

Meta-Analysis: The Effect of Ethnoscience-Based Project Based Learning Model on Students' Critical Thinking Skills

Arief Aulia Rahman^{1*}, Tomi Apra Santosa², Mohammad Edy Nurtamam³, Heru Widoyo⁴, Abdul Rahman⁵

¹ Mathematics Education, FKIP, Universitas Muhammadiyah Sumatera Utara, Medan, Indonesia.

² Civil Engineering Lecturer, Adikarya Technical Academy, Kerinci, Indonesia.

³ PGSD Education, FKIP, Trunojoyo University Madura, Madura, Indonesia.

⁴ Character Education, FKIP, Bina Nusantara University, Jakarta, Indonesia.

⁵ Social Education, FKIP, Universitas Sebelas Maret, Semarang, Indonesia.

Received: July 29, 2023

Revised: August 2, 2023

Accepted: September 25, 2023

Published: September 30, 2023

Corresponding Author:

Arief Aulia Rahman

ariefaulia@umsu.ac.id

DOI: [10.29303/jppipa.v9i9.4871](https://doi.org/10.29303/jppipa.v9i9.4871)

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



Abstract: This study aims to determine the effect size of ethnoscience-the based project-based learning model on students' critical thinking skills. This type of research is a meta-analysis. Data sources come from 20 national and international journals published from 2015-2023. The search for data sources comes from the google scholar journal database, Eric, ScienceDirect, and ProQuest. The process of selecting data sources using the PRISMA method. Data collection techniques through direct observation and documentation through journal databases. The data analysis technique in this meta-analysis is quantitative statistical analysis with the help of the Comprehensive Meta-Analysis (CMA) version 3.0 application. The results showed an average effect size of 0.827 with high criteria and a standard error of 0.088. This finding shows that the ethnoscience-based Project Based Learning (PjBL) model has a positive effect on students' critical thinking skills.

Keywords: Critical thinking; Ethnoscience; Meta-analysis; Project based learning model

Introduction

Critical thinking is an ability that students must have in facing the 21st century (Elfira et al., 2023; Oktarina et al., 2021; Ichsan et al., 2023; Bagus et al., 2022). Critical thinking is very important for students in solving a problem (Nurtamam et al., 2023; Zulkifli et al., 2022; Rahman et al., 2023; Amin et al., 2020). According to Mustofa & Hidayah (2020), Critical thinking skills help students to foster logical, systematic, and scientific reasoning in learning. In addition, critical thinking skills encourage students to think in detail in finding a solution (Haryati et al., 2022; Dakabesi et al., 2019). Thinking skills encourage students to provide odoriferous ideas in solving a problem (Yousef, 2021).

Indonesian students' critical thinking skills are still low (Kurniahtunnisa et al., 2016; Suryono et al., 2023; Rijal et al., 2021). This is supported by the results of the

2018 PISA survey of critical thinking skills of Indonesian students obtained a score of 396 ranked 71 out of 78 members (Zulyusri et al., 2023; Putra et al., 2023; Yustiana et al., 2022; Cahyono et al., 2021). Furthermore, the results of the United Nations Development Program (UNDP) conducted by the Human Development Index (HDI) in 2019, the critical thinking skills of Indonesian students obtained a score of 71.98, ranked 130 out of 199 countries (Sudirman et al., 2021). Based on the Trends in International Mathematics and Science Study (TIMSS) survey in 2015, students' thinking skills in science learning amounted to 402, which is lower than the international average score of 500 (Ayuningrum et al., 2015; Rahman & Ristiana, 2020; Rahman et al., 2023).

Yahdi et al. (2020) stated that the low critical thinking skills of students were influenced by the teacher-centered learning process, uninteresting learning models and methods, and learning evaluations

How to Cite:

Rahman, A. A., Santosa, T. A., Nurtamam, M. E., Widoyo, H., & Rahman, A. (2023). Meta-Analysis: The Effect of Ethnoscience-Based Project Based Learning Model on Students' Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 9(9), 611-620. <https://doi.org/10.29303/jppipa.v9i9.4871>

that did not lead to critical thinking skills. Learning activities only train students in understanding concepts so that they do not lead students to think critically (Rusmansyah et al., 2019; Arsih et al., 2021; Supriyadi et al., 2023; Suharyat et al., 2022; Rahman et al., 2018). Research results Ejin (2017) explained that only 50% of students have critical thinking skills in learning. Therefore, there is a need for learning methods and models that can encourage students' critical thinking skills.

Project Based Learning (PjBL) is one of the learning models that can train students to think critically (Mursid et al., 2022; Listiqowati et al., 2022; Chua & Islam, 2021; Issa et al., 2021; Sönmez et al., 2019). Project Based Learning is a learning model that leads students to create a project in learning activities (Niswara et al., 2019; Chua, 2014; Maros et al., 2021). Research results (Janah & Widodo, 2013) Project-based learning model can improve science process skills and student learning outcomes. The Project Based Learning model helps students be more active and creative in learning (Santyasa et al., 2021; Ichsan et al., 2022; Suharyat et al., 2022). Further research results by Syawaludin et al. (2022) The Project Based Learning model has a significant effect on students' cooperation skills in learning. Furthermore, ethnoscience-based Project Based Learning trains students to be more creative in applying learning materials with local wisdom (Sudarmin et al., 2020; Sudarmin et al., 2019). Ethnoscience is a process of applying traditional science with modern science (Sumarni et al., 2022). Ethnoscience-based learning fosters environmental awareness in students (Nisa et al., 2015; Rahman et al., 2023).

Research by Ardianti et al. (2022), Ethnosain-based Proeject Based Learning trains students' concept understanding skills in learning. Wulandari et al. (2020) stated that the Project Based Learning (PjBL) model has a positive impact on students' collaborative character abilities in learning activities. Research results Muzana et al. (2021) Project Based Learning model can improve students' problem solving skills in science learning. Research results by Ramandanti et al. (2020) stated that the ethnoscience-based Project Based Learning model can train students' understanding of learning concepts. Sholahuddin et al. (2021) The ethnoscience-based Project Based Learning model can increase students' science literacy in learning so as to encourage students to think critically. But in fact, many studies on Project Based Learning models are still few that analyze the size effect of ethnoscience-based Project Based Learning models. Based on these problems, this study aims to determine the size effect of the ethnoscience-based project-based learning model on students' critical thinking skills.

Method

Research Design

This research is a meta-analysis study. Meta-analysis is a type of research that analyzes previous studies that can be analyzed statistically (Öztürk et al., 2022; Putra et al., 2023; Diah et al., 2022; Santosa et al., 2021). This meta-analysis research is used to determine the effect of the ethnoscience-based Project Based Learning (PjBL) model on students' critical thinking skills.

Eligibility Criteria

Determination of eligibility criteria aims to obtain accurate research results (Demir & Kaya, 2022). The data criteria for conducting this meta-analysis are: data from journals or proceedings published in 2015-2023, The type of research must be experimental or quasi-experimental, Has a relationship with the research variable, namely the ethnoscience-based Project Based Learning Model on critical thinking skills, Journals or proceedings indexed by SINTA, DOAJ, Copernicus International, or Scopus and 5) journals or proceedings have a value (r) and (t).

Data Coding

In meta-analysis, data coding serves to facilitate data collection and data analysis (Utomo & Aliman, 2021; Ridwan, 2022). Data coding in this meta-analysis research considers the year of publication, country of origin, journal type, research sample, effect size (ES). The effect size criteria can be seen in Table 1.

Data Analysis

The data analysis technique in this study was carried out by analyzing the data according to the characteristics of the research sample, coding the data; 3) changing the T and F values to the r correlation value with the formula; 4) calculating the heterogeneity test value; 5) calculating the effect size (ES) value; 6) making funnel plot; 7) conducting hypothesis testing and 8) calculating publication bias (Cohen et al., 2007; Aybirdi, 2023; Mutohhari et al., 2021). Data analysis was done with the help of JSAP 0.8.4.0 application.

Table 1. Effect Size Value Criteria (Suparman et al., 2021; Supriyadi et al., 2023; Rahman et al., 2023)

| Effect size | Criteria |
|--------------------------|-----------|
| $0.00 \leq ES \leq 0.20$ | Ignored |
| $0.20 \leq ES \leq 0.50$ | Low |
| $0.50 \leq ES \leq 0.80$ | Medium |
| $0.80 \leq ES \leq 1.30$ | High |
| $1.30 \leq ES$ | Very High |

Result and Discussion

Result

From the results of the meta-analysis of 145 journals or proceedings related to the effect of ethnosience-based project-based learning models on students' critical

thinking skills, only 19 journals or proceedings met the inclusion criteria. Furthermore, journals or proceedings that have met the inclusion criteria become the source of data in this study which is calculated the effect size value which can be seen in Table 2.

Table 2. Effect Size Value of Each Data Source

| Journal Code | Years | Nation | N | ES | Criteria Effect Size |
|---------------------|-------|-----------|----|-------|----------------------|
| V1 | 2017 | Indonesia | 17 | 0.88 | High |
| V2 | 2020 | Indonesia | 25 | 1.07 | High |
| V3 | 2019 | Indonesia | 13 | 0.72 | Medium |
| V4 | 2017 | Indonesia | 10 | 0.90 | High |
| V5 | 2023 | Indonesia | 35 | 1.22 | High |
| V6 | 2023 | Indonesia | 20 | 0.79 | Medium |
| V7 | 2021 | India | 20 | 0.42 | Low |
| V8 | 2020 | Indonesia | 16 | 0.81 | High |
| V9 | 2023 | Indonesia | 30 | 1.40 | Very High |
| V10 | 2021 | Turki | 50 | 0.65 | Medium |
| V11 | 2022 | Meksiko | 18 | 0.30 | Low |
| V12 | 2018 | Pakistan | 15 | 1.53 | Very High |
| V13 | 2016 | Indonesia | 25 | 0.82 | High |
| V14 | 2016 | Indonesia | 25 | 0.74 | Medium |
| V15 | 2021 | Indonesia | 40 | 0.81 | High |
| V16 | 2022 | India | 30 | 0.98 | High |
| V17 | 2021 | Indonesia | 26 | 0.49 | Low |
| V18 | 2023 | Indonesia | 34 | 0.51 | Medium |
| V19 | 2021 | Indonesia | 64 | 0.69 | Medium |
| Average Effect Size | | | | 0.827 | High |

Based on Table 2. Shows that 8 articles with high effect size criteria, 2 articles with very high effect size criteria, 6 journals with medium effect size criteria and 3 articles with small effect size criteria. Furthermore, the average effect size value is 0.827 with high criteria. These

results explain that the ethnosience-based Project Based Learning model has a positive effect on students' critical thinking skills. The next step is to conduct a heterogeneity test which aims to determine the meta-analysis model used clearly in Table 3.

Table 3. Heterogeneity Test Results Based on Effect Models

| Model | Hedge's g | 95% CI | Null Hypothesis Test (2 Tail) | | Heterogeneity | |
|--------|-----------|----------------|-------------------------------|---------|---------------|---------|
| | | | Z-Value | P-Value | Q-value | P-value |
| Fixed | 0.615 | [0.624; 0.730] | 34.004 | 0.000 | 213.785 | 0.000 |
| Random | 0.783 | [0.681; 0.869] | 9.170 | 0.000 | | |

Based on Table 3. Shows that the Q-value is 213.785 or $p < 0.05$, meaning that the effect of each study has a significant difference. The meta-analysis model used is the random effect model. This analysis shows that the application of the ethnosience-based Project Based Learning model provides a high significant value compared to the conventional model.

Next, we calculated the publication bias of the studies used by using the Funnel Plot which can be seen in Figure 1.

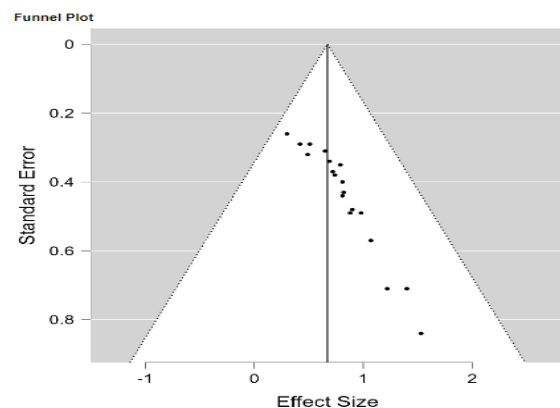


Figure 1. Funnel plot standard error by Hedge's g

Based on Figure 1 shows that the effect size is still scattered in the field of symmetrical lines in the middle of the funnel plot. The distribution is not completely symmetrical on the vertical line. Therefore, it is necessary to see the Fail save-N (FSN) value. The FSN value is meta-analyzed to determine publication bias.

From the analysis with the CMA application, the FSN value is 434 then entered in the formula $434 / (5.19 - 10) > 1 = 5.10 > 1$. This result explains that the study is not susceptible to publication bias, so it is necessary to do the Trim and Fill test which can be seen in Table 4.

Table 4. Results of Publication Bias Test with Trim and Fill

| Observed Value | Random Effect Model | | | | Q-Value |
|----------------|---------------------|----------------|-------------|-------------|---------|
| | Ommited studies | Point Estimate | Lower limit | Upper Limit | |
| Observed Value | 1 | 0.742 | 0.516 | 1.39 | 57.68 |
| Adjusted Value | | 0.617 | 0.478 | 1.04 | 134.96 |

Based on Table 4. Shows the results of the Trim and Fill test with an observed value of 0.742 and an adjusted value of 0.617. Furthermore, there is 1 article that is omitted, namely V11. The heterogeneity value is

normally distributed. The next step, conducting hypothesis testing to determine the effectiveness of the Ethnoscience-based Project Based Learning model on critical thinking skills can be seen in Table 5.

Table 5. Hypothesis Test Results Based on Random Effect Models

| Estimation model | n | Z | P | ES | Standard Error | 95 % CI |
|---------------------|----|-------|------|-------|----------------|----------------|
| Random effect model | 19 | 7.595 | 0.00 | 0.827 | 0.088 | [0.681; 0.869] |

Based on Table 5. Shows that the Z value is 7.595 or $p < 0.00$. These results can be concluded that the application of ethnoscience-based Project Based Learning model is more effective in improving students' critical thinking skills than conventional learning.

2022). Research results Yuliana et al. (2021) Ethnoscience learning trains students to think critically and creatively in learning so as to create a more interesting learning atmosphere. Furthermore, the ethnoscience-based Project Based Learning (PjBL) model helps students be more creative so as to stimulate their critical thinking skills in learning (Lazic, 2021; Rahmawati & Subali, 2019; Rofik et al., 2022; Safitri, 2021). Not only that, the ethnoscience-based Project Based Learning model trains students to learn with nature (Wati et al., 2020).

Discussion

The use of ethnoscience-based Project Based Learning (PjBL) model has a positive influence on students' critical thinking skills compared to conventional learning models. This can be seen from the average value of the effect size (ES = 0.827) high criteria. Research results Hanum et al. (2023) ethnoscience-based Project Based Learning model can encourage students' critical thinking skills in learning activities. The application of the ethnoscience-based Project Based Learning (PjBL) model helps students more easily understand learning concepts (Ardianti & Raida, 2022; Rumasyah & Sofia, 2023; Rahman et al., 2018). Ethnoscience-based learning can train students to apply learning materials with the local environment for learning resources (Sari & Wilujeng, 2023; Ilwandri et al., 2023; Elvianasti et al., 2022). Therefore, the ethnoscience-based Project Based Learning model can improve students' critical thinking skills so that they can solve a problem in learning (Hikmawati et al., 2020; Irvan & Mushlihuddin, 2020).

Temuningsih et al. (2017) the ethnoscience learning process helps students develop cognitive potential so that it can train students to think critically in learning. In learning activities students must be able to analyze a subject matter that they have learned. According to Dike et al. (2020) The application of ethnoscience concepts in the learning process makes students more active and creative in learning. Therefore, students are more motivated in learning so that it is easier to encourage students to think critically in analyzing a problem in learning (Yusuf, 2023; Vidergor, 2022). So, the selection of the right learning model greatly influences students' thinking process skills (Sudjimat, 2021). The application of Project Based Learning (PjBL) model based on one of the more effective models to improve students' critical thinking skills. In addition, the ethnoscience-based Project Based Learning model trains students to be more creative in learning (Kasi et al., 2020).

This ethnoscience-based learning encourages critical thinking and makes it easier for students to understand the subject matter (Sumarni, 2018). Critical thinking skills help students more easily remember and analyze a problem that occurs in their environment (Sudarmin et al., 2019; Que et al., 2022; Suharyat et al.,

Conclusion

From the results of this study, it can be concluded that the average effect size value is 0.827 with high

criteria and a standard error of 0.088. This finding shows that the ethnoscience-based Project Based Learning (PjBL) model has a positive effect on students' critical thinking skills. The ethnoscience-based Project Based Learning model is more effective for improving critical thinking skills than conventional learning models. The ethnoscience-based Project Based Learning model is one solution to improve students' thinking skills in learning.

Acknowledgments

We would like to thank all researchers who have distributed and facilitated the completion of this research.

Author Contributions

The first author Aried Aulia Rahman distributed in collecting research from journal databases. Authors Tomi Apra Santosa and Mohammad Edy Nurtamam distributed data selection based on inclusion criteria. Heru Widoyo and Abdul Rahman distributed in analyzing and interpreting the research data.

Funding

This research was independently funded by researchers.

Conflicts of Interest

The authors declare no conflict of interest.

References

- Aliman, U. &. (2021). The Meta-Analysis of Climate Resilience Education in Higher Education for Transformation Based on Experiential Learning Models. *Review Of International Geographical Education*, 11(2), 302-316. <https://doi.org/10.33403/rigeo.754200>
- 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. <https://doi.org/10.17478/jegys.650344>
- Ardianti, S. D., & Raida, S. A. (2022). The Effect of Project Based Learning with Ethnoscience Approach on Science Conceptual Understanding. *Journal of Innovation in Educational and Cultural Research*, 3(2), 207-214. <https://doi.org/10.46843/jiecr.v3i2.89>
- Arsih, F., Zubaidah, S., Suwono, H., & Gofur, A. (2021). Randai learning model to enhance pre-service biology teachers' critical thinking skills. *International Journal of Instruction*, 14(2), 845-860. <https://doi.org/10.29333/iji.2021.14247a>
- Aybirdi, N. (2023). The Impact of Flipped Learning on L2 Learners' Achievements: A Meta- Analysis. *International Journal of Education*, 11(1), 41-60. <https://doi.org/10.34293/education.v11i1S1-Jan.5891>
- Ayuningrum, D., Mulyani, S., & Susilowati, E. (2015). Pengaruh Model Problem Based Learning Terhadap Keterampilan Berpikir Kritis Siswa Sma Pada Materi Protista. *Unnes Journal of Biology Education*, 4(2), 50229. Retrieved from <http://journal.unnes.ac.id/sju/index.php/ujbe>
- Bagus, I., Putra, A., Id, M., & Id, C. W. (2022). The effectiveness of problem based learning in improving critical thinking , problem-solving and self-directed learning in first-year medical students: A meta-analysis. *PLoS ONE*, 17(11), 1-12. <https://doi.org/10.1371/journal.pone.0277339>
- Cahyono, B., Semarang, U. N., & Education, F. (2021). Problem-based learning supported by arguments scaffolding that affect critical thinking teacher candidates. *Cypriot Journal of Educational Sciences*, 16(6), 2956-2969. <https://doi.org/10.18844/cjes.v16i6.6480>
- Chua, K. J. (2014). A comparative study on first-time and experienced project-based learning students in an engineering design module. *European Journal of Engineering Education*, 39(5), 556-572. <https://doi.org/10.1080/03043797.2014.895704>
- Chua, K. J., & Islam, M. R. (2021). The hybrid Project-Based Learning-Flipped Classroom: A design project module redesigned to foster learning and engagement. *International Journal of Mechanical Engineering Education*, 49(4), 289-315. <https://doi.org/10.1177/0306419019838335>
- Cohen, L., Manion, L., Lecturer, P., Morrison, K., & Lecturer, S. (2007). *Research Methods in Education*. Routledge is an imprint of the Taylor & Francis Group, an informa business.
- Dakabesi, D., Supiah, I., Luoise, Y., & Info, A. (2019). The effect of problem based learning model on critical thinking skills in the context of chemical reaction rate. *Journal of Education and Learning (EduLearn)*, 13(3), 395-401. <https://doi.org/10.11591/edulearn.v13i3.13887>
- Demir, M., & Metin, K. A. Y. A. (2022). Analysis of Constructivist Learning Model's Effects on Student Outcomes: A Second Order Meta-Analysis. *Journal of Theoretical Educational Science*, 15(4), 938-957. <https://doi.org/10.30831/akukeg.1122136>
- Diah, H. R., Dayurni, P., Evasufi, L., & Fajari, W. (2022). Meta-Analysis Study : The Effect of Android-Based Learning Media on Student Learning Outcomes. *International Journal Of Asian Education*, 3(4), 253-263. <https://doi.org/10.46966/ijae.v3i4.300>
- Ejin, S. (2017). Pengaruh Model Problem Based Learning (PBL Terhadap Pemahaman Konsep dan Keterampilan Berpikir Kritis Siswa Kelas IV SDN Jambu Hilir Baluti 2 Pada Mata Pelajaran Ilmu Pengetahuan Alam. *Jurnal Pendidikan (Teori Dan Praktik)*, 1(1), 66. <https://doi.org/10.26740/jp.v1n1.p66-72>

- 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>
- Elvianasti, M., Kartikawati, E., Padang, U. N., & Utara, U. (2022). Research Trends in PjBL (Project-Based Learning) at Indonesian Journal of Biology Education. *Jurnal Iqra': Kajian Ilmu Pendidikan*, 7(2), 105-119. <https://doi.org/10.25217/ji.v7i2.2464>
- Hanum, L., Hasan, M., Ulfa, A., Pada, T., Rahmatan, H., Fazlia, R., & Rahmayani, I. (2023). Development of Learning Devices Based on Ethnoscience Project Based Learning to Improve Students ' Critical Thinking Skills. *Jurnal Pendidikan Sains Indonesia*, 11(2), 288-305. <https://doi.org/10.24815/jpsi.v11i2.28294>
- Haryati, S., Siswanto, S., Sukarno, S., Muhlisin, A., & Trisnowati, E. (2022). A Case-Based Study in ERP Instructional Model: Fostering Critical Thinking Skills and Portraying Independence on Solving Problems. *Pegem Journal of Education and Instruction*, 12(4), 220-225. <https://doi.org/10.47750/pegegog.12.04.22>
- Ichsan, Tomi Apra Santosa, Ilwandri, Aulia Sofianora, U. Y. (2022). Efektivitas Evaluasi Model CIPP Dalam Pembelajaran IPA di Indonesia: Meta-Analisis. *Jurnal Pendidikan Dan Konseling*, 5(2), 1349-1358. Retrieved from <https://journal.universitaspahlawan.ac.id/index.php/jpdk/article/view/13435>
- 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>
- Ilwandri, I., Festiyed, F., & Santosa, T. A. (2023). Development of Ethnoscience-Based Critical Thinking Instrument in Physics Learning. *Edumaspul: Jurnal Pendidikan*, 7(1), 1555-1562. <https://doi.org/10.33487/edumaspul.v7i1.6273>
- Irvan, I., & Muslihuddin, R. (2020). The Development Of Teaching Materials With Problem Based Learning On The Mathematical Statistics Subject To Improve Students' Critical Thinking Ability. *Indonesian Journal of Education and Mathematical Science*, 2(1), 1-6. <https://doi.org/10.30596/ijems.v2i1.5626>
- Issa, H. B., & Khataibeh, A. (2021). The Effect of Using Project Based Learning on Improving the Critical Thinking among Upper Basic Students from Teachers' Perspectives. *Pegem Journal of Education and Instruction*, 11(2), 52-57. <https://doi.org/10.14527/pegegog.2021.00>
- Janah, M. C., Widodo, A. T., & Kasmui, K. (2018). Pengaruh model problem based learning terhadap hasil belajar dan keterampilan proses sains. *Jurnal Inovasi Pendidikan Kimia*, 12(1). <https://doi.org/10.15294/jipk.v12i1.13301>
- Kasi, Y. F., Samsudin, A., Widodo, A., & Riandi, R. (2020). A critical analysis about ethnoscience approach of the science teachers in "Peo Nabe" - Nagekeo using rasch model A critical analysis about ethnoscience approach of the science teachers in " Peo Nabe " - Nagekeo using rasch model. *International Journal of Advanced Science and Technology*, 29(7), 3149-3165. Retrieved from <https://rb.gy/uuw12>
- Kurniahtunnisa, K., Dewi, N. K., & Utami, N. R. (2016). Pengaruh model problem based learning terhadap kemampuan berpikir kritis siswa materi sistem ekskresi. *Journal of Biology Education*, 5(3), 310-318. <https://doi.org/10.15294/jbe.v5i3.14865>
- Lazic, B. D. (2021). The influence of project-based learning on student achievement in elementary mathematics education. *South African Journal of Education*, 41(3), 1-10. Retrieved from <https://www.ajol.info/index.php/saje/article/view/217137>
- Listiqowati, I., Budijanto, Sumarmi, & Ruja, I. N. (2022). The Impact of Project-Based Flipped Classroom (PjBFC) on Critical Thinking Skills. *International Journal of Instruction*, 15(3), 853-868. <https://doi.org/10.29333/iji.2022.15346a>
- Mahadi, I., & Ariska, D. (2022). The Effect of E-Learning Based on the Problem-Based Learning Model on Students' Creative Thinking Skills during the COVID-19 Pandemic. *International Journal of Instruction*, 15(2), 329-348. <https://doi.org/10.29333/iji.2022.15219a>
- Maros, M., Korenkova, M., Fila, M., Levicky, M., & Schoberova, M. (2021). Project-based learning and its effectiveness: evidence from Slovakia. *Interactive Learning Environments*, 0(0), 1-9. <https://doi.org/10.1080/10494820.2021.1954036>
- Mursid, R., Saragih, A. H., & Hartono, R. (2022). The Effect of the Blended Project-based Learning Model and Creative Thinking Ability on Engineering Students' Learning Outcomes. *International Journal of Education in Mathematics, Science and Technology*, 10(1), 218-235. <https://doi.org/10.46328/ijemst.2244>
- Mustofa, R. F., & Hidayah, Y. R. (2020). The effect of problem-based learning on lateral thinking skills. *International Journal of Instruction*, 13(1), 463-474. <https://doi.org/10.29333/iji.2020.13130a>
- Mutohhari, F., Sutiman, S., Nurtanto, M., Kholifah, N., & Samsudin, A. (2021). Difficulties in Implementing

- 21st Century Skills Competence in Vocational Education Learning. *International Journal of Evaluation and Research in Education*, 10(4), 1229-1236. <https://doi.org/10.11591/ijere.v10i4.22028>
- Muzana, S. R., Wilujeng, I., Yanto, B. E., & Mustamin, A. A. (2021). E-STEM project-based learning in teaching science to increase ICT literacy and problem solving. *International Journal of Evaluation and Research in Education (IJERE)*, 10(4), 1386-1394. <https://doi.org/10.11591/ijere.v10i4.21942>
- Nisaâ, A., Sudarmin, S., & Samini, S. (2015). Efektivitas penggunaan modul terintegrasi etnosains dalam pembelajaran berbasis masalah untuk meningkatkan literasi sains siswa. *Unnes Science Education Journal*, 4(3). <https://doi.org/10.15294/usej.v4i3.8860>
- Niswara, R., Muhajir, M., & Untari, M. F. A. (2019). Pengaruh model project based learning terhadap high order thinking skill. *Mimbar PGSD Undiksha*, 7(2), 85-90. <https://doi.org/10.23887/jjpsgd.v7i2.17493>
- Nurtamam, M. E., Santosa, T. A., Aprilisia, S., Rahman, A., & Suharyat, Y. (2023). Meta-analysis: The Effectiveness of Iot-Based Flipped Learning to Improve Students ' Problem Solving Abilities. *Edumaspul :Jurnal Pendidikan*, 7(1), 1491-1501. <https://doi.org/10.33487/edumaspul.v7i1.6195>
- Oktarina, K., Santosa, T. A., Razak, A., & Ahda, Y. (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 & Curriculum Application*, 4(3), 184-192. <https://doi.org/10.31764/ijeca.v4i3.5505>
- Öztürk, B., Kaya, M., & Demir, M. (2022). Does inquiry-based learning model improve learning outcomes? A second-order meta-analysis. *Journal of Pedagogical Research*, 6(4), 201-216. <https://doi.org/10.33902/JPR.202217481>
- 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. <https://doi.org/10.56910/literacy.v2i1.560>
- Que, B. J., Kusnadi, I. H., Maraden, R., Silalahi, P., Aulia, A., & Kurniawan, A. (2022). The Effect of Deep Dialogue / Critical Thinking Model on Students ' Conceptual Understanding Ability. *Journal of Innovation in Educational and Cultural Research*, 3(3), 422-431. <https://doi.org/10.46843/jiecr.v3i3.130>
- Rahman, A., Suharyat, Y., Ilwandri, I., Santosa, T. A., Sofianora, A., Gunawan, R. G., & Putra, R. (2023). Meta-Analysis: Pengaruh Pendekatan STEM berbasis Etnosains Terhadap Kemampuan Pemecahan Masalah dan Berpikir Kreatif Siswa. *INNOVATIVE: Journal Of Social Science Research*, 3(2), 2111-2125. Retrieved from <https://j-innovative.org/index.php/Innovative/article/view/545>
- Rahman, A. A., Kristanti, D., Amalia, Y., Syafitri, E., Astuti, D., & Abdullah, D. (2018). Retraction: Increasing Students' Self-Efficacy Through Realistic Mathematics Education in Inclusion Classroom. In *Journal of Physics: Conference Series* (Vol. 1114, No. 1, p. 012169). IOP Publishing. <https://doi.org/10.1088/1742-6596/1114/1/012169>
- 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. <https://doi.org/10.33487/edumaspul.v4i1.201>
- Rahman, A., Santosa, T. A., Sofianora, A., Oktavianti, F., & Alawiyah, R. (2023). Systematic Literature Review : TPACK-Integrated Design Thinking in Education. *International Journal of Education and Literature (IJEL)*, 2(1), 65-77. <https://doi.org/10.55606/ijel.v2i1.57>
- Ilwandri, I., Rahman, A., Santosa, T. A., Zulkifli, Z., Suharyat, Y., & Suhaimi, S. (2023). The Effect of Problem Based Learning-STEM on Students' 21st Century Skills in Indonesia: A Meta-Analysis. *LITERACY: International Scientific Journals of Social, Education, Humanities*, 2(1), 151-162. <https://doi.org/10.56910/literacy.v2i1.550>
- 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. <https://doi.org/10.56910/literacy.v2i1.542>
- Rahman, A. A., Kristanti, D., Sapta, A., Sibuea, M. F. L., Sirait, S., Rahmadani, E., ... & Abdullah, D. (2018). Retraction: Improve The Students' Mathematics Communication Ability Using Realistic Mathematics Education. In *Journal of Physics: Conference Series* (Vol. 1114, No. 1, p. 012170). IOP Publishing. <https://doi.org/10.1088/1742-6596/1114/1/012170>
- Rahmawati, S., & Subali, B. (2019). The Effect of Ethnoscience Based Contextual Learning Toward Students ' Learning Activity. *Journal of Primary Education*, 8(2), 152-160. Retrieved from <https://journal.unnes.ac.id/sju/index.php/jpe/article/view/25688>
- Ramandanti, S. K., & Supardi, K. I. (2020). Pengaruh

- Model Problem Based Learning Terintegrasi Etnosains Terhadap Pemahaman Konsep Materi Redoks Siswa Ma Negeri Blora. *Chemistry in Education*, 9(1), 16–22. Retrieved from <https://journal.unnes.ac.id/sju/index.php/chemistry/article/view/39088>
- Ridwan, M. R. (2022). A meta-analysis study on the effectiveness of a cooperative learning model on vocational high school students' mathematics learning outcomes Samsul Hadi Jailani Jailani. *Participatory Educational Research (PER)*, 9(July), 396–421. <https://doi.org/10.17275/per.22.97.9.4>
- 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>
- Rofik, A. (2022). The Effect of Collaborative Problem Solving & Collaborative Project-Based Learning Models to Improve The Project Competences of Pre-Service Teachers. *Pegem Journal of Education and Instruction*, 12(3), 130–143. <https://doi.org/10.47750/pegegog.12.03.15>
- Rowland, D. &. (2020). Students' Understanding of Sound Energy Using Ethnoscience Based Instruction in Basic Science. *International Journal of Innovative Social & Science Education Research*, 8(4), 136–140. Retrieved from <https://seahipaj.org/journals-ci/dec-2020/IJISSER/full/IJISSER-D-16-2020.pdf>
- Rusmansyah, R., Leny, L., & Sofia, H. N. (2023). Improving students' scientific literacy and cognitive learning outcomes through ethnoscience-based PjBL model. *Journal of Innovation in Educational and Cultural Research*, 4(1), 1–9. <https://doi.org/10.46843/jiecr.v4i1.382>
- Rusmansyah, Yuanita, L., Ibrahim, M., Isnawati, & Prahani, B. K. (2019). Innovative chemistry learning model: Improving the critical thinking skill and self-efficacy of pre-service chemistry teachers. *Journal of Technology and Science Education*, 9(1), 59–76. <https://doi.org/10.3926/jotse.555>
- Safitri, D. (2021). Students' Perceptions of the Project Based on the Potential of Their Region: A Project-Based Learning. *Journal of Technology and Science Education*, 11(2), 295–314. <http://dx.doi.org/10.3926/jotse.1153>
- 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. <https://doi.org/10.15294/jbe.v10i2.48533>
- Sari, F. P., & Wilujeng, I. (2023). Ethnoscience Studies Analysis and Their Integration in Science Learning: Literature Review. *Jurnal Penelitian Pendidikan IPA*, 9(3), 1135–1142. <https://doi.org/10.29303/jppipa.v9i3.2044>
- Sholahuddin, A., Hayati, N., Iriani, R., Saadi, P., & Susilowati, E. (2021). Project-based learning on ethnoscience setting to improve students' scientific literacy. *AIP Conference Proceedings*, 2330(March). <https://doi.org/10.1063/5.0043571>
- Sönmez, E., Memiş, E. K., & Yerlikaya, Z. (2019). The effect of practices based on argumentation-based inquiry approach on teacher candidates' critical thinking. *Educational Studies*, 00(00), 1–25. <https://doi.org/10.1080/03055698.2019.1654364>
- Suastra, I. W., & Pujani, N. M. (2021, February). Local wisdom in Lombok island with the potential of ethnoscience for the development of learning models in junior high school. In *Journal of Physics: Conference Series* (Vol. 1816, No. 1, p. 012105). IOP Publishing. <https://doi.org/10.1088/1742-6596/1816/1/012105>
- Sudarmin, S., Zahro, L., Pujiastuti, S. E., Asyhar, R., Zaenuri, Z., & Rosita, A. (2019). The development of PBL-based worksheets integrated with green chemistry and ethnoscience to improve students' thinking skills. *Jurnal Pendidikan IPA Indonesia*, 8(4), 492–499. <https://doi.org/10.15294/jpii.v8i4.17546>
- Sudarmin, S., Skunda, D., Pujiastuti, S. E., Jumini, S., & Prasetya, A. T. (2020). The instructional design of ethnoscience-based inquiry learning for scientific explanation about *Taxus sumatrana* as cancer medication. *Journal for the Education of Gifted Young Scientists*, 8(4), 1493–1507. <https://doi.org/10.17478/jegys.792830>
- Sudirman. (2021). Problem-Based Learning with Character-Emphasis and Naturalist Intelligence: Examining Students Critical Thinking and Curiosity. *International Journal of Instruction*, 14(2), 217–232.
- Sudjimat, D. A. (2021). Implementation of Project-Based Learning Model and Workforce Character Development for the 21st Century in Vocational High School. *International Journal of Instruction*, 14(1), 181–198. <https://doi.org/10.29333/iji.2021.14111a>
- Suharyat, Y., Ichsan, I., Santosa, T. A., Yulianti, S., & Amalia, K. N. (2022). Literature Review: TPACK-Based Science Learning in Supporting Teacher Quality in Indonesia. *International Journal of Education and Literature*, 1(2), 44–50. <https://doi.org/10.55606/ijel.v1i2.25>

- Sumarni, W. (2018). The influence of ethnoscience-based learning on chemistry to the chemistryâ€™s literacy rate of the prospective teachers. *Unnes Science Education Journal*, 7(2), 198–205. <https://doi.org/10.15294/usej.v7i2.23722>
- Sumarni, W., Sudarmin, S., Sumarti, S. S., & Kadarwati, S. (2022). Indigenous knowledge of Indonesian traditional medicines in science teaching and learning using a science – technology – engineering – mathematics (STEM) approach Indigenous knowledge of Indonesian traditional medicines in science teaching and learning . In *Cultural Studies of Science Education* (Issue June). Springer Netherlands. <https://doi.org/10.1007/s11422-021-10067-3>
- 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>
- 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. <https://doi.org/10.55606/ijel.v2i1.53>
- 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. <https://doi.org/10.33487/edumaspul.v7i1.6087>
- Syawaludin, A., Prasetyo, Z. K., Safruddin, C., & Jabar, A. (2022). The Effect of Project-based Learning Model and Online Learning Settings on Analytical Skills of Discovery Learning , Interactive Demonstrations , and Inquiry Lessons. *Journal of Turkish Science Education*, 19(2), 608–621. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1360616.pdf>
- Temuningsih, T., Peniati, E., & Marianti, A. (2017). Pengaruh penerapan model problem based learning berpendekatan etnosains pada materi sistem reproduksi terhadap kemampuan berpikir kritis siswa. *Journal of Biology Education*, 6(1), 70–79. <https://doi.org/10.15294/jbe.v6i1.14060>
- Vidergor, H. E. (2022). Effects of Innovative Project-Based Learning Model on Students' Knowledge Acquisition, Cognitive Abilities, and Personal Competences. *Interdisciplinary Journal of Problem-Based Learning*, 16(1), n1. <https://doi.org/10.14434/ijpbl.v16i1.31183>
- Wati, E., Saregar, A., Fasa, M. I., & Aziz, A. (2020). Literature Research: Ethnoscience In Science Learning Literature Research: Ethnoscience In Science Learning. *Journal Of Physics: Conference Series*, 1796 (2021), 1–10. <https://doi.org/10.1088/1742-6596/1796/1/012087>
- Wayan Santyasa, I., Agustini, K., & Eka Pratiwi, N. W. (2021). Project Based E-Learning And Academic Procrastination Of Students In Learning Chemistry. *International Journal Of Instruction*, 14(3), 909–928. <https://doi.org/10.29333/Iji.2021.14353a>
- Wulandari, A., & Suparno, S. (2020). Pengaruh Model Problem Based Learning Terhadap Kemampuan Karakter Kerjasama Anak Usia Dini. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, 4(2), 862. <https://doi.org/10.31004/Obsesi.V4i2.448>
- Yahdi, Y., Hajaroh, S., & Marhamah, I. (2020). Pengaruh Model Pembelajaran Problem Based Learning Terhadap Keterampilan Berpikir Kritis. *Spin Jurnal Kimia & Pendidikan Kimia*, 2(1), 68–82. <https://doi.org/10.20414/Spin.V2i1.2012>
- Yuliana, I., Cahyono, M. E., Widodo, W., & Irwanto, I. (2021). The Effect of Ethnoscience-Themed Picture Books Embedded Within Context-Based Learning on Students' Scientific Literacy. *Eurasian Journal of Educational Research*, 92, 317–334. <https://doi.org/10.14689/ejer.2021.92.16>
- Yusef, W. (2021). An Assessment Of Critical Thinking In The Middle East : Evaluating The Effectiveness Of Special Courses Interventions. *Plos One*, 16(12), 1–19. <https://doi.org/10.1371/Journal.Pone.0262088>
- Yusuf, F. A. (2023). International Journal Of Educational Methodology Meta-Analysis : The Influence Of Local Wisdom-Based Learning Media On The Character Of Students In Indonesia. *International Journal Of Educational Methodology*, 9(1), 237–247. <https://doi.org/10.12973/ijem.9.1.237>
- Zulkifli, Z., Satria, E., Supriyadi, A., & Santosa, T. A. (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*, 5(1), 32–42. <https://doi.org/10.55606/Ijel.V1i2.32>
- Zulyusri, Z., Santosa, T. A., Festiyed, F., Yerimadesi, Y., Yohandri, Y., Razak, A., & Sofianora, A. (2023). Effectiveness of STEM Learning Based on Design Thinking in Improving Critical Thinking Skills in Science Learning: A Meta-Analysis. *Jurnal*

Penelitian Pendidikan IPA, 9(6), 112-119.
<https://doi.org/10.29303/jppipa.v9i6.3709>