



The Application of STEM Learning to Improve Students' STEM Literacy in The Knowledge Aspect

Harpian^{1*}, Irma Rahma Suwarma², Andhy Setiawan¹

¹Universitas Pendidikan Indonesia, Indonesia

²STEM Education Center UPI, Indonesia

*Correspondence to: harpindarta@upi.edu

Abstract: STEM literacy is a competency that cannot be seen as knowledge of science, technology, engineering, and mathematics literacy separately. It is a competency consisting of content knowledge and an interdisciplinary skill component. This study aims to analyze students' STEM literacy after implementing STEM learning. The research method was quasi-experimental, and the research design used one group pretest posttest. The subjects of this study were 31 students of class XI IPA at a private high school in Bandung, Indonesia. The instrument in the study was 20 multiple-choice questions. The results showed that scientific literacy increased very satisfactorily ($n\text{-gain} = 0.71$) with an effect size of 1.36, technology-engineering literacy also increased very satisfactorily ($n\text{-gain} = 0.72$) with an effect size of 2.12 and mathematical literacy increased satisfactorily ($n\text{-gain} = 0.57$) with an effect size of 2.14. The research results show that students' STEM literacy is improved sufficiently and has a strong effect after implementing STEM learning. The study implies that STEM learning requires good collaboration between teachers to share information about students' constraints and solutions in working on project assignments.

Keywords: STEM learning, literacy

Recommended citation: Harpian., Suwarma, I. R., & Setiawan, A. (2023). The Application of STEM Learning to Improve Students' STEM Literacy in The Knowledge Aspect. *Journal of Innovation in Educational and Cultural Research*, 4(3), 450-457.

INTRODUCTION

The development of 21st century presents rough challenges (Mutohhari et al., 2021). Various challenges stand up, among others, related to labor competition, enhancing the quality of lifestyles, equitable improvement, and the potential to expand human resources (D'Netto et al., 2014; Cooke et al., 2015; Vrontis et al., 2021). Therefore, skill is needed to answer the challenges of the 21st century. The group of skills required for the future, according to a report from the World Economic Forum (WEF) entitled Future of Jobs Report 2020, is critical thinking and analysis, problem-solving, self-management, teamwork, management, and communication of activities, use and development of technology, content literacy, and physical abilities (Schwab & Zahidi, 2020). With this urgency, action is needed to prepare human resources (HR) from elementary to secondary schools to have skills that support future careers. One of them is by implementing STEM learning.

Learning with the STEM (Science, Technology, Engineering, and Mathematics) approach is learning that integrates the four components, namely science, technology, engineering, and mathematics, in a single mastering to help college students utilize technology and gather it into experiments that can show clinical concepts supported via information that has been managed mathematically (Devi et al., 2018; Saleha, 2019; Lestari & Rahmawati, 2020). STEM-based mastering aims to enhance students' capacity to apply existing understanding to remedy complicated troubles inside the actual global, prepare themselves to stand the challenges of human beneficial resource needs inside the 21st century and broaden their competence in the STEM field (Bybee, 2013; Sukmana, 2018).

On the other hand, Bybee (2013) indicates that STEM education allows students to follow the fundamental content material and exercise STEM disciplines in existing situations that will enable them to develop STEM literacy. Balka (2011) states that STEM literacy has the potential to become aware of, follow, and combine ideas from science, technology, engineering, and mathematics to understand complicated troubles and innovate to clear them up. Based totally on the capabilities possessed by a STEM-literate individual, it is visible that those abilities are in step with the needs of 21st-century abilities and skills. However, college students' STEM literacy could be immensely regarded.

A study conducted by the Program for International Students Assessment (PISA) in the 2018 OECD (Organization for Economic Co-operation and Development) shows that Indonesian students' reading ability scored 371 with an average score of 487. Then, for the average score, students' mathematical skills reached 379, with an average score of 487. Students' science skills reached 389, with an average score of 489. The results showed that the percentage of grades earning the upper grade was only around 0.8%, and 42.3% were on the lower level. This indicates that the literacy of Indonesian students is very low. According to PISA,

Indonesian students' literacy achievements are in the low-performance quadrant with high equity. STEM literacy is primarily students' ability to suppose in an inductive and deductive way to solve numerous troubles, precisely problems related to science, technology, engineering, and mathematics (Bashoor & Supahar, 2018; Widayoko et al., 2018; Banila et al., 2021; Chairulli & Yosi, 2022).

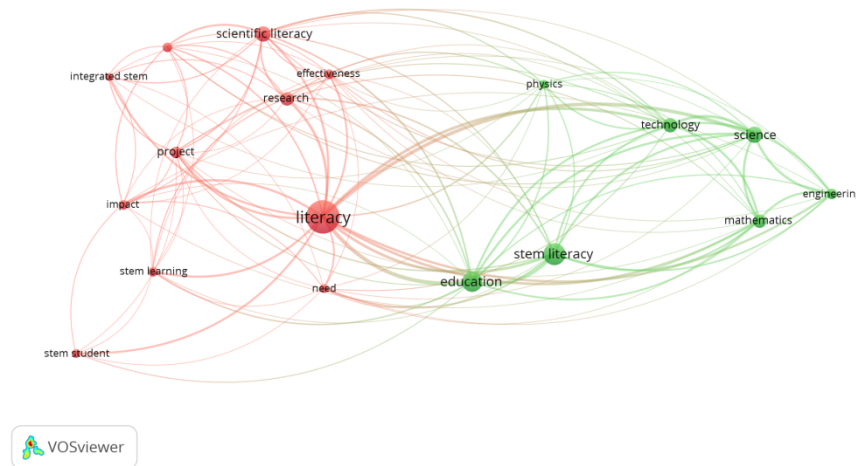


Figure 1. Mapping of STEM literacy research

Based on Figure 1, it is known that research on STEM literacy is currently not widely carried out both in Indonesia and other developed countries that have implemented STEM learning. Previous studies have only focused on one STEM component. These include Sari et al. (2017), who conduct research on the effect of project-based learning on students' scientific literacy ability. In addition, Lutfi et al. (2018) conduct research on the effect of stem-integrated project-based learning on students' scientific literacy, creativity, and learning outcomes. Techakosit and Nilsook (2016) conduct research on the development of STEM literacy using a scientific imagineering learning process through AR. Tati et al. (2017) present research on STEM literacy, which is trained on first-level students by making a boat project. Yasin et al. (2018) demonstrate experimental activities on electricity material and the help of the Arduino Android Game to improve STEM literacy for junior high school students. The results state that engineering technology literacy skills increase significantly compared to scientific literacy and mathematical literacy. A study conducted by Utami et al. (2020) on module development to improve STEM literacy shows that STEM literacy is still limited to junior high schools, and lacks training for high school students, especially in physics learning. Thus, this study aims to analyze students' STEM literacy after implementing STEM learning that is trained in high school students. This study only measures students' STEM literacy, focusing on the knowledge aspect.

METHODS

This research was a quasi-experimental study with a one-group pretest and posttest (Creswell & Creswell, 2018). The population in this study was one of the private excessive schools in Bandung, Indonesia, with a sample of 31 students in class XI IPA. The research used simple random sampling. The material taught for this research was thermal conductivity. The data collection was done by using a test. The test instrument for measuring students' STEM literacy in the knowledge aspect used 20 multiple-choice items consisting of 8 scientific literacy items, 7 technology-engineering literacy questions, and 5 mathematical literacy questions. The instruments in this research had been confirmed through three validators, precisely two lecturers and a teacher. This study device was declared to have handed the feasibility, reliability, level of difficulty, and differentiation tests. Analysis of the results of STEM literacy in the knowledge aspect was obtained from the pretest and posttest results to see an increase in STEM literacy in STEM learning. The instrument used was a test in the form of 20 multiple-choice questions. The normalized gain and the effect size were analyzed to measure the increase in STEM literacy in the knowledge aspect. After calculating the normalized gain and the effect size, the normalized gain and the effect size can be categorized at the levels shown in Table 1 and Table 2.

Table 1. Modified Normalized Gain Interpretation

<g>	Levels
$-1,00 \leq g < 0,00$	Decrease
$g = 0,00$	Stable
$0,00 < g < 0,30$	Low
$0,30 \leq g < 0,70$	Average
$0,70 \leq g \leq 1,00$	High

(Hake, 1999)

Table 2. Effect Size Criteria

Size	Criteria
$0 < ES \leq 0,2$	No practical effect
$0.2 \leq ES < 0.5$	Small effect
$0.5 \leq ES < 1.00$	Medium effect
>1.00	Large effect

(Cohen et al., 2007)

RESULT AND DISCUSSION

Based on the research results, students' STEM literacy has increased satisfactorily with a strong effect size. The recapitulation of students' stem literacy results can be seen in Table 3 below.

Table 3. STEM Literacy

Aspect	N	Pretest	Posttest	n-gain	Standard Deviation	Effect Size
STEM Literacy	20	38.55	78.55	0.64	12.91	3.10

The information in Table 3 shows that the average result of the students' pretest was 38.55, while the average result of the posttest was 78.55. Thus, the results obtained by students before and after implementing STEM learning increased. Furthermore, to see how much the students' STEM literacy increased before and after implementing STEM learning, the N-gain result was used, and the n-gain result was 0.64. This means that the increase in students' STEM literacy is moderate. The effect size is analyzed to determine how much influence STEM learning has, and the result is 3.10, which means it has a strong influence. STEM learning has an impact on increasing achievement in each STEM component, increasing interest in the STEM field (Means et al., 2016). The STEM literacy aspect of knowledge consists of 3 components, namely scientific literacy, technology-engineering literacy, and mathematical literacy. STEM literacy in each component can be seen in Table 4.

Table 4. STEM Literacy in Each Component

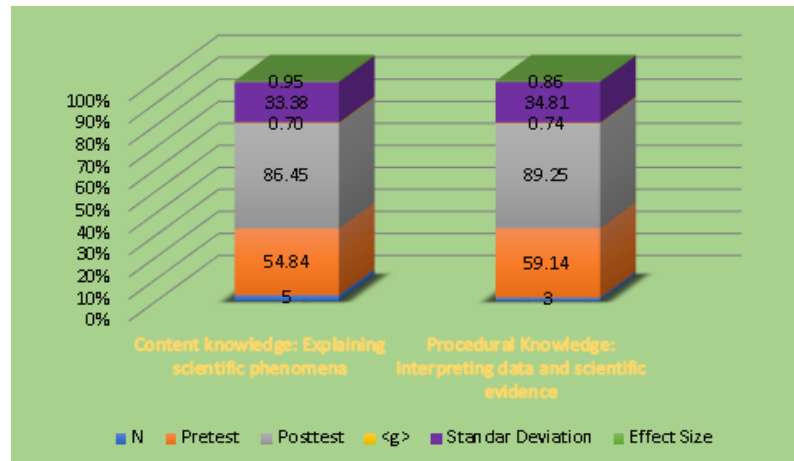
STEM Literacy	Indicator
Scientific Literacy	Content Knowledge:
	Explain scientific phenomena
	Procedural Knowledge:
Technology-Engineering Literacy	Interpret scientific data and evidence
	Explain the principles of technology
Mathematical Literacy	Develop the situation and achieve the goal
	Formulate a problem with mathematics

The increase of scientific literacy before and after implementing STEM learning by creating a food heating assignment that utilizes the concept of thermal conductivity is analyzed by calculating the n-gain and the effect size. Based on Table 4, students' STEM literacy is enhanced satisfactorily (moderate) with a strong effect size. This research is supported by the results of research from McCright (2012), which suggests that studying climate alternative initiatives can increase students' scientific and quantitative literacy. Improving students' scientific literacy may be visible from the abilities executed by using students after gaining knowledge of activities via STEM mastering. This aligns with research conducted by Yuliati et al. (2019) that STEM can increase students' scientific literacy because it can direct students in a growing understanding of standards, applying, analyzing, synthesizing, and concluding them consistently with the information received. According to Permanasari (2016), STEM learning can frame scientific literacy skills because students can solve problems related to the project they will be doing by designing. Scientific literacy needs to be improved and instilled in students in learning science, especially science so that students can be directly involved in the impact of science in everyday life (Dasgupta et al., 2019; Astuti et al., 2022).

Table 5. Scientific Literacy Recapitulation

Aspect STEM Literacy	Pretest	Posttest	N-Gain	Standard Deviation	Effect Size
Science Literacy	56.45	87.5	0.71	22.79	1.36

Scientific literacy consists of two component aspects, namely the content knowledge component and the procedural component. In this study, the scientific literacy questions regarding content knowledge components that explain phenomena scientifically consisted of 5 items, namely 2, 5, 6, 9, and 11. Meanwhile, procedural knowledge questions regarding the scientific interpretation of data and evidence consisted of 3 items—namely 1, 3, and 4. The recapitulation of scientific literacy per component can be seen in [Figure 2](#).

**Figure 2.** Recapitulation of Component Science Literacy

Based on Figure 2, the increase in scientific literacy results in the content knowledge component is lower than the scientific literacy in the procedural knowledge component. However, applying STEM learning strongly influences these two components of scientific literacy. This can be seen from the n-gain results and the effect size obtained. The findings in this study are in line with research conducted by [Aninda et al. \(2019\)](#), who found that the ability of college students to interpret information and scientific evidence is better because to research environmental phenomena that arise by analyzing diverse forms of waste, waste categories, kinds, and handling, then pouring them into in the form of display information, diagrams, and tables so that students can recognize the relationship among the statistics they have got collected. In addition, this research is also supported by research from [Astuti et al. \(2022\)](#), which indicates that the increase in scientific literacy of students in deciphering information and scientific evidence is higher because students can identify questions in keeping with records or scientific principles and students are in a position to research real questions so that the answer they get is according with the actual idea of science. Technology-engineering literacy in this study uses 5 multiple choice questions. The recapitulation of technology-engineering literacy can be seen in [Table 6](#).

Table 6. Technology-Engineering Literacy Recapitulation

STEM Literacy	Pretest	Posttest	n-gain	Standard Deviation	Effect Size
Technology-engineering STEM	36.13	81.94	0.72	21.41	2.14

To find out how far technology-engineering literacy has increased, a n-gain analysis was carried out. Based on the results of the n-gain analysis, it was found to be 0.72. To discover how a whole lot has an impact on the increase in n-gain, an effect size analysis is executed. Based on the effects of the evaluation performed, the effect size turned to 2.14. Thus, it can be concluded that the enhancement in technology-engineering literacy has increased excessively and has a sturdy impact on the implementation of STEM learning. This aligns with research conducted by [Firman et al. \(2015\)](#), which states that applying STEM learning can increase students' technology-engineering literacy.

Technology-engineering literacy consists of two component aspects, namely explaining the principles of technology, which consists of 2 items, namely numbers 7 and 18, and developing situations to achieve goals, which consists of 3 items, namely 8, 10, and 19. The recapitulation of the acquisition of technology literacy engineering on each component can be seen in [Figure 3](#).

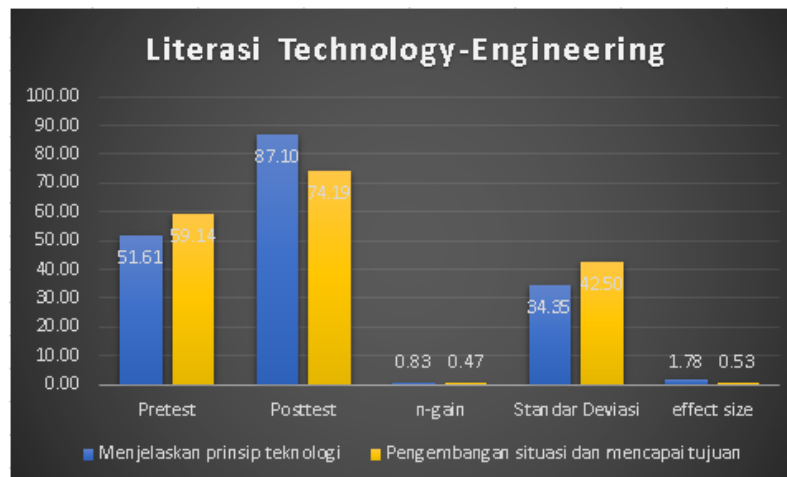


Figure 3. Technology-engineering indicator literacy recapitulation

In [Figure 3](#), the technology-engineering component literacy explains technological principles; the n-gain score is 0.83. Meanwhile, the result of calculating the effect size was 1.78, which was classified as vital. While the results of the component technology-engineering literacy of developing situations and achieving the n-gain goals obtained are 0.47. While the results of the effect size calculation obtained 0.53, the effect is relatively low. The increase in technology-engineering literacy in the components of developing situations to achieve goals based on higher n-gains with high improvement criteria, while technology-engineering literacy in the details explaining technological principles of improvement criteria is classified as moderate. This occurs because of the engineering design process; students are skilled in resolving issues by doing food heating projects that can keep the stability of the food's warmth, although it has been stored for a long time. This aligns with research from [Siew et al. \(2015\)](#), which suggests that the engineering design process increases students' creativity, thinking, and problem-solving skills. Project-based mastering is appropriate for interdisciplinary teaching because it naturally includes many unique academic talents, including analyzing, writing, and mathematics. It is suitable for constructing conceptual understanding through integrating different subjects ([Capraro et al., 2013](#)).

Mathematical literacy tested in this study consisted of 5 items, namely 12, 13, 14, 15, 16, 17, and 20, with indicators of the process of formulating situations mathematically. The recapitulation of mathematical literacy can be seen in [Table 6](#).

Table 7. Recapitulation of mathematical literacy

Aspect	Pretest	Posttest	N-Gain	Standard Deviation	Effect Size
Mathematical Literacy	19.82	65.9	0.57	21.37	2.12

Based on [Table 7](#), the analysis results of students' mathematical literacy show that the pretest score is 19.82 while the posttest score is 65.9. so that n-gain is obtained at 0.57. Thus, it means that students learning by applying STEM learning experience a moderate increase in mathematical literacy. Meanwhile, the effect size obtained is 2.12, which means that the application of STEM learning strongly increases students' mathematical literacy.

Mathematical literacy increases by applying STEM learning. However, even though there is an increase between before and after the application of STEM learning to mathematical literacy, it is seen that the average achievement achieved by students did not reach the KKM score (minimum completeness criteria) based on the standard values set for the school unit. Based on the results of the notes submitted by students to the teacher, it is known that students still experience confusion in mathematical calculations such as unit ladder configurations. Besides that, based on the results of indirect interviews conducted by the teacher, students are less interested in mathematics and considered mathematics difficult. According to [Vayssettes \(2016\)](#), students with good mathematical literacy can analyze, perform mathematical calculations, communicate mathematical knowledge and skills, and solve and interpret mathematical problems. Meanwhile, according to [Cavacanti \(2017\)](#), students with good mathematical literacy can solve real-life problems.

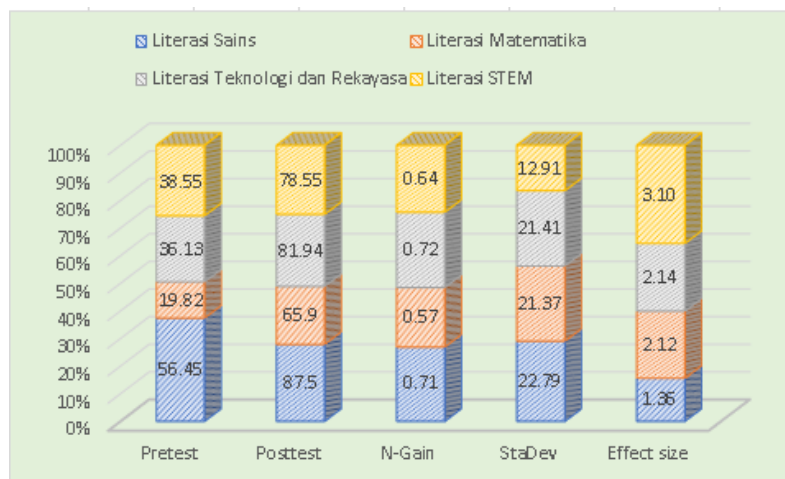


Figure 4. STEM Literacy Recapitulation

Figure 4 shows that STEM literacy, in general, has increased with an n-gain of 0.64, which is classified as moderate with a very high effect size (effect size = 3.10). A comparison of STEM literacy based on the n-gain obtained can be seen in Figure 4; for each component of STEM literacy, it shows that technology-engineering literacy increases more than increases in scientific literacy and mathematical literacy. This increase occurs because, in technology-engineering literacy, students carry out the engineering design process. Making food heating projects provides opportunities to carry out engineering design processes closely related to technology engineering. Students are skilled at solving problems by utilizing technological principles, developing solutions to achieve goals, and communicating and working together in teams according to technological literacy standards. This aligns with previous research by Utami et al. (2020) that suggest that technology-engineering literacy is enhanced as literacy, which is more dominant than scientific and mathematical literacy.

On the other hand, the smallest n-gain is mathematical literacy. Mathematical literacy provides the smallest increase compared to scientific literacy and technology-engineering literacy. This happens because students' understanding is ingrained that mathematics is complex, so interest in mathematics is low. Students in connecting mathematics in everyday life have a low impact. Students' STEM literacy by applying STEM learning can improve STEM literacy aspects of students' knowledge in identifying and integrating science, technology, engineering, and mathematics in solving real problems. This is in line with research conducted by Bybee (2013), Meeder (2014), Tati et al. (2017), and Amaira (2019) that learning with STEM can build and develop students' knowledge in solving real problems. According to Zollman (2012), STEM literacy aspects of knowledge occur when students can translate, create concepts, and apply conceptual knowledge in the real world. With STEM literacy experience (Cavalcanti, 2017), students with STEM literacy can identify problems by integrating STEM aspects to innovate and solve problems (Balka, 2011).

CONCLUSION

Based on the results obtained, students' STEM literacy increases with the implementation of STEM learning. The performance of STEM learning on thermal conductivity material can generally increase students' STEM literacy in the knowledge aspect. This can be seen from the results of the n-gain, which is 0.64, categorized as a moderate increase, and the effect size is 3.10, classified as strong (large effect). STEM literacy in each STEM component has also experienced growth in the category of high increase (scientific literacy and technology-engineering literacy) and moderate increase (mathematical literacy). As for the effect size of STEM literacy for each STEM component, the average is categorized as strong (large effect). Thus, applying STEM learning can improve students' STEM literacy in the knowledge aspect.

REFERENCES

- Aninda, A., Permanasari, A., & Ardianto, D. (2020). Implementasi pembelajaran berbasis proyek pada materi pencemaran lingkungan untuk meningkatkan literasi stem siswa sma. *JSEP (Journal of Science Education and Practice)*, 3(2), 1-16.
- Astuti, W., Sulastri, S., Syukri, M., & Halim, A. (2023). Implementasi Pendekatan Science, Technology, Engineering, and Mathematics untuk Meningkatkan Kemampuan Literasi Sains dan Kreativitas Siswa. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(1), 25-39.

- Balka, D. (2011). Standards of mathematical practice and STEM. *Math-science connector newsletter*, 6(8).
- Banila, L., Lestari, H., & Siskandar, R. (2021). Penerapan blended learning dengan pendekatan STEM untuk meningkatkan kemampuan literasi sains siswa pada pembelajaran biologi di masa pandemi covid-19. *Journal of Biology Learning*, 3(1), 25-33.
- Bashoor, K. (2018). Supahar, " Validity and reliability of STEM-based science literacy performance assessment instruments," *Jurnal Penelitian dan Evaluasi Pendidikan*, 22(2), 168-181.
- Bybee, R. (2013). *The Case for STEM Education Challenges and Opportunities*. National Science Teachers Association.
- Capraro, R. M., Capraro, M. M., & Morgan, J. R. (2013). STEM project-based learning. *An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach*, 2.
- Cavalcanti, M. A. L. (2017). *Assessing STEM literacy in an informal learning environment*.
- Chairulli, M., & Rahmi, Y. L. (2022). Biology Learning at SMA Negeri 2 Bukittinggi Analisis Capaian Literasi STEM Peserta Didik dalam Pembelajaran Biologi Kelas XI. *Journal for Lesson and Learning Studies*, 5(1).
- Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in Education*. Routledge.
- Cooke, F. L., Wood, G., & Horwitz, F. (2015). Multinational firms from emerging economies in Africa: Implications for research and practice in human resource management. *The International Journal of Human Resource Management*, 26(21), 2653-2675.
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Dasgupta, C., Magana, A. J., & Vieira, C. (2019). Investigating the affordances of a CAD-enabled learning environment for promoting integrated STEM learning. *Computers & Education*, 129, 122-142.
- Devi, P. K., Herliani, E., Setiawan, R., Yanuar, Y., & Karyana, S. (2018). Materi Bimbingan Teknis Pembelajaran Berbasis STEM dalam Kurikulum 2013. Seameo Qitep In Science dengan Direktorat Pembinaan Sekolah Menengah Pertama.
- D'Netto, B., Shen, J., Chelliah, J., & Monga, M. (2014). Human resource diversity management practices in the Australian manufacturing sector. *The International Journal of Human Resource Management*, 25(9), 1243-1266.
- Fenanlampir, A., Batlolona, J. R., & Imelda, I. (2019). The struggle of Indonesian students in the context of TIMSS and PISA has not ended. *International Journal of Civil Engineering and Technology*, 10(2), 393-406.
- Firman, H., Rustaman, N. Y., & Suwarma, I. R. (2015, November). Development of technology and engineering literacy through STEM-based education. In *2015 International Conference on Innovation in Engineering and Vocational Education* (pp. 209-212). Atlantis Press.
- Hake, R. R. (1999). *Analyzing Change/Gain Scores*. AREA-D American Education Research Association's Division.D, Measurement and Research Methodology.
- Lestari, H., & Rahmawati, I. (2020). Integrated STEM through Project Based Learning and Guided Inquiry on Scientific Literacy Abilities in Terms of Self-Efficacy Levels. *Al Ibtida: Jurnal Pendidikan Guru MI*, 19-32.
- Lutfi, L., Ismail, I., & Azis, A. A. (2018). Pengaruh project based learning terintegrasi stem terhadap literasi sains, kreativitas dan hasil belajar peserta didik. *Prosiding Seminar Nasional Biologi dan Pembelajarannya*, (pp. 189-194).
- McCright, A. M. (2012). Enhancing students' scientific and quantitative literacies through an inquiry-based learning project on climate change. *Journal of the Scholarship of Teaching and Learning*, 12(4), 86-101.
- Means, B., Wang, H., Young, V., Peters, V. L., & Lynch, S. J. (2016). STEM-focused high schools as a strategy for enhancing readiness for postsecondary STEM programs. *Journal of Research in Science Teaching*, 53(5), 709-736.
- Meeder, H. (2012). What is "STEM Literacy"? <https://www.nc3t.com/stemliteracy>

- Mutohhari, F., Sutiman, S., Nurtanto, M., Kholifah, N., & Samsudin, A. (2021). Difficulties in Implementing 21st Century Skills Competence in Vocational Education Learning. *International Journal of Evaluation and Research in Education*, 10(4), 1229-1236.
- Permanasari, A. (2016). STEM education: Inovasi dalam pembelajaran sains. In *Prosiding SNPS (Seminar Nasional Pendidikan Sains)*, 3(1), (23-34).
- Saleha. (2019). *STEM Menjawab Tantangan Abad 21*. CV. Beta Aksara.
- Sari, D. N., Rusilowati, A., & Nuswowati, M. (2017). Pengaruh Pembelajaran Berbasis Proyek terhadap Kemampuan Literasi Sains Siswa. *Pancasakti Science Education Journal*, 114-124.
- Schwab, K., & Zahidi, S. (2020). *The Future of Jobs*
- Siew, N. M., Amir, N., & Chong, C. L. (2015). The perceptions of pre-service and in-service teachers regarding a project-based STEM approach to teaching science. *SpringerPlus*, 4(1), 1-20.
- Sukmana, R. W. (2017). Pendekatan science, technology, engineering and mathematics (stem) sebagai alternatif dalam mengembangkan minat belajar peserta didik sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 2(2), 189-197.
- Tati, T., Firman, H., & Riandi, R. I. O. P. (2017). The effect of STEM learning through the project of designing a boat model toward student STEM literacy. In *Journal of Physics: Conference Series*, 895(1), p. 012157). IOP Publishing.
- Techakosit, S., & Nilsook, P. (2016). The Learning Process of Scientific Imagineering through AR in Order to Enhance STEM Literacy. *International Journal of Emerging Technologies in Learning*, 11 (7), 57-63.
- Utami, A., Rochintaniawati, D., & Suwarma, I. R. (2020, March). Enhancement of STEM literacy on knowledge aspect after implementing science, technology, engineering, and mathematics (STEM)-based instructional module. In *Journal of Physics: Conference Series* (Vol. 1521, No. 4, p. 042048). IOP Publishing.
- Vayssettes, S. (2016). *PISA 2015 assessment and analytical framework: science, reading, mathematics, and financial literacy*. OECD publishing.
- Vrontis, D., Christofi, M., Pereira, V., Tarba, S., Makrides, A., & Trichina, E. (2022). Artificial intelligence, robotics, advanced technologies, and human resource management: a systematic review. *The International Journal of Human Resource Management*, 33(6), 1237-1266.
- Widayoko, A., & Muhardjito, M. (2018). Analisis program implementasi gerakan literasi sekolah (GLS) dengan pendekatan goal-based evaluation. *Jurnal Tatsqif*, 16(1), 78-92.
- Yasin, A. I., Prima, E. C., & Sholihin, H. (2018). Learning Electricity using Arduino-Android-based Game to Improve STEM Literacy. *Journal of Science Learning*, 1(3), 77. <https://doi.org/10.17509/jsl.v1i3.11789>
- Yuliati, L., Yogismawati, F., Purwaningsih, E., & Affriyenni, Y. (2021, March). Concept acquisition and scientific literacy of physics within inquiry-based learning for STEM Education. *Journal of Physics: Conference Series*, 1835(1), 012012.
- Zollman, A. (2012). Learning for STEM literacy: STEM literacy for learning. *School Science and Mathematics*, 112(1), 12-19.