



STEM IN INDONESIAN MATHEMATICS EDUCATION

Tika Dwi Nopriyanti¹, Zulkardi^{2*}, Ratu Ilma Indra Putri³, Nyimas Aisyah⁴

^{1,2,3,4}Universitas Sriwijaya, Indonesia

*zulkardi@unsri.ac.id

ABSTRACT

STEM (Science, Technology, Engineering, Mathematics) is one approach that can be used in learning mathematics. Articles resulting from research using a STEM approach have been published in journals in Indonesia, with mathematics being one of the sciences that is the main component of STEM. However, there are still a few who categorize STEM articles as sources of information for future researchers. Therefore, this research aims to conduct STEM research using the Systematic Literature Review (SLR) method. The SLR method begins by identifying, analyzing, evaluating, and categorizing STEM articles obtained from 2020-2024 with topics related to the STEM approach. Research data was taken from 22 articles that had been published in 12 journals, consisting of two journals indexed by Sinta 1, seven journals indexed by Sinta 2, and three journals indexed by Sinta 3. The results of this research showed that of the 22 articles identified in this research consisting of STEM articles, development of STEM teaching materials, STEM learning design with thinking abilities measured, namely critical, creative, problem solving, and pedagogical thinking abilities

Keywords: *STEM, systematic literature review, mathematics*

1. INTRODUCTION

The rapid development of the times requires humans to balance the quality of their abilities and skills to adapt to the innovations that occur. The development of the 21st century can be seen in the use of technology in all aspects of human life. Information will spread quickly in a short time, so human abilities are needed to filter all existing information and be able to solve problems in the future. The world of education is one part that must keep up with the times, so innovation in learning is needed. To support 21st-century learning, 21st-century skills need to be included in the curriculum, one of which is providing a comfortable, interesting, and contextual learning atmosphere (Larson & Miller, 2011). One approach that uses context in the learning process and a pleasant learning atmosphere is the STEM (Science, Technology, Engineering, Mathematics) approach.

STEM is an innovation for the STEM field of science that aims to foster a deeper understanding of each lesson that connects scientific or interdisciplinary disciplines (Hanover Research, 2011; Bybee, 2013; Roberts, 2012). Through this STEM approach, students are also taught to use technology in learning to prepare them for careers in the fields of science and technology. Apart from this, the STEM approach can help students understand the material and, at the same time, develop creative, critical, collaborative, and problem-solving thinking skills that will be useful for students in solving problems by analyzing existing information and making the right decisions with the right reasons and evidence. so that no errors occur. The STEM approach requires students to solve problems and deal with new problems that exist in students lives, think logically to produce creative and appropriate solutions, and be able to use technology that is in line with the skills required for work in the 21st century (Widya et al., 2019; Munahefi et al., 2022; Kusyanto et al, 2022). The STEM approach to learning mathematics makes something abstract in mathematics into something concrete or real simultaneously through teaching modules that have been provided by educators so that learning becomes more meaningful (Ramadhani & Nurita, 2023)

2. METHODS

This research used the Systematic Literature Review (SLR) method. The SLR method is a method that functions to identify, evaluate, and interpret research sources in the form of relevant articles to answer research questions in detail (Calderón & Ruiz, 2015; Hidayat et al., 2019). This research took samples from ten journals



that were accredited by the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia (Kemenristekdikti). Search results via the Sinta website obtained 37 journals in accreditation categories 1, 2, and 3, which are mathematics education journals, and fourteen journals published research articles on STEM (Science, Technology, Engineering, and Mathematics) topics. The journal in Category 1 is Journal Mathematics Education (JME). The journal category with Sinta 2, which is included in the category and displays articles about STEM, is composed of six journals, namely Mosharafa (Mathematics Education Journal), Prima Edukasi Journal, Elements Journal, Mathematics Education Research Journal (JRPM), Al-Jabar: Journal of Mathematics Education, Kreano: Journal of Creative-Innovative Mathematics, Axiom Journal of Mathematics Education, Elementary Journal, Journal of Innovation in Educational and Cultural Research, and Indonesian Education Journal. The Sinta 3 category, which provides research articles on STEM topics, is Teorema: Mathematics Theory and Research, Elementary: Scientific Journal of Basic Education, and Journal of Science Education Research.

Articles that have been obtained from journals that fall into this category are then analyzed using a comprehensive approach by identifying research that meets the STEM research criteria. The analysis begins by looking for STEM, STEM in Mathematics Learning, Learning Media, Thinking Abilities, and Context in each journal of the twelve selected journals. A total of 23 articles were collected at this stage and then classified based on title, year, journal name, problem focus, method, research subject, content, context, and mathematical abilities.

This research focuses on the results of research conducted in the last five years, from 2019 to 2024. The articles that have been obtained are analyzed comprehensively, compared, categorized, and divided into several main topic sections. Development and design research that focuses on the content used or mathematical problems to be solved with STEM, the context used in STEM, and the thinking abilities that will be measured in the research

3. RESULTS AND DISCUSSION

The STEM approach to learning mathematics is currently trending as a learning solution. This is because learning that uses a STEM approach makes the student's learning process more meaningful by being student-centered to prepare students for graduation with 21st-century abilities and skills. Therefore, updated articles on the latest research results with the STEM theme in 2020–2024 can be accessed. analysis based on the year of publication, research methods, research subjects, media developed, and mathematical abilities measured

Analysis of Articles Based on Year of Publication

STEM publications in Indonesia ranged from 14 journals with a period of 2020 to 2024; the publication trend experienced an increase in 2021. However, there was a 50% decrease in publications for the following year. When compared with other journals, Kreano Journal, AL-Jabar Journal, and JRPM are journals that consistently publish articles with STEM themes. Article publications in the 2020–2024 period can be seen in Figure 1.

In the period 2020–2024, the most articles published with STEM themes were published by the journals Kreano Sinta 2, Algebra Sinta 2, and JRPM Sinta 2, with 3 articles each. For the Sinta 1 journal, JME only published 1 article in the last five times in 2022. Based on the 2020–2024 period, the first article published in the Mosharafa journal was an article written by Utomo (2020) explaining the logical reasoning abilities of prospective mathematics teachers to solve problems by integrating the STEM approach and using the Geogebra application to provide solutions, proof, and resolution of the problems given. Meanwhile, of the four articles published in 2023, the latest article published with a STEM theme written by Sukendra (2023) explained that using STEM-based e-modules for HOTS-oriented high school students can be a solution for teaching materials used by teachers in the learning process.

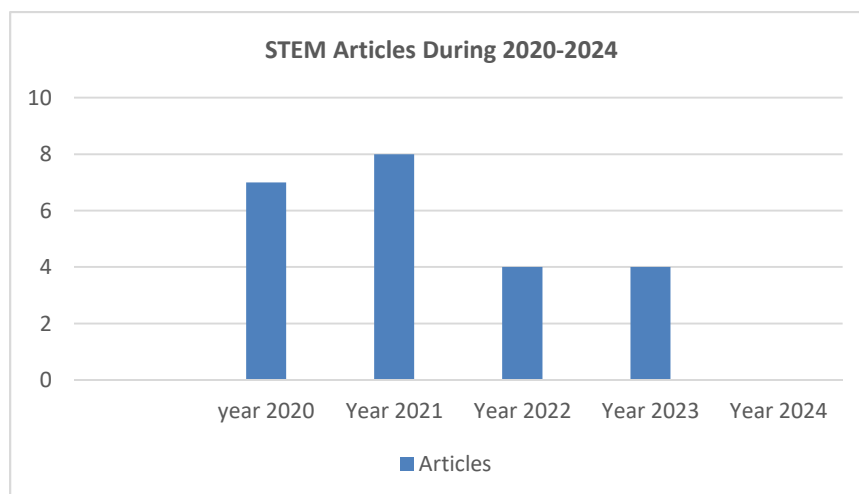


Figure 1. STEM Articles During 2020-2024

STEM Research Based on Research Methods

The STEM theme research in 23 articles used various research methods, ranging from development research, design research, application research, experimental research, and literature review research. A summary of the 23 articles can be seen in Figure 2.

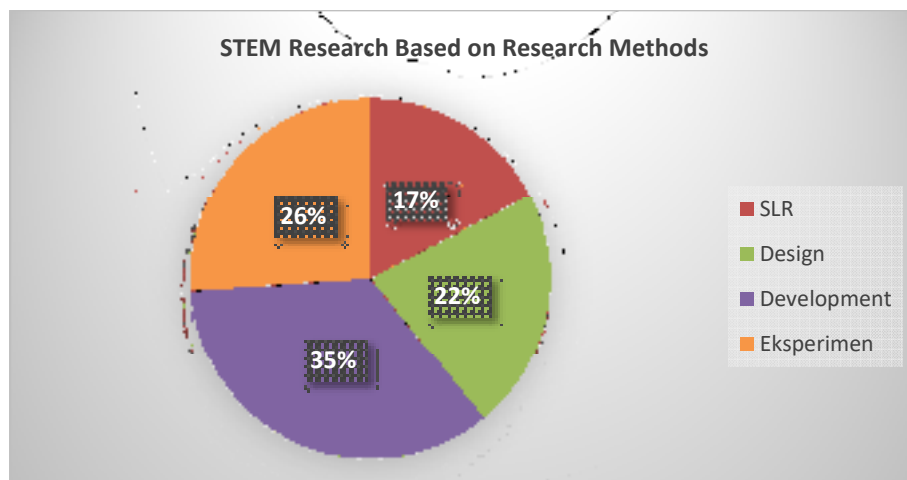


Figure 2. Articles Based on Research Methods

35% of all articles are development research, consisting of the development of activity sheets, learning media, and e-modules. The method used in development research uses the ADDIE and Plump methods. The journals that published more development research out of the 14 journals were the JRPM Journal and the Kreano Journal, which each published two articles. The results of this research are to produce products developed in the form of STEM-based Activity Sheets, Learning Media, Questions, and STEM-based e-modules that are valid, practical, and have a positive influence on learning, learning outcomes, and students' thinking abilities, which means that learning using a STEM approach and using modules or integrated STEM learning tools can improve the quality of learning, learning outcomes, and students' thinking abilities. The other 65% of articles are design research, experiments, and literature review (SLR) studies.



Based on Research Subjects

STEM is an abbreviation of Science, Technology, Engineering, and Mathematics, which is an approach formed based on the combination of various sciences such as Science, Technology, Engineering, and Mathematics (Nesa et al, 2017). The learning process that uses a STEM approach can connect several theoretical mathematical concepts based on technology and information with contextual problems that exist in everyday life (Widana & Septiari, 2021)). So the STEM approach can be used at all levels of education.

Based on the analysis, the 23 articles selected had varying research subjects. There are six research subjects, namely teachers, prospective teacher students, elementary school, middle school, high school, and articles. The STEM research subjects are dominated by junior high school students, at 39%, consisting of grades 7 and 8. The subjects are 17.4% of high school students in grades X and Systematic Literature Review, which examines articles discussing STEM published in the journals JSER, Teorema, Elementary, and Algebra Journal. STEM research subjects in Indonesia are shown in Figure 3.

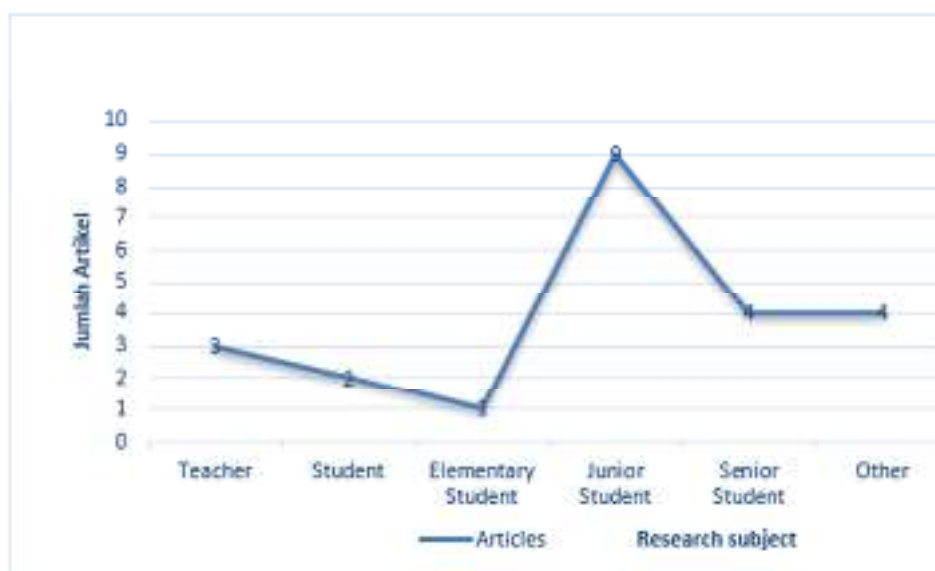


Figure3. STEM Research Subjects in Indonesia

Based on The Media Developed

The results of the analysis of 23 articles about STEM, 9 articles that developed student activity sheets based on measured abilities, The correct use of Activity Sheets in the learning process can improve learning outcomes, students' thinking abilities such as creativity, critical thinking, reasoning, understanding concepts, and student communication (Saputra et al, 2020; Argianti, et al., 2021; Arivina, 2020; Novaliyosi, et al., 2021; Sukendra, et al., 2020; Komarudin, et al., 2021; Sulistiawati, et al., 2021; Amalina & Vidakovich, 2022; Rohimah et al, 2022). A resume of STEM articles published in 2020-2024 based on the media developed can be seen in Figure 4.

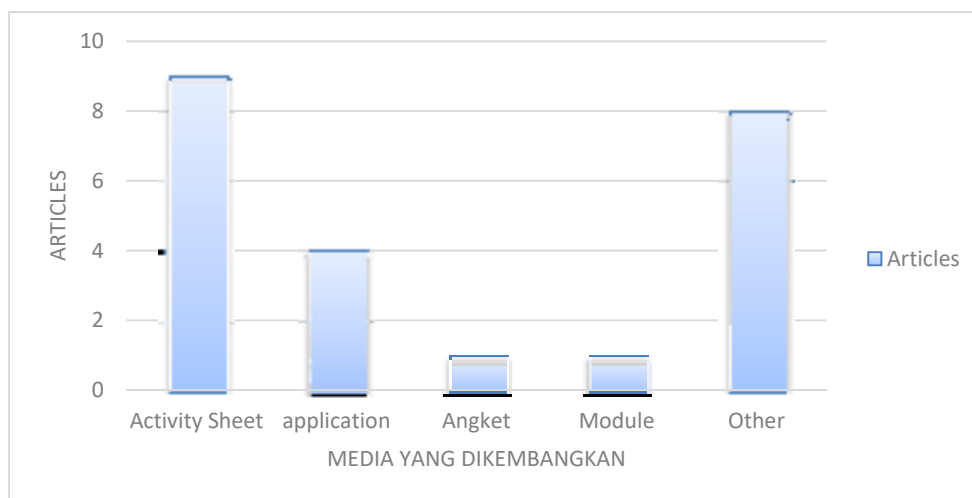


Figure 4. STEM Articles Based on Developed Media

STEM Articles Based on Measured Abilities

The following are the results of the analysis of 23 STEM articles in 14 journals accredited by the Ministry of Research, Technology, and Higher Education. Learning that uses a STEM approach can improve students' mathematical thinking abilities. The STEM approach in the mathematics learning process and learning using teaching aids, learning media, and activity sheets can train and develop students' mathematical thinking abilities, which are included in the abilities that students must have in the 21st century (Amalina & Vidákovich, 2022; Widana & Septiari, 2021; Arivina & Jailani, 2020; Rahmawati et al, 2023; Pratiwi et al, 2023). The results of the analysis of 23 articles about STEM can be seen in Figure 5.

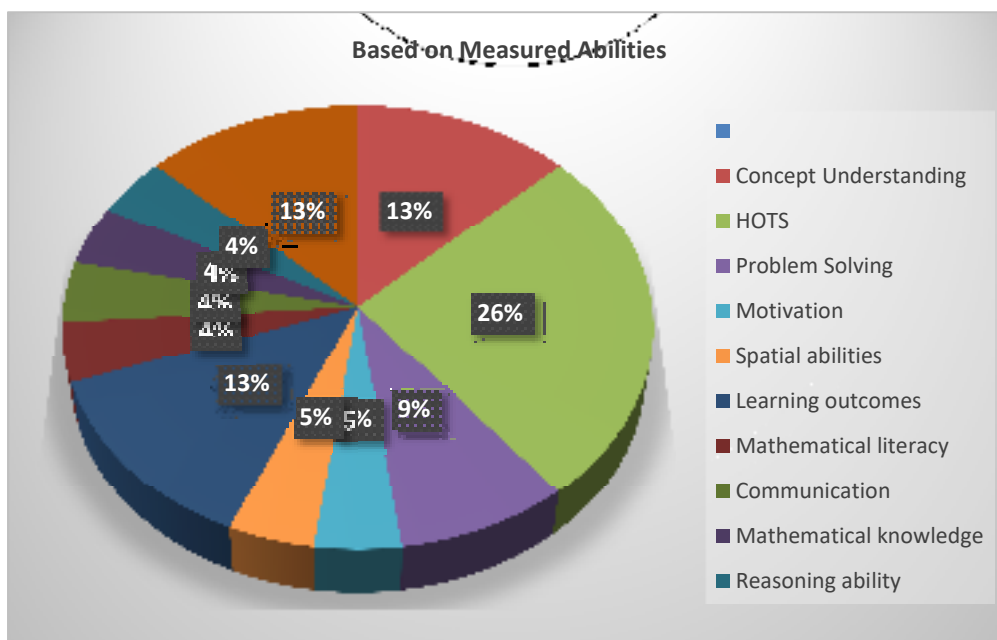


Figure 5. STEM Articles Based on Measured Abilities



23 STEM research articles published in 2020-2024 from 14 journals accredited by the Ministry of Research, Technology, and Higher Education answered that the STEM approach is an innovation in education, especially mathematics learning. In the last 5 years of STEM research, 35% of all STEM research was development research, consisting of the development of Activity Sheets, e-Modules, and Media. The products produced by development research are teaching materials that are valid, practical, and have good potential effects (Amalina & Vidakovich, 2022; Saputra et al., 2020; Arifin et al., 2020; Arivina & Jailani, 2020; Novaliyosi et al., 2021; Aprilia et al., 2021; Krisdiana et al., 2020; Sukendra & Widana, 2023).

Table 1 is the result of an analysis of 23 articles to classify them based on the focus of STEM research in Indonesia. So it is hoped that the following table can serve as a guide or reference in assessing the distribution of STEM research focus in 2020–2024.

Table 1. Resume of STEM Research Articles in Indonesia

No	Research Focus	Content	Context	References
1	Teachers' understanding of STEM	Others	Geogebra, mathematical technology knowledge About STEM, SPLDV	Sari et al. (2022); Widana et al. (2021); Ma'rufi et al. (2023);
2	Analysis of Student Abilities	Others	STEM test, SPLDV	Amalina et al. (2022); Komarudin et al. (2021)
3	Development of teaching materials	Building space, trigonometry, Linear Programming, functions, SPLDV	Box Shapes, AR, Proglin application, other, SPLDV Calc	Saputra et al. (2020); Arifin et al. (2020); Arivina et al. (2020); Novaliyosi et al. (2021); Heni et al. (2021); Krisdiana et al. (2020); Sukendra et al. (2023); Sulistiawati et al. (2021)
4	STEM collaboration with other models (PBL and PjBL)	Others	other	Widana et al. (2021); Imaduddin et al. (2021)
5	STEM-based learning design for thinking skills	One Variable Linear Equations, SPLTV, Number Patterns	Cubes, Dynamo Cars; Flower petals, games	Rohimah et al. (2022); Pratiwi et al. (2023); Susanti & Haris (2020); Oktapiani et al. (2020)
6	STEM Article Analysis	Others	Others	Rahmawati & Juandi (2023); Ardwiyananti et al. (2021)

4. CONCLUSION

Based on the results and discussion explained above, it can be concluded that to achieve the goals of learning mathematics, you can use a STEM approach by integrating STEM with learning models and tools. The STEM (Science, Technology, Engineering, and Mathematics) approach can create a comfortable, active, student-centered learning atmosphere by using context to make learning more meaningful. Using a STEM approach to learning will help prepare students for 21st-century abilities and skills. In the learning process using the STEM approach, thinking abilities develop, such as creative thinking abilities, critical thinking abilities, reasoning, communication, spatial abilities, and learning outcomes.



It is hoped that the study in this article can become literature for other researchers as a first step in conducting further research related to the STEM approach to mathematics learning.

REFERENCES

- Amalina, I. K., & Vidakovich, T. (2022). An integrated STEM-based mathematical problem-solving test: Developing and reporting psychometric evidence. *Journal Mathematics Education*, 587-604.
- Amalina, I., & Vidákovich, T. (2022). Assessment in STEM problem-solving: A systematic review. *The International Journal of Assessment and Evaluation*, 29(2), 63.
- Aprilia, E., Pujiastuti, H., & Rafianti, I. (2021). Development of mathematics learning media using STEM approach to linear program materials. *Kreano, Jurnal Matematika Kreatif-Inovatif*, 12(1), 164-177. Retrieved from <https://journal.unnes.ac.id/nju/index.php/kreano/article/view/26268>
- Aprilia, E., Pujiastuti, H., & Rafianti, I. (2021). Development of mathematics learning media using STEM Approach to Linear Program Materials. *Kreano, Jurnal Matematika Kreatif-Inovatif*, 164-177.
- Ardwiyanti, D., Prasetyo, Z., & Wilujeng, I. (2021). STEM research trends in Indonesia: A systematic literature review. *Journal of Science Education Research*, 38-45. Retrieved from https://d1wqtxts1xzle7.cloudfront.net/110257748/41752-116687-1-PB-libre.pdf?1704851771=&response-content-disposition=inline%3B+filename%3DSTEM_research_trends_in_indonesia_A_syst.pdf&Expires=1709273885&Signature=IXYZ7eFUslERZ2igu5gtA5cnl05bgTXrGXHCU~aw44M
- Argianti, A., & Andayani, S. (2021). Keefektifan pendekatan STEM berbantuan wolfram alpha pada pembelajaran matematika ditinjau dari motivasi dan kemandirian belajar. *Jurnal Riset Pendidikan Matematika*, 8(2), 217-230. Retrieved from <https://journal.uny.ac.id/index.php/jrpm/article/view/35263/17275>
- Arifin, A. M., Pujiastuti, H., & Sudiana, R. (2020). Pengembangan media pembelajaran STEM dengan augmented reality untuk meningkatkan kemampuan spasial matematis siswa. *Jurnal Riset Pendidikan Matematika (JRPM)*, 7(1), 59-73. Retrieved from <https://journal.uny.ac.id/index.php/jrpm/article/view/32135/14528>
- Arivina, A. N. & Jailani. (2020). Development of trigonometry learning kit with a STEM approach to improve problem solving skills and learning achievement. *Jurnal Riset Pendidikan Matematika (JRPM)*, 7(2), 178-194. Retrieved from <https://journal.uny.ac.id/index.php/jrpm/article/view/35063/15003>
- Bybee, R. W. (2013). <https://docplayer.net/476748-K-12-stem-education-overview.html>. Arlington: National Science Teachers Association, NSTA Press.
- Calderón, A. & Ruiz, M. (2015). A systematic literature review on serious games evaluation. *Computers & Education*, 87, 396-422. doi:<https://doi.org/10.1016/j.compedu.2015.07.011>
- Imaduddin, M., Sholikhati, S., & In'ami, M. (2021). STEM education research in Indonesian Elementary Schools: A systematic review of project-based learning. *Elementary: Islamic Teacher Journal*, 9(2), 201-228. Retrieved from <https://journal.iainkudus.ac.id/index.php/elementary/article/view/11552>



- Irman A, W. S. (2020). Developing a STEM-based students' worksheet building material in elementary school Bandar Lampung City. *Jurnal Prima Edukasia*, 8(2), 145-155. Retrieved from <https://journal.uny.ac.id/index.php/jpe/article/view/33478/pdf>
- Komarudin, K., Suherman, S., & Anggraini, A. (2021). Analysis of mathematical concept understanding capabilities: The impact of maker space STEM learning approach models and student learning activities. *Journal of Innovation in Educational and Cultural Research*, 2(1), 35-43. Retrieved from <http://www.jiecr.org/index.php/jiecr/article/view/21>
- Krisdiana, I., Setyansah, R., & Pratiwi, I. (2020). Student worksheets with the SPLDV calc application to improve creative thinking abilities. *JPI (Jurnal Pendidikan Indonesia)*, 9(4), 686-692. doi:<https://doi.org/10.23887/jpi-undiksha.v9i4.19366>
- Kusyanto, Irwan, E., & Yazid, I. (2022). Implementasi pendekatan STEM untuk meningkatkan kemampuan berpikir kritis, berpikir kreatif dan self-efficacy. *Pasundan Journal of Mathematics Education: Jurnal Pendidikan Matematika*, 12(2). Retrieved from <https://www.journal.unpas.ac.id/index.php/pjme/article/view/5438/2525>
- Larson, L. C., & Miller, T. N. (2011). 21st century skills: Prepare students for the future. *Kappa Delta Pi Record*, 121-123. doi:<https://doi.org/10.1080/00228958.2011.10516575>
- Ma'rufi, M. I. (2023). Exploring mathematical technological knowledge of teachers with GeoGebra application. *Al-Jabar: Jurnal Pendidikan Matematika*, 14(1), 1-12. Retrieved from <http://ejournal.radenintan.ac.id/index.php/al-jabar/article/view/13654/6218>
- Munahefi, D. N., Kartono, Waluya, B., & Dwijanto, D. (2022). Analysis of self-regulated learning at each level of mathematical creative thinking skill. *Bolema*, 36(72), 580-601. DOI:10.1590/1980-4415v36n72a26
- Nesa, W., Hartono, Y., & Hiltrimartin, C. (2017). Pengembangan buku siswa materi jarak pada ruang dimensi tiga berbasis Science, Technology, Engineering, and Mathematics (STEM) problem-based learning di kelas X. *Jurnal Elemen*, 3(1), 1-14.
- Novaliyosi, Khaerunnisa, E., & Khasanah, M. (2021). Development of LKS with a STEM approach that supports the mathematical communication skills of SMP Students. *Kreano, Jurnal Matematika Kreatif-Inovatif*, 12(2), 200-211. Retrieved from <https://journal.unnes.ac.id/nju/index.php/kreano/article/view/29552>
- Oktapiani, N., & Hamdu, G. (2020). Desain pembelajaran STEM berdasarkan kemampuan 4C di sekolah dasar. *Elementary: Jurnal Ilmiah Pendidikan Dasar*, 7(2), 99-108. <http://dx.doi.org/10.30659/pendas.7.2.99-108>
- Pratiwi, A. N., Aisyah, N., Somakim, S., & Kamran, M. (2023). STEM-based approach: A learning design to improve critical thinking skills. *Al-Jabar: Jurnal Pendidikan Matematika*, 14(1), 225-237. Retrieved from <http://www.ejournal.radenintan.ac.id/index.php/al-jabar/article/view/18054>
- Rahmawati, L., Juandi, D., & Nurlaelah, E. (2023). A meta-analysis on the effectiveness of the stem approach on students' mathematical creative thinking ability. *Al-Jabar: Jurnal Pendidikan Matematika*, 14(1), 109-120. Retrieved from <http://ejournal.radenintan.ac.id/index.php/al-jabar/article/view/16637>
- Ramadhani, F. A., & Nurita, T. (2023). Implementation of STEM-integrated problem based learning to improve students' problem solving skills in liquid pressure. *Jurnal Pendidikan MIPA*, 349-358. doi:<http://dx.doi.org/10.23960/jpmipa/v24i1.pp349-358>



- Hanover Research. (2011, 10 -). *K-12 STEM education overview*. Retrieved 03 01, 2024, from Hanover Research: <https://docplayer.net/476748-K-12-stem-education-overview.html>
- Roberts, A. (2012). Applying STEM instructional strategies to design and technology curriculum. *Technology Education in the 21st Century, Proceeding of the PATT 26 Conference* (pp. 111-118). Stockholm: Linkoping University.
- Rohimah, S., Darhim, D., & Juandi, D. (2022). A local instructional theory (LIT) for teaching linear equation through STEM instruction. *Jurnal Elemen*, 8(2), 340-351.
- Saputra, R. A., Herpratiwi, H., & Caswita, C. (2020). Developing a STEM-based students' worksheet building material in. *Jurnal Prima Edukasia*, 8(2), 145-155. doi:doi:<https://doi.org/10.21831/jpe.v8i2.33478>
- Sari, A. F. & Juandi, D. (2022). Analysis of senior high school mathematics teachers' perception of the application of stem-based learning. *Kreano, Jurnal Matematika Kreatif-Inovatif*, 13(2), 296-307. Retrieved from <https://journal.unnes.ac.id/nju/kreano/article/view/36522>
- Sukendra, I., & Widana, I. (2023). Senior high school mathematics e-module based on STEM orienting to higher order thinking skills questions. *JPI (Jurnal Pendidikan Indonesia)*, 647-657. doi:<https://doi.org/10.23887/jpiundiksha.v12i4.61042>
- Sulistiawati, S., Juandi, D., & Yuliardi, R. (2021). Pembelajaran terintegrasi stem untuk meningkatkan literasi matematis mahasiswa calon guru matematika pada perkuliahan pra-kalkulus 1. *Teorema: Teori Dan Riset Matematika*, 6(1), 82-97. doi:<http://dx.doi.org/10.25157/teorema.v6i1.4727>
- Susanti, E., & Kurniawan, H. (2020). Design pembelajaran matematika dengan pendekatan STEAM (Science, Technology, Engineering, Mathematics). *AKSIOMA: Jurnal Matematika dan Pendidikan Matematika*, 11(1), 37-52. Retrieved from <https://journal.upgris.ac.id/index.php/aksioma/article/view/5292>
- Utomo, E. S., Rahman, F., & Fikrati, A. N. (2020). Eksplorasi penalaran logis calon guru matematika melalui pengintegrasian pendekatan stem dalam menyelesaikan soal. *Mosharafa*, 13-22.
- Widana, I., & Septiari, K. (2021). Kemampuan berpikir kreatif dan hasil belajar matematika siswa menggunakan model pembelajaran Project-Based Learning berbasis pendekatan STEM. *Jurnal Elemen*, 7(1), 209-220.
- Widya, Rifandi, R., & Rahmi, Y. L. (2019). STEM education to fulfil the 21st century demand: A literature review. *Journal of Physics: Conference Series*, 1317(1), 12208.