields the following results.

Table 2. Average Percentage Achievement of Science Literacy Competency Aspects

Aspect Competencies	Pretest	Posttest
Explaining scientific phenomena	53%	81%
Identifying scientific issues	49%	72%
Using scientific evidence	45%	68%

Table 2 indicates that science literacy is still, on average, relatively low in the competency area during the pretest or before to learning, namely in the areas of 53% for explaining scientific phenomena, 49% for identifying scientific concerns, and 45% for applying scientific evidence. This is in accordance with the results of Afni et al. (2018) and Fuadi et al. (2020) research that found that many students have low science literacy. Based on research by Mawardini et al. (2015) mentioned that one of the factors the low achievement of students' science literacy is not yet able to interpret data and information and draw conclusions.

However, after the learning process using STEM-PjBl integrated teaching materials, the average student's science literacy increased. Science literacy increased significantly in the aspect of explaining scientific phenomena by 81% with high criteria. Meanwhile, the aspects of identifying scientific issues and using scientific evidence increased by 72% and 68% with moderate criteria. Among the three aspects of science literacy competence, the aspect of explaining scientific phenomena is the highest aspect owned by students.

This is because in this aspect, students only remember and recognize a scientific phenomenon. According to OECD (2017), in this aspect, it requires students to be able to recognize, offer, and evaluate explanations of various things that are natural and technological phenomena. The lowest science literacy competency is in the aspect of using scientific evidence, which is 68% with moderate criteria. It is suspected that students have not been able to draw the right conclusion from a data. As explained by Mawardini (2015), their research that one of the factors the possibility of low student science literacy achievement is that students have not been able to interpret data and information (tables, graphs) and draw conclusions. According to Becker et al. (2011) the STEM approach improves student learning.

Improvement of Student Motivation

Motivation is something that encourages the emergence of an action, directs action towards achieving the desired goal and determines the speed or slowness of an action (Hamalik, 2002). In measuring the increase in student learning motivation in organic compound materials, a learning motivation questionnaire was given before and after using STEM-PjBl integrated teaching materials. The learning motivation questionnaire instrument was prepared in the form of a Likert scale in accordance with the indicators developed by Uno (2009), namely concentration, enthusiasm for learning, independence, readiness to learn, enthusiasm or encouragement and self-confidence. The questionnaire was given to 92 respondents with the answer criteria strongly disagree (STS), disagree (KS), disagree (TS), agree (S) and strongly agree (SS). The following are the results of the percentage of student learning motivation in each aspect before and after learning, can be seen in Figure 5 and 6.

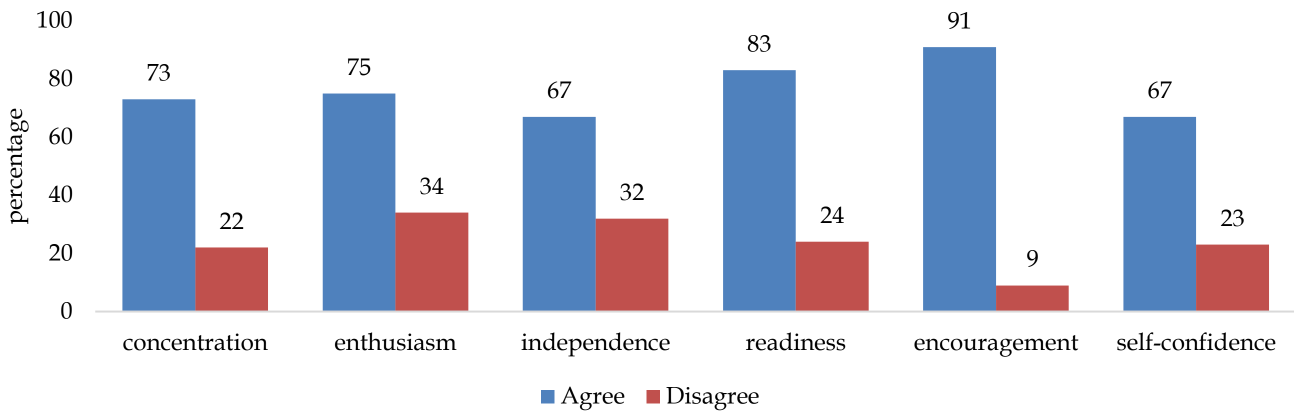


Figure 5. Percentage of student motivation before learning

Based on Figure 5, it is obtained that student learning motivation before learning using STEM-PjBl integrated teaching materials is still in the moderate category on average, which is 76%. Based on the analysis of 6 indicators of learning motivation, high learning motivation is obtained in the aspects of readiness and enthusiasm in learning, while the other 4 indicators are still in the medium category.

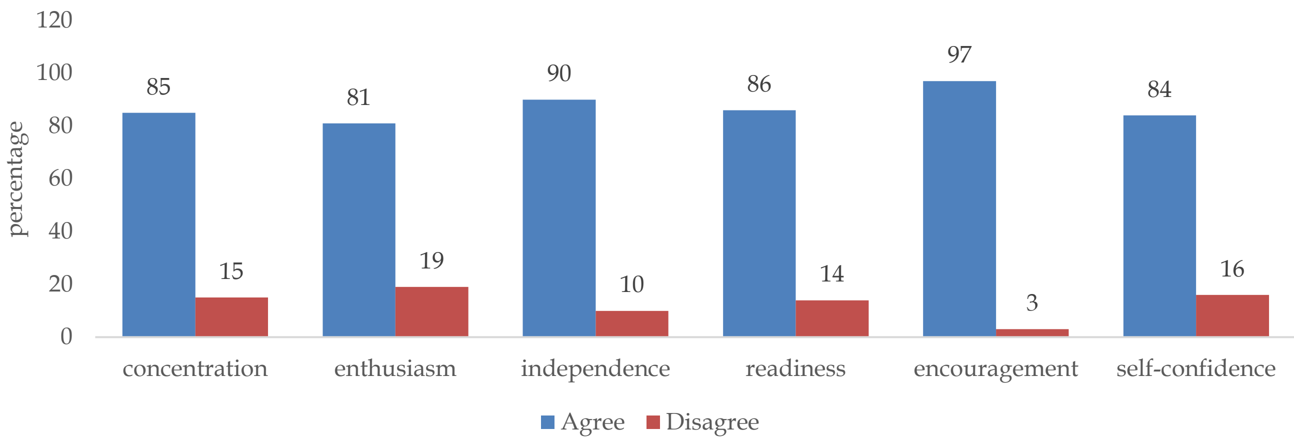


Figure 6. Percentage of student motivation after learning

Meanwhile, Figure 6 shows that student learning motivation after learning using STEM-PjBl integrated teaching materials increased by an average percentage of 87% with a high category. It can also be seen that all indicators of learning motivation obtained a value above 80% with a high category. Overall, every aspect of student learning motivation used in this study has increased after using the STEM-PjBl-based e-module on organic compound material. This is in line with Ndoa et al. (2022) research that there is an increase in student learning motivation in all indicators of learning motivation measured. Based on the above data, it can be summarized that STEM-PjBl integrated teaching materials can increase student learning motivation in organic compound materials. This is in accordance with the research proposed by Tseng et al. (2013) that the integration of STEM aspects can have a positive impact, especially in terms of problem solving and increasing learning motivation and supporting future careers. PjBL-STEM has a positive effect on increasing learning motivation and facilitating problem-solving skills of vocational students in Taiwan (Chiang et al., 2016). Furthermore, Istyadji et al. (2022) stated that the application of learning that involves students more actively can increase student learning motivation.

Conclusion

Based on the results achieved, it can be summarized that the STEM-PjBl integrated chemistry module on organic compound material can improve science literacy and student learning motivation. Recommendations for further research can be applied in learning by analyzing critical thinking skills, creative thinking skills, cooperation skills or other variables.

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Author Contributions
In this study, the authors made different contributions. Conceptualization, SA. RED; methodology, SA. RED. MIS; validation, SA. RED. DS.; formal analysis, SA. RED.; investigation, SA. RED. MIS. DS.; resources, SA. RED. MIS. DS.; data curation, SA. RED..: writing—original draft preparation, SA. RED.; writing—review and editing, SA. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors have declared that there are no conflicts of interest associated with the publication of this paper.

References

Abdullah, N., Khaldun, I., & Musman, M. (2021). The Influence of Pocketbook to Improve Student Learning Outcomes and Motivation on Electron Configuration Material. *Jurnal Penelitian Pendidikan IPA*, *7*(3), 298–304. https://doi.org/10.29303/jppipa.v7i3.647

Afni, N., & Rokhimawan, M. A. (2018). Literasi Sains Peserta Didik Kelas V di MIN Tanuraksan Kebumen. *Al-Bidayah: Jurnal Pendidikan Dasar Islam*, *10*(1), 47–68. https://doi.org/10.14421/al-bidayah.v10i1.129

Afriana, J. (2022). Pengaruh PjBL STEM terhadap Literasi Sains dan Problem Solving Siswa SMP. *Jurnal Didaktika Pendidikan Dasar*, *6*(2), 627–638. https://doi.org/10.26811/didaktika.v6i2.551

Al Sultan, A., Henson, H., & Fadde, P. J. (2018). Pre-Service Elementary Teachers' Scientific Literacy and Self-Efficacy in Teaching Science. *IAFOR Journal of Education*, *6*(1), 25–42. https://doi.org/10.22492/ije.6.1.02

Amala, I. A., Sutarto, S., Putra, P. D. A., & Indrawati, I. (2023). Analysis of Scientific Literacy Ability Junior High School Students in Science Learning on Environmental Pollution. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1001–1005. https://doi.org/10.29303/jppipa.v9i3.1816

Amdayani, S., Dalimunthe, M., & Nasution, H. A. (2022). Pengaruh Modul Termokimia Berbasis Stem Terhadap Hasil Belajar Dan Motivasi Belajar Mahasiswa Pada Mata Kuliah Kapita Selekta Kimia. *School Education Journal Pgsd Fip Unimed*, *12*(2), 95–101. https://doi.org/10.24114/sejpgsd.v12i2.34343

Asri, Y. N., Mursyidah, D. S., & Rizqi, V. (2021). Application of Project-Based Learning Through a STEM Approach to Improve Learning Outcomes During a Pandemic. *Jurnal Penelitian Pendidikan IPA*, *7*(4), 719–722. https://doi.org/10.29303/jppipa.v7i4.819

Becker, K., & Park, K. (2011). Effects of integrative approaches among science , technology , engineering , and mathematics (STEM) subjects on students ' learning : A preliminary meta-analysis. *Journal of STEM Education*, *12*(5), 23–38. Retrieved from https://www.jstem.org/jstem/index.php/JSTEM/article/view/1509

Boslaugh, S. (2008). *Statistics in a nutshell*. O'Reilly Media.

Brundiers, K., & Wiek, A. (2013). Do We Teach What We Preach? An International Comparison of Problem- and Project-Based Learning Courses in Sustainability. *Sustainability*, *5*(4), 1725–1746. https://doi.org/10.3390/su5041725

Capraro, R. M. (2013). *STEM Project-Based Learning* (R. M. Capraro, M. M. Capraro, & J. R. Morgan (eds.)). SensePublishers. https://doi.org/10.1007/978-94-6209-143-6

Chiang, C. L., & Lee, H. (2016). The Effect of Project-Based Learning on Learning Motivation and Problem-Solving Ability of Vocational High School Students. *International Journal of Information and Education Technology*, *6*(9), 709–712. https://doi.org/10.7763/IJIET.2016.V6.779

Christensen, R., Knezek, G., & Tyler-Wood, T. (2015). Alignment of Hands-on STEM Engagement Activities with Positive STEM Dispositions in Secondary School Students. *Journal of Science Education and Technology*, *24*(6), 898–909. https://doi.org/10.1007/s10956-015-9572-6

Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education* (8th ed.). New York: Routledge.

Dalimunthe, M., Amdayani, S., Syafriani, D., & Annazili N, H. (2022). Development of Electronic Module on Colligative Materials STEM Based Solutions (Science, Technology, Engineering, Mathematics) Using Kvisoft Flipbook Maker Application. *Proceedings of the 4th International Conference on Innovation in Education, Science and Culture, ICIESC 2022, 11 October 2022, Medan, Indonesia*. https://doi.org/10.4108/eai.11-10-2022.2325278

Dianti, S. A. T., Pamelasari, S. D., & Hardianti, R. D. (2023). Pendekatan Pembelajaran Berbasis Proyek dengan Pendekatan STEM terhadap Peningkatan Kemampuan Literasi Sains Siswa. *Seminar Nasional IPA XIII*, 432–442. Retrieved from https://proceeding.unnes.ac.id/index.php/snipa/article/view/2325

Fuadi, H., Robbia, A. Z., Jamaluddin, J., & Jufri, A. W. (2020). Analisis Faktor Penyebab Rendahnya Kemampuan Literasi Sains Peserta Didik. *Jurnal Ilmiah Profesi Pendidikan*, *5*(2), 108–116. https://doi.org/10.29303/jipp.v5i2.122

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2009). Science Motivation Questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching*, *46*(2), 127–146. https://doi.org/10.1002/tea.20267

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Hamalik, O. (2002). *Psikologi Belajar dan Mengajar*. Bandung: Sinar Baru Algensindo.

Istyadji, M., Yulinda, R., Amalina, D., & Fahmi. (2022). Validity and Practicality of Articulate Storyline Learning Media on Environmental Pollution Materials for Junior High School Students. *Jurnal Penelitian Pendidikan IPA*, *8*(6), 2599–2604. https://doi.org/10.29303/jppipa.v8i6.1639

Masithah, I., Wahab Jufri, A., & Ramdani, A. (2022). Bahan Ajar IPA Berbasis Inkuiri Untuk Meningkatkan Literasi Sains. *Journal of Classroom Action Research*, *4*(2), 149–152. https://doi.org/10.29303/jcar.v4i2.1758

Mawardini, A., Permanasari, A., & Sanjaya, Y. (2015). Profil literasi sains siswa SMP pada pembelajaran IPA terpadu tema pencemaran lingkungan. *Prosiding Seminar Nasional Fisika (E-Journal) SNF 2015*, *IV*(1996), 49–56. Retrieved from http://snf-unj.ac.id/kumpulan-prosiding/snf2015/

Mayasari, T., Kadarohman, A., & Rusdiana, D. (2014). Pengaruh Pembelajaran Terintegrasi Science , Technology , Engineering , and Mathematics (Stem) Pada Hasil Belajar Peserta Didik : Studi Meta Analisis. *Prosiding Semnas Pensa VI "Peran Literasi Sains" Surabaya, 20 Desember 2014*, 371–377. Retrieved from https://tantrifisikaku.files.wordpress.com/2015/07/e09_makalah-tantri-mayasari.pdf

Menggo, S., Suastra, I. M., Budiarsa, M., & Padmadewi, N. N. (2019). Needs analysis of academic-English speaking material in promoting 21 st century skills. *International Journal of Instruction*, *12*(2), 739–754. https://doi.org/10.29333/iji.2019.12247a

Muzijah, R., Wati, M., & Mahtari, S. (2020). Pengembangan E-modul Menggunakan Aplikasi Exe-Learning untuk Melatih Literasi Sains. *Jurnal Ilmiah Pendidikan Fisika*, *4*(2), 89. https://doi.org/10.20527/jipf.v4i2.2056

Ndoa, Y. A. A., & Jumadi, J. (2022). Increasing Learning Motivation Through the Application of Physics E-Module Based on Flipped Learning. *Jurnal Penelitian Pendidikan IPA*, *8*(3), 1223–1230. https://doi.org/10.29303/jppipa.v8i3.1556

Nilyani, K., Asrizal, A., & Usmeldi, U. (2023). Effect of STEM Integrated Science Learning on Scientific Literacy and Critical Thinking Skills of Students: A Meta-Analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 65–72. https://doi.org/10.29303/jppipa.v9i6.2614

OECD. (2014). *PISA 2012 Result and Focus, Programme for Internasional Student Assessmement*. Paris: OECD Publishing.

OECD. (2017). *PISA 2015 Assessment and Analytical Framework* (revised). Paris: OECD Publishing. https://doi.org/10.1787/9789264281820-en

Park, W., & Cho, H. (2022). The interaction of history and STEM learning goals in teacher-developed curriculum materials: opportunities and challenges for STEAM education. *Asia Pacific Education Review*, *23*(3), 457–474. https://doi.org/10.1007/s12564-022-09741-0

Purwanto, N. (2010). *Prinsip-prinsip dan Teknik Evaluasi Pengajaran*. Bandung: PT. Remaja Rosdakarya.

Putri, N. H. D., & Ramli, R. (2023). Preliminary Study: Development of STEM-Based E-Students Worksheet to Improve Learners' Science Literacy Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 2271–2275. https://doi.org/10.29303/jppipa.v9i4.3011

Ramdani, A., Jufri, A. W., Gunawan, G., Fahrurrozi, M., & Yustiqvar, M. (2021). Analysis of Students' Critical Thinking Skills in terms of Gender Using Science Teaching Materials Based on The 5E Learning Cycle Integrated with Local Wisdom. *Jurnal Pendidikan IPA Indonesia*, *10*(2), 187–199. https://doi.org/10.15294/jpii.v10i2.29956

Rios, J. A., Ling, G., Pugh, R., Becker, D., & Bacall, A. (2020). Identifying Critical 21st-Century Skills for Workplace Success: A Content Analysis of Job Advertisements. *Educational Researcher*, *49*(2), 80–89. https://doi.org/10.3102/0013189X19890600

Rohman, S., Rusilowati, A., & Sulhadi, S. (2017). Analisis Pembelajaran Fisika Kelas X SMA Negeri di Kota Cirebon Berdasarkan Literasi Sains. *Journal Physics Communication*, *1*(2), 12–18. https://doi.org/10.15294/physcomm.v1i2.10402

Safitri, R., Hadi, S., & Widiasih, W. (2023). Effect of the Problem Based Learning Model on the Students Motivation and Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7310–7316. https://doi.org/10.29303/jppipa.v9i9.4772

Sudjana, N. (2013). *Dasar-Dasar Proses Belajar Mengajar*. Bandung: Sinar Baru Algensindo.

Taupik, R. P., & Fitria, Y. (2023). Learning Motivation and Computational Thinking Ability of Elementary School Students in Learning Science. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7665–7671. https://doi.org/10.29303/jppipa.v9i9.4826

Tseng, K.-H., Chang, C.-C., Lou, S.-J., & Chen, W.-P. (2013). Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment. *International Journal of Technology and Design Education*, *23*(1), 87–102. https://doi.org/10.1007/s10798-011-9160-x

Uno, H. B. (2009). *Teori Motivasi dan Pengukurannya Analisis di Bidang Pendidikan*. Jakarta: Bumi Aksara.

Wahyu, Y., Edu, A. L., & Helmon, A. (2023). STEM-based PjBL Learning Model with Manggaraians Indigenous Science Content to Improve Science Literacy: is it Effective? *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8263–8273. https://doi.org/10.29303/jppipa.v9i10.4963

Wardana, I. K., Marhaeni, A. A. I. ., & Tika, I. N. (2013). Pengaruh Model Kontekstual Terhadap Keterampilan Proses Sains dan Hasil Belajar Sains Pada Siswa Kelas IV SD Gugus V Dr. Soetomo. *E-Journal Program Pascasarjana Universitas Pendidikan Ganesha Program*, *3*(3), 12. Retrieved from https://www.neliti.com/id/publications/120742/pengaruh-model-kontekstual-terhadap-keterampilan-proses-sains-dan-hasil-belajar

Zamista, A. A. (2018). Increasing Persistence of Collage Students in Science Technology Engineering and Mathematic (STEM). *Curricula*, *3*(1), 22–31. https://doi.org/10.22216/jcc.2018.v3i1.1308