



Meta-analysis Study: Effect of Problem Solving Learning Model on Problem Solving Ability in Students' Science Learning SMP-SMA

Yayat Suharyat^{1*}, Linda Winiasri², Tomi Apra Santosa³, Abdul Rahman⁴, Kartini Marzuki⁵

¹ Islamic Religious Education, Islamic University 45 Bekasi, Bekasi, Indonesia.

² Politeknik Penerbangan Surabaya, Surabaya, Indonesia.

³ Biologi Education, Padang State University, Padang, Indonesia.

⁴ Science Education, FKIP, Universitas Sebelas Maret, Semarang, Indonesia.

⁵ Non Formal Education, FIP, Makassar State University, Makassar, Indonesia.

Received: January 1, 2023

Revised: July 13, 2023

Accepted: September 25, 2023

Published: September 30, 2023

Corresponding Author:

Yayat Suharyat

yayat_suharyat@unisma.ac.id

DOI: [10.29303/jppipa.v9i9.2791](https://doi.org/10.29303/jppipa.v9i9.2791)

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



Abstract: In the era of the industrial revolution 4.0, the education system has used technology to assist the learning process. Technology-based learning makes it easy for students and teachers to carry out learning activities. However, teachers have not been able to optimally develop students' potential, low student learning outcomes and low problem-solving abilities in students. Problem solving ability is very important for a student in learning science. Problem-solving skills in science learning are the main key to training students' scientific thinking in solving phenomena in science. So, it is necessary for a teacher to improve the learning model for those who are able to develop students' problem solving abilities. Problem solving learning is a learning model based on problem solving. In addition, the problem solving learning model helps teachers to be more creative in carrying out the teaching and learning process. This study aims to analyze the effect of problem solving learning models on students' problem solving abilities in science learning. The data source for this research comes from an analysis of 30 national or international journals that have been published from 2010-2022. The search for data sources came from the Google Scholar, ScienceDirect, Emerald, Eric, Springer, Hindawi, ProQuest, Sage Journal, Wiley and Taylor of Francis databases. Sampling in this study was carried out by using purposive sampling technique. The data that can be used is related to the research variable. Furthermore, the research data search keywords are problem solving learning models, problem solving skills and science learning. Data analysis is a descriptive quantitative analysis technique with the help of the OpenMEE application. The results of the study concluded that the problem solving learning model had a significant influence on students' problem solving abilities in science learning with an effect size of 1.808, an average value of 83 and a standard deviation of 0.45

Keywords: Learning; Problem solving; Problem solving sbility; Science

Introduction

The 21st century has had a huge influence on the progress of the world of education (Zorlu & Zorlu, 2021; Osman & Marimuthu, 2010; Güven & Alpaslan, 2022). Education has used technology as an aid to the learning process. In this 21st century learning, teachers must have hard skills and soft skills in developing students' potential (Semilariski et al., 2021). Furthermore, students are also trained to develop 21st century skills which

consist of critical thinking, creative, collaborative and communication skills (Taar & Palojoki, 2022; Turhan & Demirci, 2021; Kara et al., 2022; Guo & Woulfin, 2016). These skills are needed by students in solving various phenomena that occur in life (Satria, 2018).

Teachers are educational staff who have a major role in training and developing students' knowledge in learning (Rizaldi et al., 2020). In the 2013 curriculum a teacher has applied 21st century learning. 21st century learning students must have the ability to think

How to Cite:

Suharyat, Y., Winiasri, L., Santosa, T. A., Rahman, A., & Marzuki, K. (2023). Meta-analysis Study: Effect of Problem Solving Learning Model on Problem Solving Ability in Students' Science Learning SMP-SMA. *Jurnal Penelitian Pendidikan IPA*, 9(9), 721-728. <https://doi.org/10.29303/jppipa.v9i9.2791>

scientifically (Yusuf et al., 2020). The ability to think scientifically functions to solve problems that occur in the learning process (Grushka et al., 2018; Hernández-Fernández, 2022; Ravinder et al., 2021). Science learning is one of the subjects that is still difficult for most students to understand in Indonesia (Matsun et al., 2021). In addition, students' problem-solving skills in science learning are low (Andika et al., 2020).

Science learning is a compulsory subject in schools that guides a student for scientific work (Lee et al., 2011; Ahmed, 2022). Furthermore, in learning science students must be able to apply the knowledge gained in everyday life (Hujatulatif et al., 2022). However, learning science is a subject that is still difficult for most students (Rahayu et al., 2012). Furthermore, Research by (Adiwiguna et al., 2019) states that 78% of students in Indonesia are only able to work on low category questions. Not only that, the results of the Indonesian PISA (Proram for International Student Assessment) study show that the level of learning science for Indonesian students is still relatively low with a score below 500 (Suhaimi et al., 2022; Ichsan et al., 2022). So, it is necessary to have a teacher's efforts to improve the quality of learning by improving the learning model (Santosa et al., 2021).

The problem solving learning model is a learning model that is able to increase the effectiveness of students in problem solving (Holder et al., 2017; Parwati et al., 2018; Kern, 2002). Student problem solving learning models can solve problems, discuss problems, and are able to provide solutions to any problems given by the teacher in the teaching and learning process (Hodiyanto, 2017). In addition, the problem solving learning model has five stages which consist of defining the problem, diagnosing the problem, formulating alternative strategies, determining and implementing the chosen strategy, and evaluating the problem (Turnip et al., 2016; Tampubolon & Sitindaon, 2013; Surya et al., 2017).

Research by Putri et al. (2018) stated that the problem-solving learning model was able to improve conceptual understanding and motivation to learn the rest in science learning. Research by Kopparla et al. (2019) states that the problem solving learning model can improve the solving abilities of elementary school students. Furthermore, research by Muhammad (2015) states that the problem solving learning model has a positive influence on students' problem solving abilities in students' mathematics learning. According to Gunawan et al. (2020) problem solving models are able to encourage students' critical thinking skills in science learning. Based on the problems above, this study aims to analyze the effect of problem solving learning models on problem solving abilities in science learning for junior high school students.

Method

Research is a type of quantitative research with meta-analysis method. Meta-analysis research is a type of research that conducts a literature search that can be analyzed statistically (Santosa et al., 2021). The source of the data in this study came from an analysis of 30 national and international journals published in 2010-2022. The data search process was through Google Scholar, ScienceDirect, Emerald, Eric, Springer, Hindawi, ProQuest, Sage Journal, Wiley and Taylor of Francis. Data selection was carried out systematically and thoroughly. Data collection techniques in research are observation by observing the research components to be studied.

The sampling technique is a purposive sampling technique. The sample used for this research data must have a relationship with the research variable. The keywords used in the data search were problem solving learning models, problem solving abilities and science learning. The data analysis technique in this study is descriptive quantitative data analysis by calculating the Effect size, Mean and Standard Deviation values with the help of the OpenMEE application. The effect size criteria can be seen in table 1.

Table 1. Effect Size Criteria (Suparman et al., 2021; Oktarina et al., 2021)

Effect Size	Criteria
$0.00 \leq ES \leq 0.20$	Ignored
$0.20 \leq ES \leq 0.50$	Small
$0.50 \leq ES \leq 0.80$	Currently
$0.80 \leq ES \leq 1.30$	Tall
$1.30 \leq ES$	Very High

Furthermore, statistical analysis in this study was carried out by calculating the effect size of each study and the combined effect size; Perform heterogeneity tests and choose an estimation model; carry out publication bias checks and calculate P values with the aim of testing the research hypotheses analyzed with the help of Comprehensive Meta-Analysis (CMA) 3.0 software.

Result and Discussion

Result

Results should be clear and From the results of an analysis of 125 national and international journals about the influence of problem solving learning models on problem solving abilities in science learning for high school-junior high school students. However, the results of the study based on the criteria contained 27 articles analyzed can be seen in the table 2.

Table 2. Analysis of 27 National and International Journal Articles

Author	Hedge's	Criteria
(Sari et al., 2021)	0.325	Low
(Huang et al., 2020)	1.430	Very Hight
(Cooper et al., 2008)	0.781	Medium
(Khoiriyah & Husamah, 2018)	2.140	Very Hight
(Alfin et al., 2019)	-0.302	ignored
(Sarican & Akgunduz, 2018)	0.457	Low
(Fuad et al., 2019)	0.892	Hight
(Argaw et al., 2017)	3.210	Very Hight
(Kinay & Bagceci, 2016)	-0.180	ignored
(Frerejean et al., 2018)	0.741	Medium
(Musna et al., 2021)	1.20	Hight
(Urena et al., 2012)	2.051	Very Hight
(Hong & Diamond, 2012)	-0.285	ignored
(Klegeris & Hurren, 2011)	2.654	Very Hight
(Senar, 2014)	2.780	Very Hight
(Subali et al., 2017)	0.451	Low
(Purwaningsih et al., 2020)	1.320	Very Hight
(Abtokhi et al., 2021)	0.910	Hight
(Ahghar, 2012)	-0.650	ignored
(Batlolona et al., 2018)	1.070	Hight
(Haenilah et al., 2021)	0.651	Medium
(Yuberti et al., 2019)	3,150	Very Hight
(Yuberti et al., 2019)	0.120	Ignored
(Lin et al., 2021)	1.421	Very Hight
(Binar et al., 2020)	0.912	Hight
(Serin et al., 2009)	-0.631	ignored
(Cavallo, 2011)	0.450	Low
Average Effect Size	1.808	Very Hight

Based on table 2 explains the analysis of 27 national and international journals regarding the effect of problem solving models on problem solving abilities in science learning with an average effect size of 1,808 very high criteria. This shows that the problem solving learning model has a significant influence on problem solving abilities in science learning. Furthermore, a publication bias test was carried out which can be seen in Table 3.

Table 3. Publication Bias Test with Trim and Fill Test

	Random Effect Size				Q-Value
	Omitted Studies	Point estimate	Lower limit	Upper limit	
Observed Value	4	0.674	0.780	1.756	114.901
Adjusted Value		0.561	0.420	1.045	125.90

Based on table 3, it shows the results of the publication bias test, the effect size observed value is 0.674 and the adjusted value is 0.561. Furthermore, the heterogeneity test of the effect size distribution was carried out. The results of the heterogeneity test can be seen in table 4.

Table 4. Heterogeneity Test for Effect Size

Heterogeneity				
Q-Value	df (Q)	P-value	I-squared	Q-Table
31.00	19	0.000	87.087	22.10

Based on table 4, the results of the heterogeneity test for the influence of the effect size of the problem solving learning model on problem solving abilities in science learning is 22.10. This explains that the heterogeneity of the effect size distribution influences the problem solving model used in this study, which is the random effect model. Furthermore, to see the effectiveness of the problem solving learning model on problem solving abilities in science learning, the N-Gain test was carried out. The results of the N-Gain test can be seen in table 5.

Table 5. N-gain Test of the Effectiveness of the Problem Solving Model > Problem Solving Ability

Class	Pretest	Postest	Mean	SD	N-gain
Exsperiment	60	90	83	0.45	0.72
Control	50	75			

Based on table 5, the results of the N-gain test of the problem solving model on problem solving abilities are 0.72. Not only that, the problem solving model was able to increase student learning outcomes by 83. This shows that the problem solving learning model is effective in encouraging problem solving skills in science learning for junior high school students. So, a teacher must apply the problem solving learning model in carrying out the teaching and learning process, especially in science subjects.

Discussion

The problem solving learning model is a learning model that can improve problem solving abilities in science learning for junior high school students. This can be seen from the results of the effect size of 1,808 very high criteria. So, the problem solving model has a significant influence on the problem solving abilities of students in junior and senior high schools. This is in line with research by Fülöp (2021) stated that the problem solving model had an influence on students' ability to solve a problem in the learning process. In addition, the problem solving model can increase the effectiveness of students in learning and assist students in analyzing problems that occur (Sudarsono et al., 2022; Hobri et al., 2020). Menurut Zulkarnain et al. (2020) stated that the problem solving model was able to foster students' critical and creative thinking skills in learning science for junior and senior high school students.

Furthermore, based on the results of the N-gain test of 0.72, the problem solving model is effective in helping students solve various problems that occur in learning science. Ridwan et al. (2021) stated that the problem

solving learning model was able to encourage critical thinking skills and problem solving for students. However, a teacher's problem solving model must have better teaching skills. In learning science, junior and senior high school students have applied a way of thinking in solving problems. Therefore, the problem solving model is a solution for teachers to develop students' competence in learning science (Sudarsana et al., 2019). Besides that, Susanti et al. (2021) problem solving models make it easier for students to master learning concepts.

Applying the right learning model will make it easier for students to understand the lessons conveyed by the teacher (Yapatang & Polyiem, 2022; Suharyat et al., 2022; Santosa & Yulianti, 2020). Teachers who have the ability to apply problem solving models will make students have competitiveness in facing the 21st century (Ichsan et al., 2022). In this 21st century learning, students must be able to solve various science problems that occur in everyday life. According to Parwati et al. (2018) states that the problem solving model is a very appropriate learning model to train students to solve problems in the learning process. Research by Surur et al. (2020) the problem solving model has a positive effect on improving students' cognitive skills in learning science. So, the problem solving learning model is a model that needs to be applied to junior and senior high school students in improving problem solving abilities (Ismail, 2020; Yunus et al., 2021).

Science learning is a learning that requires high critical thinking skills in solving scientific phenomena (Razak et al., 2021). Science learning at the present time is a subject that must be mastered by junior and senior high school students. Research by Suharyat et al. (2022) Science learning is a subject that requires students to think scientifically and be able to solve science problems quickly and precisely in life. Not only that, the problem solving model used by the teacher in the teaching and learning process will make it easier for students to think scientifically and critically in learning science (Satria & Sopandi, 2019).

Conclusion

From the research that has been done, it is concluded that the problem solving learning model has a significant influence on students' problem solving abilities in science learning with an effect size of 1,808, an average value of 83 and a standard deviation of 0.45. The problem solving model gives positive results in encouraging ability solving student problems in learning science in junior and senior high schools. In addition, the problem solving model is able to improve student learning outcomes in learning.

Acknowledgments

We would like to thank the researchers involved in completing the research so that it can contribute to the advancement of educational science in Indonesia.

Author Contributions

This research involved five researchers who had their respective roles. Yayat Suharyat: collecting and formulating research data; Linda Winiasri and Tomi Apra Santosa: conducting data selection process and statistical analysis; Abdul Rahman and Kartini Marzuki: Analyzed and interpreted the data.

Funding

This research received no external funding.

Conflicts of interest

Authors declare no conflict of interest.

References

- Abtokhi, A., Jatmiko, B., & Wasis, W. (2021). Problem-Solving Skills In Online Basic Physics Learning. *Journal of Technology and Science Education*, 11(2), 541–555. Retrieved from <https://repository.uin-malang.ac.id/9331/>
- 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. <https://doi.org/10.23887/jpdi.v3i2.2871>
- Ahghar, G. (2012). Effect of Problem-solving Skills Education on Auto-Regulation Learning of High School Students in Tehran. *Procedia - Social and Behavioral Sciences*, 69(Icepsy), 688–694. <https://doi.org/10.1016/j.sbspro.2012.11.462>
- Alfin, J., Fuad, A. Z., Nur, M., Yuanita, L., & Prahani, B. K. (2019). Development of group science learning (GSL) model to improve the skills of collaborative problem solving, science process, and self-confidence of primary schools teacher candidates. *International Journal of Instruction*, 12(1), 147–164. <https://doi.org/10.29333/iji.2019.12110a>
- Andika, F., Pramudya, I., & Subanti, S. (2020). Problem posing and problem solving with scientific approach in geometry learning. *International Online Journal of Education and Teaching (IOJET)*, 7(4), 1635–1642. Retrieved from <http://iojet.org/index.php/IOJET/article/view/1037>
- Apra, T. S., Razak, A., Arsih, F., Sepriyani, E. M., & Hernaya, N. (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. Retrieved from <http://journal.unnes.ac.id/sju/index.php/ujbe>
- Argaw, A. S., Haile, B. B., Ayalew, B. T., & Kuma, S. G. (2017). The effect of problem based learning (PBL) instruction on students' motivation and problem solving skills of physics. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(3), 857–871. <https://doi.org/10.12973/eurasia.2017.00647a>
- Batlolona, J. R., Baskar, C., Kurnaz, M. A., & Leasa, M. (2018). The improvement of problem-solving skills and physics concept mastery on temperature and heat topic. *Jurnal Pendidikan IPA Indonesia*, 7(3), 273–279. <https://doi.org/10.15294/jpii.v7i3.12432>
- Binar, K., Prahani, A., Prahani, B. K., Ramadani, A. H., Kusumawati, H., Suprpto, N., Jatmiko, B., Arifin, Z., Supardi, I., Mubarak, H., Safitri, S., & Deta, U. A. (2020). ORNE Learning Model to Improve Problem-Solving Skills of Physics Bachelor Candidates: An Alternative Learning in the Covid-19 Pandemic. *Jurnal Penelitian Fisika Dan Aplikasinya (JPFA)*, 10(01), 2087–9946. <https://doi.org/10.26740/jpfa.v10i1.p71>
- Cooper, M. M., Cox, C. T., Nammouz, M., Case, E., & Stevens, R. (2008). An assessment of the effect of collaborative groups on students' problem-solving strategies and abilities. *Journal of Chemical Education*, 85(6), 866–872. <https://doi.org/10.1021/ed085p866>
- Frerejean, J., van Strien, J. L. H., Kirschner, P. A., & Brand-Gruwel, S. (2018). Effects of a modelling example for teaching information problem solving skills. *Journal of Computer Assisted Learning*, 34(6), 688–700. <https://doi.org/10.1111/jcal.12276>
- Fuad, A. Z., Alfin, J., Fauzan, Astutik, S., & Prahani, B. K. (2019). Group Science Learning model to improve collaborative problem solving skills and self-confidence of primary schools teacher candidates. *International Journal of Instruction*, 12(3), 119–132. <https://doi.org/10.29333/iji.2019.1238a>
- Fülöp, É. (2021). Developing Problem-Solving Abilities by Learning Problem-Solving Strategies: An Exploration of Teaching Intervention in Authentic Mathematics Classes. *Scandinavian Journal of Educational Research*, 65(7), 1309–1326. <https://doi.org/10.1080/00313831.2020.1869070>
- Grushka, K., Hope, A., Clement, N., Lawry, M., & Devine, A. (2018). New Visuality in Art/Science: A Pedagogy of Connection for Cognitive Growth and Creativity. *Peabody Journal of Education*, 93(3), 320–331. <https://doi.org/10.1080/0161956X.2018.1449927>
- Gunawan, G., Harjono, A., Nisyah, M., Kusdiastuti, M., & Herayanti, L. (2020). Improving students' problem-solving skills using inquiry learning model combined with advance organizer. *International Journal of Instruction*, 13(4), 427–442. <https://doi.org/10.29333/iji.2020.13427a>
- Haenilah, E. Y., Yanzi, H., & Drupadi, R. (2021). The Effect of the Scientific Approach-Based Learning on Problem Solving Skills in Early Childhood: Preliminary Study. *International Journal of Instruction*, 14(2), 289–304. <https://doi.org/10.29333/iji.2021.14217a>
- Hodiyanto, H. (2017). Pengaruh model pembelajaran problem solving terhadap kemampuan komunikasi matematis ditinjau dari gender. *Jurnal Riset Pendidikan Matematika*, 4(2), 219. <https://doi.org/10.21831/jrpm.v4i2.15770>
- Holder, L. N., Scherer, H. H., & Herbert, B. E. (2017). Student learning of complex earth systems: A model to guide development of student expertise in problem-solving. *Journal of Geoscience Education*, 65(4), 490–505. <https://doi.org/10.5408/17-261.1>
- Hong, S. Y., & Diamond, K. E. (2012). Two approaches to teaching young children science concepts, vocabulary, and scientific problem-solving skills. *Early Childhood Research Quarterly*, 27(2), 295–305. <https://doi.org/10.1016/j.ecresq.2011.09.006>
- Huang, S. Y., Kuo, Y. H., & Chen, H. C. (2020). Applying digital escape rooms infused with science teaching in elementary school: Learning performance, learning motivation, and problem-solving ability. *Thinking Skills and Creativity*, 37(129), 100681. <https://doi.org/10.1016/j.tsc.2020.100681>
- Hujatutatif, A., Kuswanto, H., & Ilma, A. Z. (2022). Analyzing and Comparing Frequency of the Birds Sound Spectrum using Audacity Software in Practicum Activity. 8(6), 2586–2592. <https://doi.org/10.29303/jppipa.v8i6.1697>
- Ichsan, Suhaimi, Amalia, K. N., Santosa, T. A., & Yulianti, S. (2022). Pengaruh Model Pembelajaran Problem Based Learning Berbasis TPACK Terhadap Keterampilan Literasi Sains Dalam Pembelajaran IPA Siswa Tingkat SD Sampai SMA: Sebuah Meta-Analisis. *Jurnal Pendidikan Dan Konseling*, 4(5), 2173–2181. Retrieved from <https://journal.universitaspahlawan.ac.id/index.php/jpdk/article/view/6931>
- Ismail, Y. (2020). Semiotic procedural knowledge model on solution of problems and problem-solving analysis. *International Journal of Educational Administration and Policy Studies*, 12(2), 101–111. <https://doi.org/10.5897/ijeaps2020.0660>
- Khoiriyah, A. J., & Husamah, H. (2018). Problem-based learning: Creative thinking skills, problem-solving skills, and learning outcome of seventh grade

- students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 4(2), 151–160. <https://doi.org/10.22219/jpbi.v4i2.5804>
- Kinay, I., & Bagceci, B. (2016). The Investigation of the Effects of Authentic Assessment Approach on Prospective Teachers' Problem-Solving Skills. *International Education Studies*, 9(8), 51. <https://doi.org/10.5539/ies.v9n8p51>
- Klegeris, A., & Hurren, H. (2011). Impact of problem-based learning in a large classroom setting: Student perception and problem-solving skills. *American Journal of Physiology-Advances in Physiology Education*, 35(4), 408–415. <https://doi.org/10.1152/advan.00046.2011>
- Kopparla, M., Bicer, A., Vela, K., Lee, Y., Bevan, D., Kwon, H., Caldwell, C., Capraro, M. M., & Capraro, R. M. (2019). The effects of problem-posing intervention types on elementary students' problem-solving. *Educational Studies*, 45(6), 708–725. <https://doi.org/10.1080/03055698.2018.1509785>
- Learning, M., & Ability, R. (2011). Meaningful Learning, Reasoning Ability, and Students' Understanding and Problem Solving of Topics in Genetics. *Journal of Research in Science Teaching*, 33(6), 625–656.
- Lee, S. W. Y., Tsai, C. C., Wu, Y. T., Tsai, M. J., Liu, T. C., Hwang, F. K., Lai, C. H., Liang, J. C., Wu, H. C., & Chang, C. Y. (2011). Internet-based science learning: A review of journal publications. *International Journal of Science Education*, 33(14), 1893–1925. <https://doi.org/10.1080/09500693.2010.536998>
- Lin, X., Yang, W., Wu, L., Zhu, L., Wu, D., & Li, H. (2021). Using an Inquiry-Based Science and Engineering Program to Promote Science Knowledge, Problem-Solving Skills and Approaches to Learning in Preschool Children. *Early Education and Development*, 32(5), 695–713. <https://doi.org/10.1080/10409289.2020.1795333>
- Matsun, M., Boisandi, B., Sari, I. N., Hadiati, S., & Hakim, S. L. (2021). Use of Arduino Microcontroller and Proteus Software in Physics Lesson in Review of Mathematics Ability and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 7(SpecialIssue), 20–27. <https://doi.org/10.29303/jppipa.v7ispecialissue.916>
- Muhammad, S. (2015). Pengaruh Model Pembelajaran Creative Problem Solving Berbantuan Media Maple 11 Terhadap Kemampuan Pemecahan Masalah Matematis. *Al-Jabar: Jurnal Pendidikan Matematika*, 6(1), 91–98. <https://doi.org/10.24042/ajpm.v6i1.58>
- Musna, R. R., Juandi, D., & Jupri, A. (2021). 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). <https://doi.org/10.1088/1742-6596/1882/1/012090>
- Oktarina, K., Suhaimi, S., Santosa, T. A., & ... (2021). Meta-Analysis: The Effectiveness of Using Blended Learning on Multiple Intelligences and Student Character Education During the Covid-19 Period. *IJECA (International Journal of Education and Curriculum Application)*, 4(3), 184–192. Retrieved from <http://journal.ummat.ac.id/index.php/IJECA/article/view/5505><https://doi.org/10.1088/1742-6596/1882/1/012090>
- Osman, K., & Marimuthu, N. (2010). Setting new learning targets for the 21st century science education in Malaysia. *Procedia-Social and Behavioral Sciences*, 2(2), 3737–3741. <https://doi.org/10.1016/j.sbspro.2010.03.581>
- Parwati, N. N., Sudiarta, I. G. P., Mariawan, I. M., & Widiana, I. W. (2018). Local wisdom-oriented problem-solving learning model to improve mathematical problem-solving ability. *Journal of Technology and Science Education*, 8(4), 310–320. <https://doi.org/10.3926/jotse.401>
- Purwaningsih, E., Sari, S. P., Sari, A. M., & Suryadi, A. (2020). The effect of stem-pjbl and discovery learning on improving students' problem-solving skills of the impulse and momentum topic. *Jurnal Pendidikan IPA Indonesia*, 9(4), 465–476. <https://doi.org/10.15294/jpii.v9i4.26432>
- Putri, A. U., Rusyati, L., & Rochintaniawati, D. (2018). The Impact of Problem-Solving Model on Students' Concept Mastery and Motivation in Learning Heat Based on Gender. *Journal of Science Learning*, 1(2), 71. <https://doi.org/10.17509/jsl.v1i2.9793>
- Rahayu, P., Mulyani, S., & Miswadi, S. S. (2012). Pengembangan pembelajaran IPA terpadu dengan menggunakan model pembelajaran problem base melalui lesson study. *Jurnal Pendidikan IPA Indonesia*, 1(1), 63–70. <https://doi.org/10.15294/jpii.v1i1.2015>
- 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. <https://doi.org/10.37058/bioed.v6i1.2930>
- Ridwan, M. R., Retnawati, H., Hadi, S., & Jailani, J. (2021). The Effectiveness of Innovative Learning on Mathematical Problem-Solving Ability: A Meta-

- Analysis. *International Journal of Research in Education and Science*, 7(3), 910-932. <https://doi.org/10.46328/ijres.2287>
- Rizaldi, D. R., Nurhayati, E., & Fatimah, Z. (2020). The Correlation of Digital Literation and STEM Integration to Improve Indonesian Students' Skills in 21st Century. *International Journal of Asian Education*, 1(2), 73-80. <https://doi.org/10.46966/ijae.v1i2.36>
- Sari, Y. I., Sumarmi, Utomo, D. H., & Astina, I. K. (2021). The Effect of Problem Based Learning on Problem Solving and Scientific Writing Skills. *International Journal of Instruction*, 14(2), 11-26. <https://doi.org/10.29333/iji.2021.1422a>
- Sarican, G., & Akgunduz, D. (2018). The impact of integrated STEM education on academic achievement, reflective thinking skills towards problem solving and permanence in learning in science education. *Cypriot Journal of Educational Sciences*, 13(1), 94-113. <https://doi.org/10.18844/cjes.v13i1.3352>
- Satria, E. (2018). Projects for the implementation of science technology society approach in basic concept of natural science course as application of optical and electrical instruments' material. *Journal of Physics: Conference Series*, 983(1). <https://doi.org/10.1088/1742-6596/983/1/012049>
- Satria, E., & Sopandi, W. (2019). Applying RADEC model in science learning to promoting students' critical thinking in elementary school. *Journal of Physics: Conference Series*, 1321(3). <https://doi.org/10.1088/1742-6596/1321/3/032102>
- Semilarski, H., Soobard, R., & Rannikmäe, M. (2021). Promoting students' perceived self-efficacy towards 21st century skills through everyday life-related scenarios. *Education Sciences*, 11(10). <https://doi.org/10.3390/educsci11100570>
- Senar, T. (2014). The effects of problem-based learning on pre-service teachers' critical thinking dispositions and perceptions of problem-solving ability. *South African Journal of Education*, 34(1), 1-20. Retrieved from <http://search.ebscohost.com/login.aspx?direct=true&db=eue&AN=94767462&camp\nglang=ko&site=ehost-live>
- Serin, O., Serin, N. B., & Saygili, G. (2009). The effect of educational technologies and material supported science and technology teaching on the problem solving skills of 5 th grade primary school student. *Procedia - Social and Behavioral Sciences*, 1(1), 665-670. <https://doi.org/10.1016/j.sbspro.2009.01.116>
- Subali, B., Rusdiana, D., Firman, H., Kaniawati, I., & Ellianawati, E. (2017). Computer-based experiment of free fall movement to improve the graphical literacy. *Jurnal Pendidikan IPA Indonesia*, 6(1), 41-48. <https://doi.org/10.15294/jpii.v6i1.8750>
- Sudarsana, I. K., Nakayanti, A. R., Sapta, A., Haimah, Satria, E., Saddhono, K., Achmad Daengs, G. S., Putut, E., Helda, T., & Mursalin, M. (2019). Technology Application in Education and Learning Process. *Journal of Physics: Conference Series*, 1363(1). <https://doi.org/10.1088/1742-6596/1363/1/012061>
- Sudarsono, Kartono, Mulyono, & Mariani, S. (2022). The Effect of STEM Model Based on Bima's Local Cultural on Problem Solving Ability. *International Journal of Instruction*, 15(2), 83-96. <https://doi.org/10.29333/iji.2022.1525a>
- 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. <https://doi.org/10.29408/didika.v8i1.5776>
- Suharyat, Y., Ichsan, I., Satria, E., Santosa, T. A., & Amalia, K. N. (2022). Meta-Analisis Penerapan Model Pembelajaran Problem Based Learning Untuk Meningkatkan Ketrampilan Abad-21 Siswa Dalam Pembelajaran IPA. *Jurnal Pendidikan dan Konseling (JPDK)*, 4(5), 5081-5088. <https://doi.org/10.31004/jpdk.v4i5.7455>
- Suparman, Juandi, D., & Tamur, M. (2021). Review of problem-based learning trends in 2010-2020: A meta-analysis study of the effect of problem-based learning in enhancing mathematical problem-solving skills of Indonesian students. *Journal of Physics: Conference Series*, 1722(1). <https://doi.org/10.1088/1742-6596/1722/1/012103>
- Surur, M., Degeng, I. N. S., Setyosari, P., & Kuswandi, D. (2020). The Effect of Problem-Based Learning Strategies and Cognitive Styles on. *International Journal of Instruction*, 13(4), 35-48. <https://doi.org/10.29333/iji.2020.1343a>
- Susanti, A., Diani, R., Satiarti, R. B., Munawaroh, R., & Fujiani, D. (2021). Blended learning model: The effect on physics problem-solving skills viewed from self-efficacy. *IOP Conference Series: Earth and Environmental Science*, 1796(1). <https://doi.org/10.1088/1742-6596/1796/1/012014>
- Taar, J., & Palojoki, P. (2022). Applying interthinking for learning 21st-century skills in home economics education. *Learning, Culture and Social Interaction*, 33. <https://doi.org/10.1016/j.lcsi.2022.100615>
- Tampubolon, T., & Sitindaon, S. F. (2013). Pengaruh Model Pembelajaran Problem Solving Terhadap

- Hasil Belajar Siswa Kelas X SMA Negeri 7 Medan. *Jurnal INPAFI*, 1(3), 260-268. <https://doi.org/10.24114/inpafi.v1i3.1915>
- Urena, S. S., Melanie, M. C., & Ron, S. (2012). Effect of Cooperative Problem-based Lab. Instruction on Metacognition and Problem-solving Skills. *Journal of Chemical Education*, 89(1), 700-706. <https://doi.org/10.1021/ed1011844>
- Yapatang, L., & Polyiem, T. (2022). Development of the Mathematical Problem-Solving Ability Using Applied Cooperative Learning and Polya's Problem-Solving Process for Grade 9 Students. *Journal of Education and Learning*, 11(3), 40. <https://doi.org/10.5539/jel.v11n3p40>
- Yuberti, Latifah, S., Anugrah, A., Saregar, A., Misbah, & Jermsttiparsert, K. (2019). Approaching problem-solving skills of momentum and impulse phenomena using context and problem-based learning. *European Journal of Educational Research*, 8(4), 1217-1227. <https://doi.org/10.12973/eu-er.8.4.1217>
- Yusuf, M., Witro, D., Diana, R., Santosa, T. A., Alfikri, A. 'Alwiyah, & Jalwis, J. (2020). Digital Parenting to Children Using The Internet. *Pedagogik Journal of Islamic Elementary School*, 3(1), 1-14. <https://doi.org/10.24256/pijies.v3i1.1277>
- Zulkarnain, Zulnaidi, H., Heleni, S., & Syafri, M. (2020). Effects of SSCS Teaching Model on Students' Mathematical Problemsolving Ability and Self-efficacy. *International Journal of Instruction*, 14(1), 475-488. <https://doi.org/10.29333/IJI.2021.14128A>