

Stem Education in Science Learning: Systematic Literature Review

Rudi Pranata¹, Syahril¹, Ruth Rize Paas Megahati S^{2*}

¹Education Administration Study Program, Universitas Negeri Padang, Padang, Indonesia

²Medical Laboratory Engineering Study Program, Politeknik Kesehatan Kesuma Bangsa, Bandar Lampung, Indonesia

Received: June 10, 2023

Revised: July 12, 2023

Accepted: August 25, 2023

Published: August 31, 2023

Corresponding Author:

Ruth Rize Paas Megahati S

megahatis23@gmail.com

DOI: [10.29303/jppipa.v9i8.4655](https://doi.org/10.29303/jppipa.v9i8.4655)

© 2023 The Authors. This open-access article is distributed under a (CC-BY License)



Abstract: As one of the efforts to produce Sumber Human Resources (HR) who have century competence 21st, a learning design is needed which integrates skills or 21st century skills. By including students are involved in remembering, understanding, apply, analyze, evaluate as well create both in scientific theory and at the time their daily life. A review is conducted on the state-of-the-art methods using the preferred reporting items for reviews and meta-analyses (PRISMA) guideline. We review literature from several publications and analyze STEM approach is a very appropriate approach to use in 21st century learning. After applying STEM approach, students are expected to be able mastering scientific and technological literacy. In learning there is a process of interaction between educators and students and learning resources in a learning environment to achieve learning goals. Learning is done using learning strategies in facilitating the teaching and learning process. So that the process can be carried out properly and conveyed correctly, STEM learning is carried out which can integrate knowledge, skills and values of science, technology, engineering, and mathematics to be able to solve a problem related to learning in the context of everyday life.

Keywords: Education; STEM education; strategies

Introduction

Education in Indonesia can guarantee the survival of a country and nation. Improving the quality of human resources must start from improving the quality of basic education. Education is something that is done consciously with a design in achieving educational goals, namely making quality human resources (Ali et al., 2020). Many things can be obtained through education such as adding insight (knowledge) and making a person more skilled in honing skills (hard and soft skills). So, it can also be said that education as training is given from an early age (Romero-Tena et al., 2020). The educational process in schools can be seen in terms of learning innovation.

Learning innovation is something new in certain social circumstances to solve problems in learning activities (Ovbiagbonhia et al., 2019). Doing an innovation must be done as a whole. When viewed from

all existing learning components, innovation can be started from learning which must include consideration of elements such as students, teachers, materials and materials, media, facilities and infrastructure, costs, and hidden curriculum (Mudiono, 2018). In addition, the learning process uses clear methods, media and learning resources. The choice of one particular teaching method will affect the appropriate type of learning media, although there are still various other aspects that must be considered in selecting media, including learning objectives, types of assignments and responses expected to be mastered by students. after learning takes place, and the context of learning including student characteristics.

The learning strategy is a very important factor in helping to increase student motivation in learning so that it is more active and interactive (Sutarto et al., 2020). This causes the strategy can't be separated from the learning process in the classroom. As a result of the

strategy in the learning process, the delivery of a material will be well received thereby increasing students' interest and desire to learn (Tong et al., 2022). Learning strategies are one of the causes of motivated students to achieve maximum learning outcomes (Wei et al., 2023). The learning strategy in its use can facilitate the teacher in carrying out the learning process in class compared to if the teacher still applies a monotonous learning strategy and only relies on the lecture method. Apart from teachers, students can also utilize learning strategies in the learning process in class, namely helping students understand the material and being able to achieve their learning achievements. There is a purposeful learning strategy to make it easier to acquire knowledge, and can give a new impression in the learning process so that students do not feel bored with the same learning activities from the past (Dwivedi et al., 2022).

To prepare a generation that is literate in science and technology, of course, learning is needed that can prepare a generation that is ready to work in the STEM field. The main goal of STEM is to grow the workforce in science, technology, engineering and mathematics, but it also aims to increase global competitiveness in science and technology or science and technology innovation. STEM learning is very important to implement because it is one of the 21st century learning.

In the 21st century, STEM and STEAM will become centers of in-demand learning (Stehle & Peters-Burton, 2019). Not only developed countries such as America, Japan, England, Australia, Korea and Germany, but also Vietnam, Thailand have implemented STEM and STEAM learning, with the hope that their young generation can compete in the global world who are reliable and professional in their fields. various fields, especially science and technology. The importance of STEAM integration has an impact on the world of work which is looking for graduates who have knowledge. The results of previous research, STEAM learning can increase cognitive knowledge, environment, converted thinking, creative thinking and have a positive attitude towards learning mathematics (Hsiao & Su, 2021), produce new technologies, improve learning outcomes (Bertrand & Namukasa, 2020), improve critical thinking, problem solving (Wilson et al., 2021), increase creativity

(Conradty et al., 2020). Based on the explanation above, a systematic literature review research was conducted which aims to determine stem education in science learning.

Method

We conducted this research as a systematic review by following the PRISMA guidelines. The PRISMA guidelines provide several items that need to be considered in preparing a systematic review. In this study, we will mainly focus on several key items: Education; STEM education; strategies. This helps form the basis of our assessment. Initially, we collected the latest studies on the exploration of thermophilic bacteria, based on a few selected keywords. Then, we apply eligibility criteria to the collection. We only selected literature published in 2017 or later to provide an overview of recent trends. In addition, we limit the types of literature, namely only literature in the form of journals and proceedings.

Result and Discussion

Preferred Reporting Items for Systematic Review (PRISMA) is the preferred reporting technique used in this study. The research was conducted methodically over the course of the necessary research stages. The information offered is thorough, and impartial, and attempts to combine pertinent study findings. The steps of a systematic review of the literature involve developing research questions, searching the literature, screening and choosing relevant articles, filtering and choosing the best research findings, analyzing, synthesizing qualitative findings, and composing a research report. Writing background and study objectives, gathering research questions, scanning the literature, choosing articles, extracting articles, evaluating the caliber of basic studies, and synthesizing data are all steps in the systematic literature review research process. Complete articles published in international journals from 2016-2023, indexed in databases, and themed STEM education in science learning.

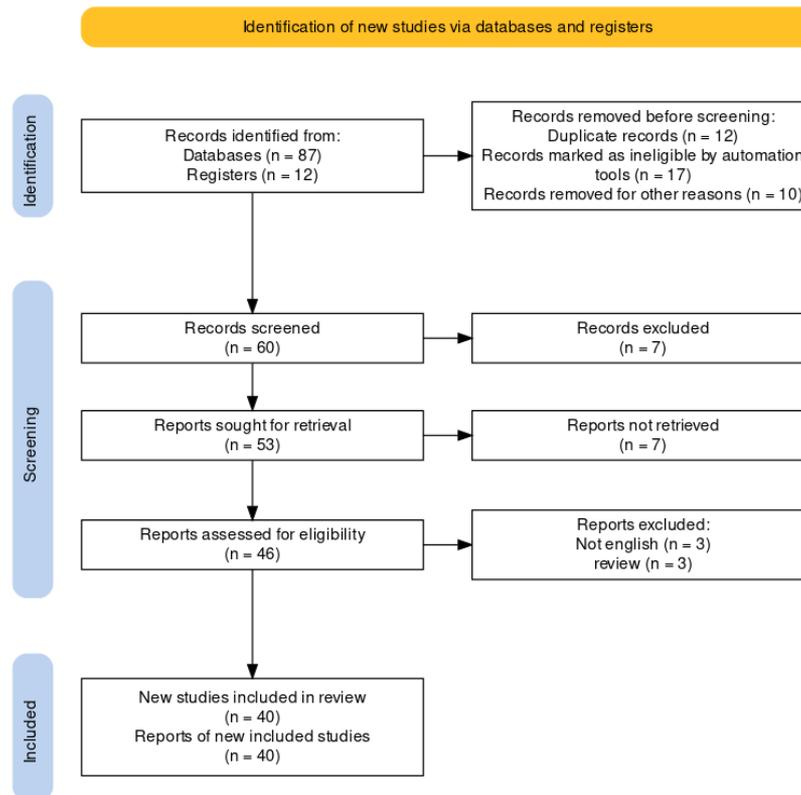


Figure 1. Flow process literatures search base on PRISMA guidelines

Table 1. Learning

Sources	Components in Learning
(Harris & Clayton, 2019); (Kintu et al., 2017); (Hailikari et al., 2022)	Learning objectives
(Erlia, 2021); (Luna & Selmer, 2021); (Keiler, 2018)	Teacher
(Firnando Sabetra et al., 2021); (Case, 2022); (Kumar & Sharma, 2021)	Students
(Abdulrahaman et al., 2020); (González-Pérez & Ramírez-Montoya, 2022); (Fernández-Río, 2016)	Materials
(Miranda et al., 2021); (Thomas et al., 2021); (Loeng, 2020)	Learning methods
(Sorojiti & Aini, 2021); (Dziuban et al., 2018); (Lin et al., 2017)	Instructional Media
(Swiecki et al., 2022); (Masih & Ariana, 2018); (Nugraha et al., 2018)	Evaluation

Learning is an activity that intentionally modifies various conditions directed at achieving a goal, namely achieving curriculum goals. Meanwhile, in daily life in schools, the term learning or the learning process is often understood to be the same as the teaching and learning process in which there is interaction between teachers and students and between fellow students to achieve a goal, namely changes in student attitudes and behavior. From the table above it can be explained that the components in learning consist of objectives in learning which are important components that must be determined in the learning process which has a function as a benchmark for learning success. Teachers have teaching authority based on qualifications as teaching staff and have professional abilities in the process. learning. student is someone who acts as a seeker, receiver and store of lesson content so it is necessary to

get guidance from the teacher through the teaching and learning process at school, subject matter is all lesson material provided by the teacher to students in the teaching and learning process in order to achieve learning objectives.

Learning methods is one of the methods used by the teacher in establishing relationships with students during learning to achieve the goals set, learning media is anything that can be used in teaching and learning activities to convey teaching messages from the teacher to students so that they can stimulate the mind, feelings, concerns, interests, and students' attention in learning, evaluation is an assessing activity carried out by the teacher to determine the level of student success in a planned, systematic, and directed way based on predetermined goals.

Table 2. Learning strategies

Sources	Types of Learning Strategies
(Syamsu Nahar, 2022); (Fauqi, 2022); (Martin, 2019)	Expository
(Miftahul Jannah et al., 2020); (Rafida & Idayani, 2021); (Suárez et al., 2018)	Inquiry
(Silva et al., 2018); (Ahmad et al., 2020); (Chang et al., 2022)	Problem Based
(Herlina, 2022); (Bećirović et al., 2022); (Fatima et al., 2022)	Cooperative
(Biwer et al., 2020); (Rea et al., 2022); (Nguyen et al., 2021)	Affective
(Jayanti & Rozimela, 2022); (Huang, 2018); (Glogger-Frey et al., 2018)	Contextual

Learning strategies are methods that will be used by teachers to choose learning activities that will be used during the learning process. The types of learning strategies are learning strategies Expository is a learning strategy that emphasizes the process of delivering material verbally from a teacher to a group of students with the intention that students can master the subject matter optimally, Inquiry learning strategy is an Inquiry learning strategy, Problem-based Learning Strategy is one of the learning strategies used by teachers in the process of learning activities by using problems as a step to gather knowledge, so as to stimulate students to think critically and learn individually or in small groups to find solutions to these problems.

Cooperative learning strategies are those that place students in small groups whose members are heterogeneous, consisting of students with high, medium, and low achievements, women and men with different ethnic backgrounds to help each other and work together to study the subject matter so that all members learn optimally, Affective learning strategies generally expose students to situations that contain conflict or problematic situation. Through this situation, students are expected to be able to make decisions based on values they consider good, and the last is a contextual learning strategy which is a learning strategy that shows where each learner has the main role and function as the main actor in learning activities.

Table 3. STEM

Sources	STEM Disciplines
(Park et al., 2020); (Dare et al., 2021); (Amirtham & Kumar, 2023)	Science
(Mpopu, 2020); (Johnston et al., 2019); (Felder, 2021)	Technology
(Naukkarinen & Bairoh, 2020); (Finnie & Childs, 2018); (Kulakoglu & Kondakci, 2023)	Engineering
(May et al., 2022); (Kajonmanee et al., 2020); (Tan et al., 2019); (Kocabas et al., 2019)	Mathematic

There are several disciplines in STEM, namely Science, which is the Ability to use scientific knowledge in understanding the natural world as well as the ability to participate in taking decision to influence it, Technology is Knowledge how to use new technology how technology newly developed, and have ability to how technology just affects the individual, society, nation and state. next is Engineering is the Understanding of how technology can be developed through engineering process using project-based lesson themes with how to integrate from several subjects. the last is Mathematical which is the ability to analyze reasoning and communicating ideas effectively and from the way of behaving, formulate, and interpret solutions for deep math problems apply to different situations.

Conclusion

In learning there is a process of interaction between educators and students and learning resources in a learning environment to achieve learning goals.

Learning is done using learning strategies in facilitating the teaching and learning process. So that the process can be carried out properly and conveyed correctly, STEM learning is carried out which can integrate knowledge, skills and values of science, technology, engineering, and mathematics to be able to solve a problem related to learning in the context of everyday life.

Acknowledgments

Thanks to all parties who have supported the implementation of this research. I hope this research can be useful.

Author Contributions

Conceptualization, R. R. P. M. S., R. P; methodology, S. S; validation, R. R. P. M. S and S. S.; formal analysis, S. S.; investigation, R. P and S. S.; resources, R.R.P.M.S and S.S; data curation, R.P.: writing – original draft preparation, R.P. and S. S.; writing – review and editing, R.R.P.M.S.: visualization, R.P and S.S.; supervision,; project administration, Y. S. All authors have read and agreed to the published version of the manuscript.

Funding

This research was independently funded by researchers.

Conflicts of Interest

The authors declare no conflict of interest.

References

- Abdulrahman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V., Imam-Fulani, Y. O., Fahm, A. O., & Azeez, A. L. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon*, 6(11), e05312. <https://doi.org/10.1016/j.heliyon.2020.e05312>
- Ahmad, K., Nurkhin, A., Muhsin, M., & Pramusinto, H. (2020). Problem-Based Learning Strategy: Its Impact on Students' Critical and Creative Thinking Skills. *European Journal of Educational Research*, 9(3), 1141-1150. <https://doi.org/10.12973/eurjer.9.3.1141>
- Ali, E. Y., Munir, M., Permana, J., & Kurniady, D. A. (2020). Academic Service Quality in Education Management in Higher Education. *Proceedings of the 3rd International Conference on Research of Educational Administration and Management (ICREAM 2019)*, 455-461. <https://doi.org/10.2991/assehr.k.200130.221>
- Amirtham S, N., & Kumar, A. (2023). The underrepresentation of women in STEM disciplines in India: A secondary analysis. *International Journal of Science Education*, 1-24. <https://doi.org/10.1080/09500693.2023.2179901>
- Bećirović, S., Dubravac, V., & Brdarević-Čeljo, A. (2022). Cooperative Learning as a Pathway to Strengthening Motivation and Improving Achievement in an EFL Classroom. *SAGE Open*, 12(1), 215824402210780. <https://doi.org/10.1177/21582440221078016>
- Bertrand, M. G., & Namukasa, I. K. (2020). STEAM education: Student learning and transferable skills. *Journal of Research in Innovative Teaching & Learning*, 13(1), 43-56. <https://doi.org/10.1108/JRIT-01-2020-0003>
- Biwer, F., Egbrink, M. G. A. O., Aalten, P., & De Bruin, A. B. H. (2020). Fostering effective learning strategies in higher education—A mixed-methods study. *Journal of Applied Research in Memory and Cognition*, 9(2), 186-203. <https://doi.org/10.1016/j.jarmac.2020.03.004>
- Case, A. S. (2022). The Role of Teachable Ownership of Learning Components in College Adjustment. *Journal of Student Affairs Research and Practice*, 59(2), 180-195. <https://doi.org/10.1080/19496591.2020.1825459>
- Chang, Y.-H., Yan, Y.-C., & Lu, Y.-T. (2022). Effects of Combining Different Collaborative Learning Strategies with Problem-Based Learning in a Flipped Classroom on Program Language Learning. *Sustainability*, 14(9), 5282. <https://doi.org/10.3390/su14095282>
- Conradty, C., Sotiriou, S. A., & Bogner, F. X. (2020). How Creativity in STEAM Modules Intervenes with Self-Efficacy and Motivation. *Education Sciences*, 10(3), 70. <https://doi.org/10.3390/educsci10030070>
- Dare, E. A., Keratithamkul, K., Hiwatig, B. M., & Li, F. (2021). Beyond Content: The Role of STEM Disciplines, Real-World Problems, 21st Century Skills, and STEM Careers within Science Teachers' Conceptions of Integrated STEM Education. *Education Sciences*, 11(11), 737. <https://doi.org/10.3390/educsci11110737>
- Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., Dennehy, D., Metri, B., Buhalis, D., Cheung, C. M. K., Conboy, K., Doyle, R., Dubey, R., Dutot, V., Felix, R., Goyal, D. P., Gustafsson, A., Hinsch, C., Jebabli, I., ... Wamba, S. F. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, 66, 102542. <https://doi.org/10.1016/j.ijinfomgt.2022.102542>
- Dziuban, C., Graham, C. R., Moskal, P. D., Norberg, A., & Sicilia, N. (2018). Blended learning: The new normal and emerging technologies. *International Journal of Educational Technology in Higher Education*, 15(1), 3. <https://doi.org/10.1186/s41239-017-0087-5>
- Erlia, W. (2021). Roles of the teacher for increasing learning quality of students. *ETUDE: Journal of Educational Research*, 1(3), 77-86. <https://doi.org/10.56724/etude.v1i3.35>
- Fatima, H. G., Akbar, H., Khan, B. S., Amin, H., & Anjum, M. A. (2022). Cooperative Learning As An Innovative Method In Teaching Science At Elementary Level. *Journal of Positive School Psychology*, 879-889. Retrieved from <https://journalppw.com/index.php/jpsp/article/view/14795>
- Fauqi, I. F. (2022). Teacher Strategies in Online Learning due to Pandemic: A Literature Review. *SUJANA (Education and Learning Review)*, 1(1), 13-27. Retrieved from <https://journal.jfpublisher.com/index.php/sujana/article/view/182>
- Felder, R. M. (2021). STEM education: A tale of two paradigms. *Journal of Food Science Education*, 20(1), 8-15. <https://doi.org/10.1111/1541-4329.12219>

- Fernández-Río, J. (2016). Student-teacher-content-context: Indissoluble Ingredients in the Teaching-learning Process. *Journal of Physical Education, Recreation & Dance*, 87(1), 3–5. <https://doi.org/10.1080/07303084.2016.1110476>
- Finnie, R., & Childs, S. (2018). Who Goes into STEM Disciplines? Evidence from the Youth in Transition Survey. *Canadian Public Policy*, 1–13. <https://doi.org/10.3138/cpp.2017-077>
- Firnando Sabetra, Ambiyar, & Ishak Aziz. (2021). The Component of Lesson Plan on Classroom Management. *International Journal of Humanities Education and Social Sciences (IJHESS)*, 1(3). <https://doi.org/10.55227/ijhess.v1i3.72>
- Glogger-Frey, I., Ampatziadis, Y., Ohst, A., & Renkl, A. (2018). Future teachers' knowledge about learning strategies: Misconcepts and knowledge-in-pieces. *Thinking Skills and Creativity*, 28, 41–55. <https://doi.org/10.1016/j.tsc.2018.02.001>
- González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of Education 4.0 in 21st Century Skills Frameworks: Systematic Review. *Sustainability*, 14(3), 1493. <https://doi.org/10.3390/su14031493>
- Hailikari, T., Virtanen, V., Vesalainen, M., & Postareff, L. (2022). Student perspectives on how different elements of constructive alignment support active learning. *Active Learning in Higher Education*, 23(3), 217–231. <https://doi.org/10.1177/1469787421989160>
- Harris, R., & Clayton, B. (2019). The current emphasis on learning outcomes. *International Journal of Training Research*, 17(2), 93–97. <https://doi.org/10.1080/14480220.2019.1644777>
- Herlina, E. (2022). Implementation Of Cooperative Learning Methods In Improving Reading Comprehension. *SIGEH ELT: Journal of Literature and Linguistics*, 2(2), 117–124. <https://doi.org/10.36269/sigeh.v2i2.1143>
- Hsiao, P.-W., & Su, C.-H. (2021). A Study on the Impact of STEAM Education for Sustainable Development Courses and Its Effects on Student Motivation and Learning. *Sustainability*, 13(7), 3772. <https://doi.org/10.3390/su13073772>
- Huang, S. C. (2018). Language learning strategies in context. *The Language Learning Journal*, 46(5), 647–659. <https://doi.org/10.1080/09571736.2016.1186723>
- Jayanti, G. S., & Rozimela, Y. (2022). Using Contextual Teaching and Learning (CTL) Strategy to Improve Students' Writing Skill. In *67th TEFLIN International Virtual Conference & the 9th ICOELT 2021 (TEFLIN ICOELT 2021)*, 110–114. <https://doi.org/10.2991/assehr.k.220201.020>
- Johnston, A. C., Akarsu, M., Moore, T. J., & Guzey, S. S. (2019). Engineering as the integrator: A case study of one middle school science teacher's talk. *Journal of Engineering Education*, 108(3), 418–440. <https://doi.org/10.1002/jee.20286>
- Kajonmanee, T., Chaipidech, P., Srisawasdi, N., & Chaipah, K. (2020). A personalised mobile learning system for promoting STEM discipline teachers' TPACK development. *International Journal of Mobile Learning and Organisation*, 14(2), 215. <https://doi.org/10.1504/IJMLO.2020.106186>
- Keiler, L. S. (2018). Teachers' roles and identities in student-centered classrooms. *International Journal of STEM Education*, 5(1), 34. <https://doi.org/10.1186/s40594-018-0131-6>
- Kintu, M. J., Zhu, C., & Kagambe, E. (2017). Blended learning effectiveness: The relationship between student characteristics, design features and outcomes. *International Journal of Educational Technology in Higher Education*, 14(1), 7. <https://doi.org/10.1186/s41239-017-0043-4>
- Kocabas, S., Ozfidan, B., & Burlbaw, L. M. (2019). American STEM Education in Its Global, National, and Linguistic Contexts. *EURASIA Journal of Mathematics, Science and Technology Education*, 16(1). <https://doi.org/10.29333/ejmste/108618>
- Kulakoglu, B., & Kondakci, Y. (2023). STEM Education as a Concept Borrowing Issue: Perspectives of School Administrators in Turkey. *ECNU Review of Education*, 6(1), 84–104. <https://doi.org/10.1177/20965311221107390>
- Kumar, V., & Sharma, D. (2021). E-Learning Theories, Components, and Cloud Computing-Based Learning Platforms. *International Journal of Web-Based Learning and Teaching Technologies*, 16(3), 1–16. <https://doi.org/10.4018/IJWLTT.20210501.0a1>
- Lin, M.-H., Chen, H.-C., & Liu, K.-S. (2017). A Study of the Effects of Digital Learning on Learning Motivation and Learning Outcome. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(7), 3553–3564. <https://doi.org/10.12973/eurasia.2017.00744a>
- Loeng, S. (2020). Self-Directed Learning: A Core Concept in Adult Education. *Education Research International*, 2020, 1–12. <https://doi.org/10.1155/2020/3816132>
- Luna, M., & Selmer, S. (2021). Examining the Responding Component of Teacher Noticing: A Case of One Teacher's Pedagogical Responses to Students' Thinking in Classroom Artifacts. *Journal of Teacher Education*, 72(5), 579–593. <https://doi.org/10.1177/00224871211015980>
- Martin, N. M. (2019). Processing Different Kinds of Expository Text: An Investigation of Students' Strategy Use in Postsecondary Education. *Journal of*

- College Reading and Learning*, 49(1), 3–18. <https://doi.org/10.1080/10790195.2018.1472944>
- Masih, N. K., & Ariana, I. M. (2018). Industries' Assessment of Student Learning Outcomes. In *International Conference on Social Sciences (ICSS 2018)*, 226(1), 530-533. <https://doi.org/10.2991/icss-18.2018.109>
- May, B. K., Wendt, J. L., & Barthlow, M. J. (2022). A comparison of students' interest in STEM across science standard types. *Social Sciences & Humanities Open*, 6(1), 100287. <https://doi.org/10.1016/j.ssaho.2022.100287>
- Miftahul Jannah, Z. A. Imam Supardi, & Prabowo. (2020). Guided Inquiry Model with the REACT Strategy Learning Materials to Improve the Students' Learning Achievement. *IJORER: International Journal of Recent Educational Research*, 1(2), 156-168. <https://doi.org/10.46245/ijorer.v1i2.45>
- Miranda, J., Navarrete, C., Noguez, J., Molina-Espinosa, J.-M., Ramírez-Montoya, M.-S., Navarro-Tuch, S. A., Bustamante-Bello, M.-R., Rosas-Fernández, J.-B., & Molina, A. (2021). The core components of education 4.0 in higher education: Three case studies in engineering education. *Computers & Electrical Engineering*, 93, 107278. <https://doi.org/10.1016/j.compeleceng.2021.107278>
- Mpofu, V. (2020). *A Theoretical Framework for Implementing STEM Education*. In *Theorizing STEM Education in the 21st Century*, IntechOpen. <https://doi.org/10.5772/intechopen.88304>
- Mudiono, A. (2018). Developing Innovative and Interactive Learning in Elementary School. *Proceedings of the 1st International Conference on Early Childhood and Primary Education (ECPE 2018)*, 7-11. <https://doi.org/10.2991/ecpe-18.2018.2>
- Naukkarinen, J. K., & Bairoh, S. (2020). STEM: A help or a hinderance in attracting more girls to engineering? *Journal of Engineering Education*, 109(2), 177-193. <https://doi.org/10.1002/jee.20320>
- Nguyen, K. A., Borrego, M., Finelli, C. J., DeMonbrun, M., Crockett, C., Tharayil, S., Shekhar, P., Waters, C., & Rosenberg, R. (2021). Instructor strategies to aid implementation of active learning: A systematic literature review. *International Journal of STEM Education*, 8(1), 9. <https://doi.org/10.1186/s40594-021-00270-7>
- Nugraha, S. T., Suwandi, S., Nurkamto, J., & Saddhono, K. (2018). The Importance of Needs Assessment for the Implementation of E-Learning in a Language Program. *KnE Social Sciences*, 3(9), 254. <https://doi.org/10.18502/kss.v3i9.2686>
- Ovbiagbonhia, A. R., Kollöffel, B., & Brok, P. D. (2019). Educating for innovation: Students' perceptions of the learning environment and of their own innovation competence. *Learning Environments Research*, 22(3), 387-407. <https://doi.org/10.1007/s10984-019-09280-3>
- Park, W., Wu, J.-Y., & Erduran, S. (2020). The Nature of STEM Disciplines in the Science Education Standards Documents from the USA, Korea and Taiwan: Focusing on Disciplinary Aims, Values and Practices. *Science & Education*, 29(4), 899-927. <https://doi.org/10.1007/s11191-020-00139-1>
- Rafida, T., & Idayani, E. (2021). The Influence of Guided Inquiry Learning Strategies and Learning Motivation on the Outcomes of Islamic Education Learning in SMP Negeri 2 Bireuen. *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences*, 4(2), 1945-1952. <https://doi.org/10.33258/birci.v4i2.1881>
- Rea, S. D., Wang, L., Muenks, K., & Yan, V. X. (2022). Students Can (Mostly) Recognize Effective Learning, So Why Do They Not Do It? *Journal of Intelligence*, 10(4), 127. <https://doi.org/10.3390/jintelligence10040127>
- Romero-Tena, R., Barragán-Sánchez, R., Llorente-Cejudo, C., & Palacios-Rodríguez, A. (2020). The Challenge of Initial Training for Early Childhood Teachers. A Cross Sectional Study of Their Digital Competences. *Sustainability*, 12(11), 4782. <https://doi.org/10.3390/su12114782>
- Silva, A. B. D., Bispo, A. C. K. D. A., Rodriguez, D. G., & Vasquez, F. I. F. (2018). Problem-based learning: A proposal for structuring PBL and its implications for learning among students in an undergraduate management degree program. *Revista de Gestão*, 25(2), 160-177. <https://doi.org/10.1108/REGE-03-2018-030>
- Sorohiti, M., & Aini, E. N. (2021). Grammar Teaching Materials: What Makes Them Interesting?: *Proceedings of the 4th International Conference on Sustainable Innovation 2020-Social, Humanity, and Education (ICoSIHESS 2020)*, 270-277. <https://doi.org/10.2991/assehr.k.210120.135>
- Stehle, S. M., & Peters-Burton, E. E. (2019). Developing student 21st Century skills in selected exemplary inclusive STEM high schools. *International Journal of STEM Education*, 6(1), 39. <https://doi.org/10.1186/s40594-019-0192-1>
- Suárez, Á., Specht, M., Prinsen, F., Kalz, M., & Ternier, S. (2018). A review of the types of mobile activities in mobile inquiry-based learning. *Computers & Education*, 118, 38-55. <https://doi.org/10.1016/j.compedu.2017.11.004>
- Sutarto, S., Sari, D. P., & Fathurrochman, I. (2020). Teacher strategies in online learning to increase

- students' interest in learning during COVID-19 pandemic. *Jurnal Konseling Dan Pendidikan*, 8(3), 129. <https://doi.org/10.29210/147800>
- Swiecki, Z., Khosravi, H., Chen, G., Martinez-Maldonado, R., Lodge, J. M., Milligan, S., Selwyn, N., & Gašević, D. (2022). Assessment in the age of artificial intelligence. *Computers and Education: Artificial Intelligence*, 3, 100075. <https://doi.org/10.1016/j.caeai.2022.100075>
- Syamsu Nahar, S., Candra Wijaya. (2022). The Influence of Learning Strategies For Concept Maps And Thinking Styles On The Learning Outcomes Of Islamic Religious Education And Ethics. *International Journal of Islamic Education, Research and Multiculturalism (IJIERM)*, 3(3), 216–235. <https://doi.org/10.47006/ijierm.v3i3.123>
- Tan, A.-L., Teo, T. W., Choy, B. H., & Ong, Y. S. (2019). The S-T-E-M Quartet. *Innovation and Education*, 1(1), 3. <https://doi.org/10.1186/s42862-019-0005-x>
- Thomas, N., Bowen, N. E. J. A., Reynolds, B. L., Osment, C., Pun, J. K. H., & Mikolajewska, A. (2021). A Systematic Review of the Core Components of Language Learning Strategy Research in Taiwan. *English Teaching & Learning*, 45(3), 355–374. <https://doi.org/10.1007/s42321-021-00095-1>
- Tong, D. H., Uyen, B. P., & Ngan, L. K. (2022). The effectiveness of blended learning on students' academic achievement, self-study skills and learning attitudes: A quasi-experiment study in teaching the conventions for coordinates in the plane. *Heliyon*, 8(12), e12657. <https://doi.org/10.1016/j.heliyon.2022.e12657>
- Wei, X., Saab, N., & Admiraal, W. (2023). Do learners share the same perceived learning outcomes in MOOCs? Identifying the role of motivation, perceived learning support, learning engagement, and self-regulated learning strategies. *The Internet and Higher Education*, 56, 100880. <https://doi.org/10.1016/j.iheduc.2022.100880>
- Wilson, H. E., Song, H., Johnson, J., Presley, L., & Olson, K. (2021). Effects of transdisciplinary STEAM lessons on student critical and creative thinking. *The Journal of Educational Research*, 114(5), 445–457. <https://doi.org/10.1080/00220671.2021.1975090>