



The Effect of the STEM Learning Model on Student's Critical Thinking in Indonesia: Meta-Analysis

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Abstrak

Penelitian ini bertujuan untuk mengetahui pengaruh model pembelajaran STEM terhadap keterampilan berpikir kritis siswa di Indonesia. Jenis penelitian ini adalah penelitian meta-analisis. Sumber data berasal dari 13 jurnal nasional dan internasional. Penelusuran sumber data berasal dari Google Scholar, ScienceDirect, ProQuest, Eric Journal dan Springer. Proses penyeleksian sumber data dilakukan secara sistematis dan teliti. Teknik pengumpulan adalah observasi langsung. Kriteria inklusi dalam penelitian yakni 1) Sumber Data berasal dari jurnal dan prosiding terindeks SINTA, Scopus dan WOS; 2) Jenis penelitian berupa eksperimen atau quasi eksperimen; 3) Penelitian berkaitan dengan model STEM terhadap keterampilan berpikir kritis; 4) Jurnal terbitan 2015-2023; 5) Penelitian mempunyai sumber data yang dapat dihitung nilai effect size (ES). Hasil penelitian menunjukkan nilai rata-rata effect size (ES) sebesar 0.968 kriteria tinggi. Temuan ini menunjukkan bahwa model STEM memberikan pengaruh yang sangat besar terhadap keterampilan berpikir kritis siswa. Model STEM membantu siswa lebih kreatif dan inovatif dalam proses pembelajaran.

Kata Kunci: Model Pembelajaran, STEM, Berpikir Kritis, Meta-analisis

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Abstract

This study aims to determine the effect of STEM learning models on students' critical thinking skills in Indonesia. This type of research is a meta-analysis. Data sources came from 13 national and international journals. Data sources were searched from Google Scholar, ScienceDirect, ProQuest, Eric Journal, and Springer. The process of selecting data sources was carried out systematically and thoroughly. The collection technique was direct observation. Inclusion criteria in the study are 1) Data sources come from journals and proceedings indexed by SINTA, Scopus, and WOS; 2) The type of research is experimental or quasi-

experimental; 3) Research related to the STEM model on critical thinking skills; 4) Journal publications 2015-2023; 5) Research has data sources that can be calculated effect size (ES) values. The results showed the average effect size (ES) value of 0.968 high criteria. This finding shows that the STEM model has a very large influence on students' critical thinking skills. The STEM model helps students be more creative and innovative in the learning process

Keywords: Learning Model, STEM, Critical Thinking, Meta-analysis

Introduction

Critical thinking is a skill that students have in solving a problem systematically and logically in the learning process (Sularmi et al., 2018; Alandia et al., 2019; Elfira et al., 2023; Rahman & Ristiana, 2020). Critical thinking skills are very important for students in developing their cognitive potential (Londa & Domu, 2020; Raggi et al., 2021). Rijal *et al.*, (2021) students who have critical thinking skills have high curiosity. Furthermore, students who have critical thinking skills are faster in understanding learning content (Amin et al., 2020; Hidayati et al., 2022; Temel, 2022; Saputro & Rayahu, 2020). Critical thinking skills encourage students to be more active and creative in learning activities (Permata et al., 2018). Students who have critical thinking skills will be more active in finding information (Allanta & Puspita, 2021; Nashar et al., 2021).

Indonesian students' critical thinking skills are still low (Putra et al., 2023; Suharyat et al., 2022; Razak et al., 2021; Zulkifli et al., 2022). This can be seen from the 2012 PISA survey of Indonesian students' science literacy obtained a score of 382 with an average PISA score of 501 (Afriana et al., 2016). Furthermore, the 2018 PISA results show that the level of critical thinking of Indonesian students in the field of science obtained a score of 396, ranked 71 out of 78 countries (Suhaimi et al., 2022; Suharyat et al., 2022; Ichsan et al., 2023). Melani et al., (2022) stated that the low critical thinking skills were caused by learning models that did not involve students actively in learning. Research

results Ismoyo (2012) The low critical thinking skills of Indonesian students are influenced by the selection of inappropriate learning methods and models, unsupportive learning facilities and learning activities that are too teacher-centered Therefore, students are not trained in critical thinking. The problem needs to be fixed by choosing the right learning model.

STEM learning model is a learning model that combines Science Technology Engineering and Mathematics in learning activities (Mataka et al., 2020; Pimthong & Williams, 2021; Rahming, 2022; Suganda et al., 2021; Supriyadi et al., 2023; Zulyusri et al., 2023). The STEM model helps students be more competent in mastering their fields and being able to apply them in everyday life (Ismail et al., 2016; Mohtar et al., 2016). Research results Aulia et al. (2021) STEM learning model helps in mastering technology in the learning process. STEM learning model can encourage students' problem solving skills and learning outcomes (Lolanesa et al., 2020; Fradila et al., 2021; Rahman et al., 2023; Anita et al., 2021). Research results Amalia et al., (2022) stated that the STEM learning model shapes students' character and independence in learning.

Previous research by Yuliati & Saputra (2019) Science Technology Engineering and Mathematics (STEM) learning model has a significant influence on student literacy in teaching and learning activities. Research by Adiwiguna et al., (2019) STEM-oriented learning process improves students' critical thinking skills

and science literacy. The Science Technology Engineering and Mathematics (STEM) model helps students be more motivated to learn. Next, Kristiani et al., (2017) the application of the STEM learning model in learning activities stimulates students' creative thinking skills. Research by Erkan & Duran (2023) STEM models help students and teachers in mastering science and technology that help the learning process. However, in reality, there are many studies on the influence of STEM in the learning process but there are still few that illustrate how much influence STEM has on critical thinking skills in students in Indonesia. So, this research aims to influence the STEM learning model on students' critical thinking skills in Indonesia.

Methods

This research is a type of meta-analysis research. Meta-analysis is a type of research that collects previous research literature that can be statistically analyzed (Santosa et al., 2021; Zulyusri et al., 2022; Suharyat et al., 2022; Loturco et al., 2022). The steps in this meta-analysis are 1) formulating the problem; 2) collecting studies that have relevance to the research problem; 3) coding the data; and 4) analyzing and interpreting the data.

Literature search process

The data source search process comes from Google Scholar, ScienceDirect, ProQuest, Wiley and Eric. Selection of data sources in research with the Preferred Reporting Item for Systematic Literature Reviews and Meta-analysis (PRISMA) method can be seen in Figure 1.

Inclusion Criteria

The inclusion criteria in this meta-analysis are 1) the source comes from

national and international journals or proceedings published from 2015-20123; 2) The type of research is experimental or quasi-experimental; 3) The data source has data that can be calculated the effect size value; 4) The data source is related to the effect of STEM on critical thinking skills; 5) Sources indexed by DOAJ, SINTA, Web of science and Scopus.

Analisis Effect Size

For data analysis in this study using the JSAP application to calculate the effect size value of each data source. The effect size criteria can be seen in Table 1.

Table 1. Effect Size Criteria

<i>Effect Size (ES)</i>	Criteria
$-0.15 \leq 0.15$	Ignored
$0.15 < ES \leq 0.40$	Small
$0.40 < ES \leq 0.75$	Medium
$0.75 < ES \leq 1.10$	High
$1.10 < ES \leq 1.45$	Very High
$1.45 > ES$	High Influence

Sumber : (Musna et al., 2021; Suharyat et al., 2022; Rahman et al., 2023)

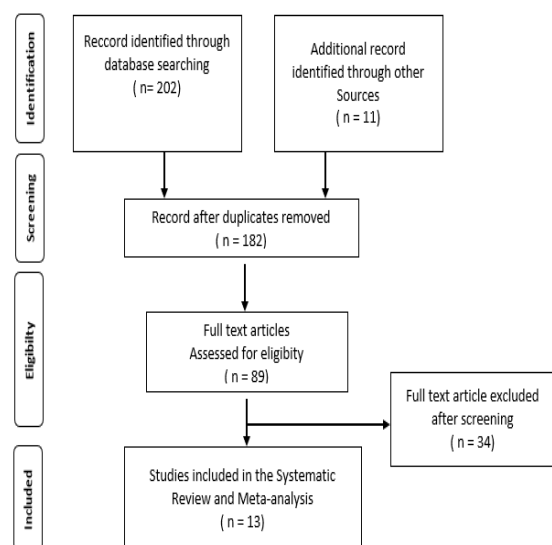


Figure 1. PRISMA method of literature search process

Result and Discusion

From the results of the meta-analysis of 202 national and international journals on the influence of Science Technology Engineering and Mathamatics (STEM) on students' critical thinking skills in Indonesia, only 13 journals met the inclusion criteria. Journals that have met the inclusion criteria are used as data sources for meta-analysis. The complete 13 national and international journals can be seen in Table 2.

Table 2. Meta-analysis of data sources that met the inclusion criteria

Journal Code	Year	Effect Size	Criteria Effect Size
K1	2018	0.91	Hight
K2	2022	0.97	Hight
K3	2020	0.69	Medium
K4	2020	1.36	Very Hight
K5	2021	0.90	Hight
K6	2017	0.45	Medium
K7	2018	0.81	Medium
K8	2020	1.05	Hight
K9	2023	1.40	Very Hight
K10	2022	0.84	Medium
K11	2023	0.61	Medium
K12	2023	0.73	Medium
K13	2020	1.87	Very Hight
Average Effect Size (ES)		0.968	Hight

Based on Table 2. Shows the average effect size value (ES = 0.968) with high criteria. These results explain the significant influence of the Science Technology Engineering and Mathamatics (STEM) learning model on students' critical thinking skills rather than conventional learning models. Ariyatun et al., (2020) The application of the STEM model in learning activities has an influence on students'

critical thinking skills and encourages students to be more active in learning. The Science Technology Engineering and Mathamatics (STEM) learning model encourages students to be more creative and innovative in developing their thoughts (Ramdani, 2016; Othman et al., 2022; Hasancebi, 2021). Research results Tureni et al.,(2021) Critical thinking skills are very important for students in facing the industrial revolution 4.0 which requires students to provide a solution in dealing with all phenomena that occur.

Furthermore, the application of the STEM model in the learning process really helps students and teachers more easily achieve learning goals (Suryono et al., 2023; Fadhilah & Wajdi, 2022; Irma et al., 2016). Learning objectives are important in teaching and learning activities as an evaluation of student learning success (Intang et al., 2018). STEM learning model can develop students' interest and motivation in learning (Sukmawijaya et al., 2019). Not only that, the application of the Science Technology Engineering and Mathamatics (STEM) model helps students understand and master technology in learning so that it provides solutions to problem solving (Nyoman et al., 2023; Hacıoglu & Gulhan , 2021; Putri et al., 2019; Rahman et al., 2023). Research results oleh Baran et al., (2021) stated that STEM learning models can improve science literacy and critical thinking skills of students in Indonesia. Furthermore, a meta-analysis of education levels that apply STEM learning models to encourage students' critical thinking skills can be seen in Figure 2.

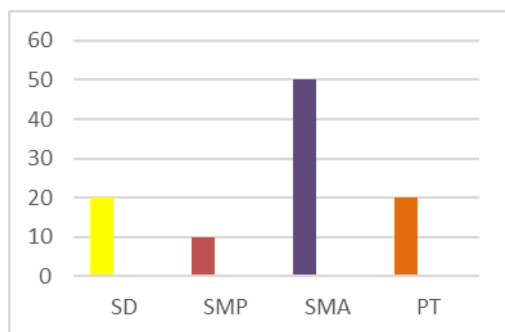


Figure 2. Meta-analysis by education level

Based on Figure 2. Explains the level of education that applies a lot of STEM learning models, namely high school by 50%, junior high school by 10%, elementary school and college 20%. The results show that the Science Technology Engineering and Mathematics (STEM) learning model has generally been widely applied in schools in Indonesia. Amin et al., (2022) stated that the learning model is effective in improving learning outcomes and student creativity at the high school level. The STEM model is very well applied at the high school level because the mindset of students has begun to develop and understand technology in the learning process (Divayana et al., 2017). Research results by Artika et al., (2021) STEM learning models apply their knowledge in designing something that provides ideas or solutions in learning activities. Knowledge is all information obtained by students from various sources (Ferry et al., 2019). So, the STEM model develops students' knowledge in obtaining information that encourages critical thinking skills in students in Indonesia. Not only that, the STEM learning model increases students' science literacy in learning (Putri et al., 2022).

Furthermore, hypothesis testing was conducted to determine the effectiveness of the STEM learning model on critical thinking skills in students in Indonesia. Hypothesis

testing with random effect model can be seen in Table 3.

Table 3. Hypothesis Test with *Random Effect Model*

Estimation Model	Model				
	n	Z	P	ES	SE
Random effect model	13	6.041	0.000	0.968	0.240

Based on Table 3. Shows the results of hypothesis testing Z value of 6.041 with p-value = 0.000 with (ES = 0.968) then the STEM learning model is effective in improving critical thinking skills in Indonesian students. The STEM learning model is highly effective in promoting students' problem solving and critical thinking skills (Şahin, 2021). Research results Oschepkov et al., (2022) STEM learning model is effective in encouraging students' creative skills in learning. Therefore, the application of STEM models has a great positive impact on the education system in Indonesia. STEM learning model is effective in helping students' critical thinking, creative and collaborative skills in learning (Ernawati & Maniarta, 2022). Dywan et al., (2020) stated that the STEM model really needs to be implemented in the learning system in Indonesia because it is effective in improving the critical thinking skills of students in Indonesia.

Conclusion

Based on this research, it can be concluded that the average effect size (ES) value is 0.968 with high criteria. This finding shows that the STEM model has a very large influence on students' critical thinking skills. The STEM model helps students be more creative and innovative in the learning process. The STEM model is very helpful for students and teachers in

understanding science, technology, engineering and mathematics to solve fresh problems that occur in everyday life

Reference

- Adiwiguna, P. S., Dantes, N., & Gunamantha, I. M. (2019). Pengaruh Model Problem Based Learning (Pbl) Berorientasi Stem terhadap Kemampuan Berpikir Kritis dan Literasi Sains Siswa Kelas V Sd di Gugus I Gusti Ketut Pudja. *Jurnal Pendidikan Dasar Indonesia*, 3(2), 94–103.
- Afriana, J., Permanasari, A., & Fitriani, A. (2016). Penerapan Project Based Learning Terintegrasi STEM untuk Meningkatkan Literasi Sains Siswa Ditinjau dari Gender Implementation Project-Based Learning Integrated STEM to Improve Scientific Literacy Based on Gender. *Jurnal Inovasi Pendidikan IPA*, 2(2), 202–212.
- Alandia, R. G., Jumadi, Wilujeng, I., & Kuswanto, H. (2019). The Effects of Web-Assisted Problem Based Learning Model of Physics Learning on High School Students' Critical Thinking Skills. *Journal of Physics: Conference Series*, 1233(1), 1–8. <https://doi.org/10.1088/1742-6596/1233/1/012048>
- Allanta, T. R., & Puspita, L. (2021). Analisis keterampilan berpikir kritis dan self efficacy peserta didik : Dampak PjBL - STEM pada materi ekosistem An analysis of students ' critical thinking skills and self-efficacy : The influence of PjBL-STEM on ecosystem learning materials. *Jurnal Inovasi Pendidikan IPA*, 7(2), 158–170.
- Amalia, D., Sutarto, J., Kurniawati, Y., & Pranoto, S. (2022). Pengaruh Pembelajaran Jarak Jauh Bermuatan STEAM Terhadap Karakter Kreatif dan Kemandirian. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, 6(3), 1233–1246. <https://doi.org/10.31004/obsesi.v6i3.1765>
- Amin, S., Utaya, S., Bachri, S., & Susilo, S. (2020). Effect of problem-based learning on critical thinking skills and environmental attitude. *Journal for the Education of Gifted Young Scientists*, 8(2), 743–755.
- Anita, Y., Thahir, A., & Rahmawati, N. D. (2021). Buku Saku Digital Berbasis STEM : Pengembangan Media Pembelajaran terhadap Kemampuan Pemecahan Masalah Mosharafa : *Jurnal Pendidikan Matematika Mosharafa : Jurnal Pendidikan Matematika*. *Mosharafa: Jurnal Pendidikan Matematika*, 10(September), 401–412.
- Ariyatun1, D. F. O. (2020). Pengaruh Model Problem Based Learning Terintegrasi STEM Terhadap Kemampuan Berpikir Kritis Siswa 1 , 2 Pendidikan Kimia Pascasarjana , Universitas Negeri Semarang. *Journal of Educational Chemistry*, 2(1), 33–39. <https://doi.org/10.21580/jec.2020.2.1.5434>
- Artika, W., Nurmaliah, C., Studi, P., Pendidikan, M., Fkip, B., Syiah, U., & Aceh, B. (2021). Penerapan Model Discovery Learning Berbasis STEM pada Materi Sistem Gerak Untuk Meningkatkan Keterampilan Berpikir Kritis Pendahuluan. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 9(1), 99–107. <https://doi.org/10.24815/jpsi.v9i1.18591>

- Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The Influence of Project-Based STEM (PjBL-STEM) Applications on the Development of 21st-Century Skills. *Journal of Turkish Science Education*, 18(4), 798–815.
- D M Aulia^{1*}, Parno², dan S. K. (2021). Pengaruh E-modulee Berbasis TPACK-STEM terhadap Literasi Sains Alat Optik dengan Model PBL-STEM Disertai Asesmen Formatif. *Jurnal Riset Pendidikan Fisika*, 6(1), 7–12.
- Dewa Gede Hendra Divayana, Zanak Agung Gede Agung, & baso Intang Sappaile, 4wakhinuddin Simatupang, 5yuliatrisastrawijaya, 6i Made Sundayana, 7gusti Ayu Dessy Sugiharn. (2017). Utilization Of Open Source Technology In Determining Of Validity And Reliability Of Evaluation Model Instruments Based On Aneka Values In Order To Evaluate The Quality Of. *Journal of Theoretical and Applied Information Technology*, 95(20), 5517–5534.
- Dharma Ferry¹, Tomi Apra Santosa, D. K. (2019). Pengetahuan Mahasiswa Institut Agama Islam Negeri Kerinci Tentang Teori Asal Usul Manusia Dharma. *Bioeduca: Journal of Biology Education*, 1(1), 12–17.
- Dywan, A. A., Airlanda, G. S., Kristen, U., Wacana, S., & Tengah, J. (2020). EFEKTIVITAS MODEL PEMBELAJARAN PROJECT BASED LEARNING BERBASIS STEM DAN TIDAK BERBASIS STEM TERHADAP KETERAMPILAN BERPIKIR KRITIS SISWA. *JURNAL BASICEDU*, 4(2), 344–354.
- Elfira, I., & Santosa, T. A. (2023). Literature Study : Utilization of the PjBL Model in Science Education to Improve Creativity and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 9(1), 133–143. <https://doi.org/10.29303/jppipa.v9i1.2555>
- Erkan, H., & Duran, M. (2023). The Effects of STEM Activities Conducted with the Flipped Learning Model on Primary School Students ' Scientific Creativity , Attitudes and Perceptions towards STEM. *Science Insights Education Frontiers 2023;*, 15(1), 2175-2225. <https://doi.org/10.15354/sief.23.or115>
- Ernawati, E., & Maniarta, T. (2022). Implementation of free inquiry approach based on blended learning on creative thinking and student collaboration skills. *Jurnal Pendidikan Biologi Indonesia*, 8(3), 216–225.
- Fadhilah, N., & Wajdi, M. (2022). Integrasi STEM- Problem Based Learning melalui Daring Terhadap Keterampilan Berpikir Kritis Mahasiswa Pendidikan Biologi Pendahuluan. *Jurnal IPA Dan Pembelajaran IPA*, 6(1), 1–10. <https://doi.org/10.24815/jipi.v6i1.22721>
- Fradila, E., Razak, A., Santosa, T. A., Arsih, F., & Chatri, M. (2021). Development Of E-Module-Based Problem Based Learning (PBL) Applications Using Sigil The Course Ecology And Environmental Education Students Master Of Biology. *International Journal of Progressive Sciences and Technologies (IJPSAT)*, 27(2), 673–682.

- Hidayati et al. (2022). The PBL vs . Digital Mind Maps Integrated PBL : Choosing Between the two with a view to Enhance Learners ' Critical Thinking Nurkhairo Hidayati Sri Amnah. *Participatory Educational Research (PER)*, 9(3), 330–343.
- Ichsan, Yayat Suharyat, Tomi Apra Santosa, E. (2023). The Effectiveness of STEM-Based Learning in Teaching 21 st Century Skills in Generation Z Student in Science Learning: A. *Jurnal Penelitian Pendidikan IPA*, 9(1), 150–166. <https://doi.org/10.29303/jppipa.v9i1.2517>
- Intang, B., La, S., Masuddin, O., Saludung, J., & Sappaile, P. (2018). Influence of implementation of academic supervision by the school supervisor , interpersonal communication , and teacher motivation on the quality of learning in secondary high schools in regency of South Buton , Indonesia. *Journal of Educational Research and Review*, 6(2), 29–37.
- Iolanessa, L., Kaniawati, I., & Nugraha, M. G. (2020). Pengaruh Model Problem Based Learning (PBL) Menggunakan Pendekatan STEM dalam Meningkatkan Keterampilan Pemecahan Masalah Siswa SMP. *WaPfi (Wahana Pendidikan Fisika)*, 5(1), 113–117.
- Irma, E., Davidi, N., Sennen, E., & Supardi, K. (2016). Integrasi Pendekatan STEM (Science , Technology , Enggeenering and Mathematic) Untuk Peningkatan Keterampilan Berpikir Kritis Siswa Sekolah Dasar. *Scholaria: Jurnal Pendidikan Dan Kebudayaan*, 11(1), 24–31.
- Ismail, I., Permanasari, A., & Setiawan, W. (2016). Efektivitas Virtual Lab Berbasis STEM dalam Meningkatkan Literasi Sains Siswa dengan Perbedaan Gender STEM-Based Virtual Lab Effectiveness in Improving the Scientific Literacy of Students with Gender Differences. *Jurnal Inovasi Pendidikan IPA*, 2(2), 190–201.
- Ismoyo, H. (2012). Effect Of Problem-Based Learning On Improvement Physics Achievement And Critical Thinking Of Senior High School Student. *Journal of Baltic Science Education*, 16(5), 761–780.
- Kornelia Devi Kristiani¹, Tantri Mayasari², E. K. (2017). Pengaruh pembelajaran STEM-PjBL terhadap keterampilan berpikir kreatif. *SEMINAR NASIONAL PENDIDIKAN FISIKA III 2017*, 21, 1–9.
- Londa, K., & Domu, I. (2020). Pengaruh Model Pembelajaran Project Based Leaning Berbasis Web Pada Kemampuan Higher Order Thinking Skills (Hots). *MARISEKOLA: Jurnal Matematika Riset Edukasi Dan Kolaborasi*, 1(2), 25–28. <https://doi.org/10.53682/marisekola.v1i2.1029>
- Loturco, I., Montoya, N. P., Ferraz, M. B., Berbat, V., & Pereira, L. A. (2022). education sciences A Systematic Review of the Effects of Physical Activity on Specific Academic Skills of School Students. *Educ. Sci.*, 12, 1–15.
- Luvia Raggi, N., Yokhebed, Ramli, M., & Yuliani, H. (2021). Meta-Analysis of the Effectiveness of Problem-Based Learning towards Critical Thinking Skills in Science Learning. *Journal of Physics: Conference Series*, 1842(1),

1–10. <https://doi.org/10.1088/1742-6596/1842/1/012071>

- Mataka, L. M., Saderholm, J. C., & Hodge, T. T. (2020). College STEM Faculty Teaching Practices : The Influence of a Professional Development. *ELECTRONIC JOURNAL FOR RESEARCH IN SCIENCE & MATHEMATICS EDUCATION*, 26(3), 40–56.
- Mika Dwi Permata¹, Irwan Koto², I. S. (2018). Pengaruh Model Project Based Learning Terhadap Minat Belajar Fisika Dan Kemampuan Berpikir Kritis Siswa Sma Negeri 1 Kota Bengkulu . *Jurnal Kumparan Fisika*, 1(1), 1–10.
- Mohtar, L. E., Halim, L., & Rahman, N. A. (2006). A MODEL OF INTEREST IN STEM CAREERS AMONG SECONDARY. *Journal of Baltic Science Education*, 18(3), 404–416.
- Muhamad Amin¹, Malik Ibrahim^{2*}, A. (2022). META ANALISIS: KEEFEKTIFAN STEM TERHADAP KEMAMPUAN BERPIKIR KREATIF SISWA Muhamad. *Journal of Authentic Research on Mathematics Education (JARME)*, 4(2), 248–262.
- Nashar^{1*}, A. N. and R. F. (2021). The Effectiveness of Critical Thinking Ability on the Basis of Quizizz Application Viewed from Problem Based Learning Model in History Learning of Senior High School. *IOP Conf. Series: Earth and Environmental Science*, 747, 1–9. <https://doi.org/10.1088/1755-1315/747/1/012046>
- Nyoman, N., Kamala, S., Bagus, I., Arnyana, P., & Margunayasa, I. G. (2023). Project Based Learning Berbasis STEM : Meningkatkan Kemampuan Berpikir Kritis dan Hasil Belajar Siswa. *JURNAL ILMIAH PENDIDIKAN PROFESI GURU*, 6(1), 133–143.
- Oschepkov, A. A., Egorova, E. V, & Zhdanov, S. P. (2022). STEM technology-based model helps create an educational environment for developing students ’ technical and creative thinking. *EURASIA Journal of Mathematics, Science and Technology Education*, 18(5).
- Othman, O. (2022). Creative Teaching STEM Module: High School Students’ Perception. *European Journal of Educational Research*, 11(4), 2127–2137.
- Pimthong, P., & Williams, P. J. (2021). Methods Course for Primary Level STEM Preservice Teachers : Constructing Integrated STEM Teaching. *URASIA Journal of Mathematics, Science and Technology Education*, 17(8), 1–14.
- Putra, M., Rahman, A., Suhayat, Y., Santosa, T. A., & Putra, R. (2023). The Effect of STEM-Based REACT Model on Students ’ Critical Thinking Skills : A Meta-Analysis Study. *LITERACY : International Scientific Journals Of Social, Education and Humaniora*, 2(1), 207–217.
- Putri, N., Rusdiana, D., & Suwarma, I. R. (2019). The Comparison of Student Creative Thinking Skill using CBL Implemented in STEM Education and Combined with PSL Worksheet

- in Indonesian. *Journal of Science Learning*, 3(May).
<https://doi.org/10.17509/jsl.v3i1.17557>
- R R Musna¹, *, D. J. 1 and A. J. 1. (2021). A meta-analysis study of the effect of Problem-Based Learning model on students' mathematical problem solving skills A meta-analysis study of the effect of Problem-Based Learning model on students' mathematical problem solving skills. *Journal of Physics: Conference Series*, 1882, 1–8.
<https://doi.org/10.1088/1742-6596/1882/1/012090>
- Rahman, A., Islam, P. A., Bekasi, U. I., Ipa, P., Padang, U. N., Jambi, U., Pendidikan, M., Islam, A., Uin, F., & Bonjol, I. (2023). Meta-Analysis : Pengaruh Pendekatan STEM berbasis Etnosains Terhadap Kemampuan Pemecahan Masalah dan Berpikir Kreatif Siswa. 3, 2111–2125.
- Rahman, A., & Ristiana, E. (2020). Pengaruh Model PBL Terhadap Kemampuan Berpikir Kritis dan Pemahaman Konsep IPA Siswa Kelas V SDN 30 Sumpangbita. *Edumaspul: Jurnal Pendidikan*, 4(1), 29–41.
- Rahman, A., Santosa, T. A., & Suharyat, Y. (2023). The Effect of Problem Based Learning-STEM on Students' 21st Century Skills in Indonesia : A Meta-Analysis. 2(1).
- Rahman, A., Santosa, T. A., Suharyat, Y., & Aprilisia, S. (2023). The Effectiveness of AI Based Blended Learning on Student Scientific Literacy : LITERACY : *International Scientific Journals Of Social, Education and Humaniora*, 2(1), 141–150.
- Rahming, S. (2022). The STEM Glass Ceiling : The Influence of Immigration Status on STEM Trajectories of Afro-Caribbean Women (A Narrative Approach). *Journal of International Students*, 12(1), 156–174.
<https://doi.org/10.32674/jis.v12i1.3367>
- Ramdani, D. (2016). The Effectiveness of Collaborative Learning on Critical Thinking, Creative Thinking, and Metacognitive Skill Ability: Meta-Analysis on Biological Learning. *European Journal of Educational Research Volume*, 11(3), 1607–1628.
- Razak, A., Santosa, T. A., Lufri, & Zulyusri. (2021). Meta-Analysis: Pengaruh HOTS (Higher Order Thinking Skill) terhadap Kemampuan Literasi Sains dan Lesson Study Siswa pada Materi Ekologi dan Lingkungan pada Masa Pandemi Covid-19. *Bioedusiana: Jurnal Pendidikan Biologi*, 6(1), 79–87.
- Rijal, M., Mastuti, A. G., Safitri, D., Bachtiar, S., & Samputri, S. (2021). Differences in learners' critical thinking by ability level in conventional , NHT , PBL , and integrated NHT-PBL classrooms. *International Journal of Evaluation and Research in Education (IJERE)*, 10(4), 1133–1139.
<https://doi.org/10.11591/ijere.v10i4.21408>
- Rima Melani Putri*, Asrizal, U. (2022). Metaanalisis Efek Pendekatan STEM pada Literasi Sains dan Pemahaman

- Konsep Peserta Didik di Setiap Satuan Pendidikan Pendahuluan. *Jurnal IPA Dan Pembelajaran IPA*, 6(1), 86–98. <https://doi.org/10.24815/jipi.v6i1.23897>
- ŞAHİN, H. (2021). The Effect Of Stem-Based Education Program On Problem Solving Skills Of Five Year Old. *Malaysian Online Journal of Educational Technology*, 9(4), 69–88.
- Santosa, T. A., Razak, A., Arsih, F., & Sepriyani, E. M. (2021). Meta-Analysis : Science Learning Based on Local Wisdom Against Preserving School Environments During the Covid-19 Pandemic. *Journal of Biology Education*, 10(2), 244–251.
- Saputro, O. A., & Rayahu, T. S. (2020). PERBEDAAN PENGARUH PENERAPAN MODEL PEMBELAJARAN PROJECT BASED LEARNING (PJBL) DAN PROBLEM BASED LEARNING (PBL) BERBANTUAN MEDIA MONOPOLI. *Jurnal Imiah Pendidikan Dan Pembelajaran*, 4(1), 185–193.
- Suganda, E., Latifah, S., Irwandani, Sari, P. M., Rahmayanti, H., Ichsan, I. Z., & Rahman, M. M. (2021). STEAM and Environment on students' creative-thinking skills: A meta-analysis study. *Journal of Physics: Conference Series*, 1796(1). <https://doi.org/10.1088/1742-6596/1796/1/012101>
- Suhaimi, Santosa, T. A., & Aprilisia, S. (2022). Analisis Pendekatan Saintifik Dalam Pembelajaran IPA Selama Pandemi Covid-19 di Sekolah Dasar. *Jurnal Didika: Wahana Ilmiah Pendidikan Dasar*, 8(1), 92–101.
- Suharyat, Y., Ichsan, Satria, E., Santosa, T. A., & Amalia, K. N. (2022). Meta-Analysis Penerapan Model Pembelajaran Problem Based Learning Untuk Meningkatkan Keterampilan Abad-21 Siswa Dalam Pembelajaran IPA. *Jurnal Pendidikan Dan Konseling*, 4(5), 5081–5088.
- Suharyat, Y., Santosa, T. A., Aprilisia, S., & Yulianti, S. (2022). International Journal of Education and Literature (IJEL) Meta-Analysis Study : The Effectiveness of Problem Solving Learning in Science Learning in Indonesia. *International Journal of Education and Literature (IJEL) Amik Veteran Porwokerto*, 1(3), 6–13.
- Sukmawijaya, Y., Juhanda, A., Sukabumi, M., Syamsudin, J., & Cikole, S. H. N. (2019). PENGARUH MODEL PEMBELAJARAN STEM-PJBL TERHADAP KEMAMPUAN BERPIKIR KREATIF SISWA. *BIOEDUN: Jurnal Program Studi Pendidikan Biologi*, 0417(9).
- Sularmi, Hari Utomo, D., & Nyoman Ruja, I. (2018). Pengaruh Project-Based Learning terhadap Kemampuan Berpikir Kritis. *Jurnal Pendidikan*, 3(4), 475–479. <http://journal.um.ac.id/index.php/jptpp/>
- Supriyadi, A., Suharyat, Y., Santosa, T. A., & Sofianora, A. (2023). The Effectiveness of STEM-Integrated Blended Learning on Indonesia Student Scientific Literacy : A Meta-analysis. *International Journal of*

- Education and Literature (IJEL), 2(1), 41–48.
- Suryono, W., Haryanto, B. B., Santosa, T. A., Suharyat, Y., & Sappaile, B. I. (2023). The Effect of The Blended Learning Model on Student Critical Thinking Skill : Meta-analysis. *Edumaspul - Jurnal Pendidikan*, 7(1), 1386–1397.
- TEMEL, H. (2022). The Effect of Critical Thinking Course Carry Out with Distance Education on Critical Thinking Skills and Dispositions. *International Journal of Psychology and Educational Studies*, 9(3), 792–808.
<https://doi.org/10.52380/ijpes.2022.9.3.894>
- Tureni, D., Febriawan, A., Fardha, R., & Buntu, A. (2021). Pengaruh Model Pembelajaran STEM di Era Revolusi Industri 4 . 0 terhadap Kemampuan Berpikir Kritis Siswa SMAN 5 Palu. *Jurnal Kreatif Online (JKO)*, 9(3), 66–72.
- Yasemin Hacıoglu, F. G. (2021). The Effects of STEM Education on the Students ' Critical Thinking Skills and To cite this article : The Effects of STEM Education on the Students ' Critical Thinking Skills and STEM Perceptions. *Journal of Education in Science, Environment and Health*, 7(2), 1–18.
- Yesildag-hasancebi, F. (2021). Impact of Stem Integrated Argumentation-Based Inquiry Applications on Students ' Academic Success , Reflective Thinking and Creative Thinking Skills Omer Guner Cagla Kutru Mehmet Hasancebi. *Participatory Educational Research (PER)*, 8(December), 274–296.
- Yuliati, Y., & Saputra, D. S. (2019). Urgensi Pendidikan STEM terhadap Literasi Sains Mahasiswa Calon Guru. *Proceeding of ICECRS*, 2(1), 321–326.
<https://doi.org/10.21070/picecrs.v2i1.2420>
- Zulkifli Zulkifli, Agus Supriyadi, Erwinsyah Satria, & Tomi Apra Santosa. (2022). Meta-analysis: The Effectiveness of the Integrated STEM Technology Pedagogical Content Knowledge Learning Model on the 21st Century Skills of High School Students in the Science Department. *Psychology, Evaluation, and Technology in Educational Research*, 1(2), 68–76.
<https://doi.org/10.55606/ijel.v1i2.32>
- Zulyusri, Elfira, I., Violita, & Santosa, T. A. (2022). Meta-Analysis Study : Correlation Study of the Influence of Motivation on Student Learning Outcomes. *International Journal of Education and Literature (IJEL)*, 1(3), 34–45.
- Zulyusri1*, Tomi Apra Santosa , Festiyed1, Yerimadesi1, Yohandri1, Abdul Razak1, S. (2023). Effectiveness of STEM Learning Based on Design Thinking in Improving Critical Thinking Skills in Science Learning : A. *Jurnal Penelitian Pendidikan IPA*, 9(6), 112–119.
<https://doi.org/10.29303/jppipa.v9i6.3709>