JPPIPA 10(7) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Effectiveness of the Ethnochemistry-based Problem Based Learning Model on Students' Problem-Solving Ability in Chemistry Learning: A Meta-analysis Study in 2021-2024

Hotmauli Gultom[1*], Eli Rohaeti[2]

[1] Master of Chemistry Education, FMIPA, Universitas Negeri Yogyakarta, Indonesia.
[2] Postgraduate Lecturer, FMIPA, Universitas Negeri Yogyakarta, Indonesia.

Received: January 05, 2024
Revised: June 13, 2024
Accepted: July 25, 2024
Published: July 31, 2024

Corresponding Author:
Hotmauli Gultom
hotmaulig@gmail.com

DOI: 10.29303/jppipa.v10i7.8089

© 2024 The Authors. This open access article is distributed under a (CC-BY License)

Abstract: This research is based on many ethnoscience-based problem-based learning studies on students' problem-solving skills. However, many different studies are related to drawing conclusions regarding the application of ethnochemistry-based project-based learning to students' problem-solving skills. This study aims to analyze the influence of ethnochemistry-based problem-based learning model on students' problem-solving ability in chemistry learning. Compared to conventional models. This research is a type of meta-analysis research. Data collection techniques through google scholar database searching; ERIC; ScienceDirect; Wiley; and IEEE. The research data was analyzed to calculate the effect size value of 17 primary studies that met the inclusion criteria. Data analysis with the help of JSAP 0.16.3 software. The results of this study concluded that the ethnochemistry-based problem-based learning model had a significant influence on students' problem-solving ability with an mean effect size ($d = 0.997$; $p < 0.001$) including the high effect size category. These findings conclude that the ethnochemistry-based problem-based learning model is effective in improving students' problem-solving skills compared to conventional learning models. The results of the meta-analysis provide more accurate information so that it can improve the quality of chemistry learning for students at school.

Keywords: Effect size; Ethnochemistry; PBL; Problem solving

Introduction

Problem-solving skills are one of the skills that students must have in learning chemistry (Treepob et al., 2023; Afacan & Kaya, 2022). Problem-solving skills help students develop a deep understanding of scientific concepts as well as their real-life applications (Tessema et al., 2024; Özpınar & Arslan, 2023; ÇetiN et al., 2023). In addition, students' problem-solving skills are faced with various problems that require the application of theory to provide solutions in problem solving (Rahmawati et al., 2024). Therefore, students who have problem-solving skills are able to interpret data and conduct appropriately and can encourage students' higher-level thinking skills in learning chemistry.

Furthermore, problem-solving skills in chemistry learning motivate students to be more active and involved in the chemistry learning process (Kök & Duman, 2023; Kök & Duman, 2023; Zeng et al., 2023). Problem-solving skills are also very important in chemistry learning because they allow students to think critically and creatively. In chemistry learning, students are faced with a variety of situations that require innovative and effective solutions. Therefore, problem-solving abilities allow students to think creatively and find innovative solutions to the problems they face. Not

How to Cite:
Gultom, H., & Rohaeti, E. (2024). The Effectiveness of the Ethnochemistry-based Problem Based Learning Model on Students' Problem-Solving Ability in Chemistry Learning: A Meta-analysis Study in 2021-2024. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 508–514. https://doi.org/10.29303/jppipa.v10i7.8089

only that, problem-solving skills can help students develop critical and creative thinking skills.

Conventional chemistry learning models often focus on teaching chemistry concepts theoretically and do not provide opportunities for students to develop problem-solving skills (Jr & Cruz, 2022; Valdez & Bungihan, 2019). Thus, students can only remember and repeat the material without having the ability to apply those concepts in different situations (Tessema et al., 2024a). This can lead to students lacking the ability to think critically and develop effective solutions in dealing with complex chemical problems.

Chemistry learning also often does not provide opportunities for students to actively participate in the learning process (Kök & Duman, 2023). Students are only instructed to follow predetermined steps and are not given the opportunity to think critically and develop their own ideas. As such, students do not have the opportunity to develop effective problem-solving skills and do not have the ability to adapt to different situations (Tessema et al., 2024). Therefore, the conventional chemistry learning model needs to be changed in order to provide opportunities for students to develop effective problem-solving skills (Ningsih et al., 2023; Purwanto et al., 2022). Therefore, it is necessary to have a learning model that can encourage students' problem-solving skills in learning.

Problem based learning is a learning model that focuses on developing students' abilities in dealing with complex problems (Rattanakha & Chatwattana, 2023; Siagian et al., 2019; Ernawati et al., 2022). In this model, students are given specific problems and instructed to solve them in a critical thinking and collaborative manner with classmates (Dakabesi & Luoise, 2019). Thus, students can develop problem-solving abilities that are chemistry learning.

The problem-based learning model can also help students develop soft skills such as teamwork, courage to think, and adaptability (Amïn et al., 2020). In addition, the problem-based learning model gives students the opportunity to actively participate in the learning process and to develop their own ideas (Duda & Susilo, 2018; Wynn, 2022). Thus, students can develop effective problem-solving skills and have the opportunity to adapt to different situations (Amanda et al., 2022; Maksum et al., 2023; Nurlaily et al., 2019). Therefore, the PBL model can be an effective alternative in improving students' ability to face chemistry learning problems. However, the problem-based learning model can be combined with local culture, one of which is ethnochemistry.

Ethnochemistry is an ethnoscience related to problems related to chemistry (Singh & Chibuye, 2016). In the ethnochemistry-based problem-based learning model, students are given problems related to daily life related to local culture related to chemistry (Marasinghe, 2016). This teaching model allows students to develop their problem-solving, critical thinking, and communication skills, as well as have the opportunity to develop cultural awareness and concern for the environment. Previous research from Indonesia based on ethnoscience-based problem-based learning models can improve students' critical and creative thinking skills (Aristin et al., 2023; Ardianti & Raida, 2022; Yanto et al., 2023). In addition, the ethnoscience-based problem-based learning model can also improve learning outcomes and students' critical thinking skills in learning (Hikmawati et al., 2020). Research by Yuliana et al. (2021) stated that the ethnoscience-based problem-based learning model can improve students' science literacy.

Method

This research is a type of meta-analysis research. Meta-analysis is a type of research that quantitatively analyzes previous primary research (Martin et al., 2022; Li et al., 2022). This meta-analysis serves to evaluate the influence of ethnochemistry-based problem-based learning models on students' problem-solving abilities in chemistry learning. According to Borenstein et al. (2007), the meta-analysis research procedure consists of 1) determining the inclusion criteria of each study; 2) collecting and encoding research data and 3) analyzing data statistically can be seen in figure 1.

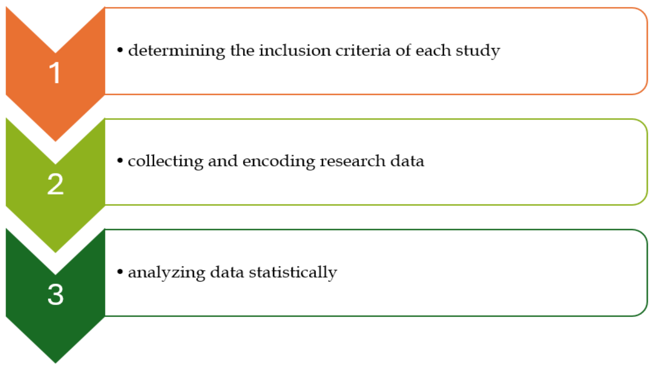

Figure 1. Research procedure

Eligibility Criteria

The research data included in this study must meet the inclusion criteria, namely 1) research data comes from SINTA and Scopus indexed journals; 2) The research was published in 2021-2024; 3) research must be experimental and quasi-experimental methods; The research was obtained through the Google Scholar database; ERIC; ScienceDirect; Wiley and IEEE; 4) The research must be open access and 5) the research presents complete results to calculate the effect size value. From the results of the data search, 17 applications that met the inclusion criteria were obtained which can be seen in (Table 2).

Data Collection

The data collection process in this meta-analysis comes from the google scholar database; ERIC; sciencedirect; Wiley and IEEE. The research data collected is related to the influence of ethnochemistry-based problem-based learning model on students' problem-solving ability in chemistry teaching; The keywords used are "problem based learning model"; "Problem based learning based on ethnochemistry"; "Ethnochemical-based problem-based learning on problem-solving skills"; and "Students' problem-solving skills in chemistry learning".

Data Analysis

The data analysis used in the meta-analysis study calculated the effect size value (Aybirdi et al., 2023). The effect size calculated is the magnitude of the influence of the ethnochemistry-based problem-based learning model on students' problem-solving ability in chemistry learning. According to Borenstein et al. (2007) the steps of data analysis in meta-analysis research are 1) calculating the effect size value of each study; 2) conducting data heterogeneity tests and determining estimation models; 4) testing publication bias and 5) p-value analysis to test research hypotheses. Furthermore, statistical analysis is carried out with the help of the JSAP application. The effect size criteria for this study can be seen in Table 1.

Table 1. Criteria for Effect Size Value (Borenstein et al., 2007)

Effect Size	Effect Size Criteria
-015 ≤ ES ≤ 0.15	No effect
0.15 ≤ ES ≤ 0.40	Small Effect
0.40 ≤ ES ≤ 0.75	Medium Effect
0.75 ≤ ES ≤ 1.10	Large Effect
0.10 ≤ ES ≤ 01.45	Very large effect
ES ≥ 1.45	Amazing Effect

Result and Discussion

Based on the results of the analysis of 17 studies that have met the inclusion criteria, effect size and error standard can be seen in Table 2. Based on Table 2, the analysis of the effect size value ranges from 0.49 to 2.13 and the standard error ranges from 0.16 to 0.52. According to the criteria of effect size value (Gignac & Szodorai, 2016; Borenstein et al., 2007), of the 17 effect sizes analyzed, there were three studies (17.64%) with medium criteria, five studies (29.41%) with large criteria, six studies (35.29%) with very large criteria, and three studies (17.64%) with Criteria Amazing's effect size. Furthermore, an effective estimation model was determined to analyze the 17 effect sizes used as research data. The results of the analysis of the fixed and random models can be seen in Table 3.

Table 2. Effect Size and Standard Error

Journal Code	Year	Effect Size	Standard Error
PK1	2024	1.32	0.34
PK2	2024	0.98	0.29
PK3	2021	2.13	0.47
PK4	2023	0.72	0.22
PK5	2023	1.18	0.37
PK6	2023	1.02	0.31
PK7	2024	0.81	0.28
PK8	2024	1.45	0.44
PK9	2022	0.76	0.21
PK10	2022	0.94	0.39
PK11	2021	1.23	0.47
PK12	2023	1.09	0.35
PK13	2021	2.04	0.52
PK14	2024	1.33	0.41
PK15	2024	0.66	0.18
PK16	2023	0.49	0.16
PK17	2023	1.28	0.42

Table 3. Fixed and Random Effect Model

	Q	Df	p
Omnibus test of Coefficients Model	53.316	1	< 0.001
Test of Residual Heterogeneity	157.779	16	<.0001

Note: p – value are approximate
Notes: The model was estomated using restricted ML Methods

Table 3 the results of the Q value analysis of 157.779 are greater than 53.316 with a confidence level of 95%. This finding concluded that 17 effect sizes were heterogeneously distributed with a p < value of 0.001. Therefore, the effective model used to analyze the 17 effect sizes is the random effect model.

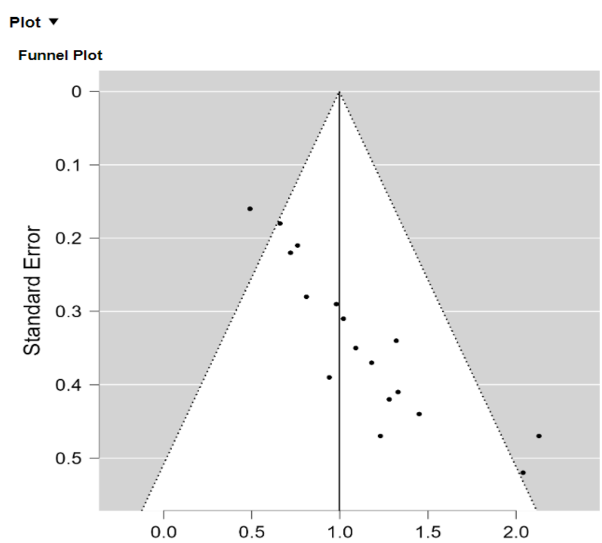

Figure 2. Funnel plot standard error

Furthermore, the publication bias of the 17 effect sizes analyzed was checked. Bias checking functions to find out whether there is a publication bias against the data entered. Publication bias checking using plot funnel analysis and Rosenthal Fail Safe N (Borenstein et al., 2007; Li et al., 2022; Aybirdi et al., 2023). The results of publication bias analysis with funnel plot can be seen in Figure 2.

Based on Figure 2, the results of the effect size analysis with the funnel plot are difficult to know whether it is symmetrical or asymmetrical. Thus, it is necessary to carry out further tests of Rosenthal Fail Safe N. The results of the Rosentahl Fail Safe N test can be seen in Table 4.

Table 4. Rosenthal Test Fail Safe N

	File Drawer Analysis		
	Safe N Files	Target Significance	Observed Significance
Rosenthal	1161.000	0.050	< 0.001

Table 4 the value k = 17 then (5k + 10) = 5 (17) + 10 = 95. The Rosenthal Fail Safe N test score was 1161 with a target significance of 0.050 and $p < 0.001$. Because the Fail Safe N value > 5k + 10, this finding concludes that the effect size included is not biased in publication and can be scientifically accounted for. Furthermore, calculate the p-value to test the research hypothesis through mean effect size analysis. The results of the mean effect size analysis can be seen in Table 5.

Table 5. Mean Effect Size

Coeficients				
	Estimate	Standard Error	z	p
Intercept	0.997	0.298	10.165	< 0.001

Table 5 the results of the mean effect size analysis with a random effect model obtained a mean effect size value of 0.997 with a standard error of 0.298. This finding is included in the large effect size. The results of the statistical calculation obtained a value of z 10.165 and $p < 0.001$. These results conclude that the ethnochemistry-based problem-based learning model has a significant effect on students' problem-solving ability in chemistry learning compared to conventional models.

This research is in line with Rusmansyah et al. (2023) that the ethnoscience-based problem-based learning model can improve students' critical thinking and problem-solving skills in learning. The findings are in accordance with Yanto et al. (2023) that the ethnochemistry-based problem-based learning model in developing students' problem-solving skills and learning outcomes. Problem-based learning (PBL) that integrates ethnochemistry brings chemistry materials closer to students' real lives, using the local cultural context as a foothold in solving problems (Sudarmin et al., 2019). This model is designed to not only improve conceptual understanding of chemistry, but also to develop students' cognitive and metacognitive skills (Ernawati et al., 2022). Ethnochemistry that explores the relationship between chemical knowledge and cultural practices has the potential to be a powerful tool to make subject matter more relevant and increase students' motivation to learn.

In the ethnochemistry-based PBL model, students are required to analyze problems, identify relevant variables, and develop pragmatic solutions based on chemical knowledge (Winarto et al., 2022). Through this approach, students not only gain more in-depth knowledge of chemistry, but also learn to apply that knowledge in a broader and more diverse context, thus strengthening their ability to solve problems (Hikmawati et al., 2021). The application of ethnochemistry-based PBL model in chemistry learning shows significant potential in improving students' problem-solving skills. The relevance of chemical content to the local cultural context not only increases the relevance of the material, but also motivates students to be more active in the learning process (Yuliana et al., 2021). Despite the challenges, the benefits that can be gained suggest that more schools should consider adopting this model as part of their learning strategies. With the right adjustments and support, this model can be very effective in shaping students' critical thinking and analytical abilities in chemistry learning.

Conclusion

From the results of this study, it can be concluded that the ethnochemistry-based problem-based learning model has a significant influence on students' problem-solving ability with a mean effect size ($d = 0.997$; $p < 0.001$) including the high effect size category. These findings conclude that the ethnochemistry-based problem-based learning model is effective in improving students' problem-solving skills compared to conventional learning models. The results of the meta-analysis provide more accurate information so that it can improve the quality of chemistry learning for students at school. The integration of ethnochemical aspects in chemistry learning not only deepens students' understanding of the material, but also increases the social and cultural relevance of what they learn. Thus, students become more engaged and motivated to actively participate in the learning process, which ultimately helps them develop the critical skills necessary to apply chemical knowledge in real-life situations.

Acknowledgments
The research expresses gratitude to the supervisor who has provided input and suggestions to complete this research, and we would like to thank the JPPIPA editorial board for accepting our paper.

Author Contributions
In the research, the author Hotmauli Gultom contributed to collecting, selecting and analyzing the results of the research. Second author: Eli Rohaeti contributed to providing input and criticism on the content of this study.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

References

Afacan, Ş., & Kaya, E. E. (2022). Investigating Problem-Solving Skills of Students Having Professional Music Training in Terms of Multiple Variables. *International Journal of Educational Methodology*, *8*(1), 117–127. https://doi.org/10.12973/ijem.8.1.117

Am, M. A., Hadi, S., Istiyono, E., & Retnawati, H. (2023). Does differentiated instruction affect learning outcome Systematic review and meta-analysis. *Journal of Pedagogical Research*, 5. https://doi.org/10.33902/JPR.202322021

Amanda, F. F., Sumitro, S. B., Lestari, S. R., & Ibrohim, I. (2022). Developing complexity science-problem based learning model to enhance conceptual mastery. *Journal of Education and Learning (EduLearn)*, *16*(1), 65–75. https://doi.org/10.11591/edulearn.v16i1.20408

Amin̈, S., Utaya, S., Bachri̇, S., Sumarmi̇, S., & Susi̇lo, S. (2020). Effect of Problem Based Learning on Critical Thinking Skill and Enviromental 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

Aristin, N. F., Hastuti, K. P., Arisanty, D., Adyatma, S., & Donna, C. (2023). Effectiveness of problem-based learning models to improve learning outcomes of geography in the new normal learning era. *Journal of Education and Learning (EduLearn)*, *17*(4), 623–632. https://doi.org/10.11591/edulearn.v17i4.20834

Aybirdi, N., Efe, H., & Şal, Ç. A. (2023). The Impact of Flipped Learning on L2 Learners' Achievements: A Meta-Analysis. *Shanlax International Journal of Education*, *11*(S1-Jan), 41–60. https://doi.org/10.34293/education.v11iS1-Jan.5891

Borenstein, M., Hedges, L., & Rothstein, H. (2007). *Introduction to Meta-Analysis*. John Wiley & Sons.

Çeti̇n, İ., Erümi̇t, A. K., Nabi̇yev, V., Karal, H., Kösa, T., & Kokoç, M. (2023). The Effect of Gamified Adaptive Intelligent Tutoring System Artibos on Problem-Solving Skills. *Participatory Educational Research*, *10*(1), 344–374. https://doi.org/10.17275/per.23.19.10.1

Dakabesi, D.-, & Luoise, I. S. Y. (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

Duda, H. J., & Susilo, H. (2018). Science Process Skill Development: Potential of Practicum through Problems Based Learning and Authentic Assessment. *Anatolian Journal of Education*, *3*(1). https://doi.org/10.29333/aje.2018.315a

Ernawati, M. D. W., Sudarmin, S., Asrial, A., Damris, M., Haryanto, H., Nevriansyah, E., Fitriani, R., & Putri, W. A. (2022). How Scaffolding Integrated With Problem Based Learning Can Improve Creative Thinking in Chemistry? *European Journal of Educational Research*, *11*(3), 1349–1361. https://doi.org/10.12973/eu-jer.11.3.1349

Gignac, G. E., & Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personality and Individual Differences*, *102*, 74–78. https://doi.org/10.1016/j.paid.2016.06.069

Hikmawati, H., Suastra, I., & Pujani, N. (2020). Ethnoscience-Based Science Learning Model to Develop Critical Thinking Ability and Local Cultural Concern for Junior High School Students in Lombok. *Jurnal Penelitian Pendidikan IPA*, *7*, 60. https://doi.org/10.29303/jppipa.v7i1.530

Hikmawati, H., Suastra, I. W., Suma, K., Sudiatmika, A. A. I. A. R., & Rohani, R. (2021). Effect of Problem-Based Learning Integrated Local Wisdom on Student Hots and Scientific Attitude. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 233–239. https://doi.org/10.29303/jppipa.v7iSpecialIssue.1118

Jr, M. V. H., & Cruz, M. L. D. (2022). The Gap Between Comprehension Level and Problem-Solving Skills in Learning Mathematics. *Universal Journal of Educational Research*, *1*(1). Retrieved from https://philpapers.org/rec/HIJTGB

Kök, F. Z., & Duman, B. (2023). The effect of problem-based learning on problem-solving skills in English language teaching. *Journal of Pedagogical Research*, 1. https://doi.org/10.33902/JPR.202318642

Li, B., Yu, Q., & Yang, F. (2022). The Effect of Blended Instruction on Student Performance: A Meta-Analysis of 106 Empirical Studies from China and Abroad. *Best Evidence in Chinese Education*, *10*(2), 1395–1403. https://doi.org/10.15354/bece.22.ar018

Maksum, H., Purwanto, W., Siman, S., Ampera, D., Yuvenda, D., & Hasan, H. (2023). Improving Problem-Solving and Communication Skills in Automotive Vocational Education through the Development of Teaching Factory Model with Problem-Based Learning (TEFA-PBL) Concept. *International Journal of Education in Mathematics, Science and Technology*, *12*(2), 364–386. https://doi.org/10.46328/ijemst.3941

Marasinghe, B. (2016). Ethnochemistry and Ethnomedicine of Ancient Papua New Guineans and Their Use in Motivating Students in Secondary Schools and Universities in PNG. *Universal Journal of Educational Research*, *4*(7), 1718–1720. https://doi.org/10.13189/ujer.2016.040726

Martin, F., Wu, T., Wan, L., & Xie, K. (2022). A Meta-Analysis on the Community of Inquiry Presences and Learning Outcomes in Online and Blended Learning Environments. *Online Learning*, *26*(1). https://doi.org/10.24059/olj.v26i1.2604

Ningsih, W., Prayitno, B. A., & Santosa, S. (2023). The effectiveness of environment-oriented e-books based on problem-based learning for problem-solving skills. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(3), 511–520. https://doi.org/10.22219/jpbi.v9i3.25603

Nurlaily, V. A., Soegiyanto, H., & Usodo, B. (2019). Elementary School Teacher's Obstacles in the Implementation of Problem-Based Learning Model in Mathematics Learning. *Journal on Mathematics Education*, *10*(2), 229–238. https://doi.org/10.22342/jme.10.2.5386.229-238

Özpınar, İ., & Arslan, S. (2023). Teacher-based Evaluation of Students' Problem Solving Skills. *International Journal of Psychology and Educational Studies*, *10*(2), 543–560. https://doi.org/10.52380/ijpes.2023.10.2.1160

Purwanto, A., Rahmawati, Y., Rahmayanti, N., Mardiah, A., & Amalia, R. (2022). Socio-critical and problem-oriented approach in environmental issues for students' critical thinking skills development in Chemistry learning. *Journal of Technology and Science Education*, *12*(1), 50. https://doi.org/10.3926/jotse.1341

Rahmawati, Y., Erdawati, E., Ridwan, A., Veronica, N., & Hadiana, D. (2024). Developing students' chemical literacy through the integration of dilemma stories into a STEAM project on petroleum topic. *Journal of Technology and Science Education*, *14*(2), 376. https://doi.org/10.3926/jotse.2221

Rattanakha, R., & Chatwattana, P. (2023). The Problem-based Learning Model: PBL Model via Cloud Technology to Promote Programming Skills. *Higher Education Studies*, *13*(4), 201. https://doi.org/10.5539/hes.v13n4p201

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

Siagian, M. V., Saragih, S., & Sinaga, B. (2019). Development of Learning Materials Oriented on Problem-Based Learning Model to Improve Students' Mathematical Problem Solving Ability and Metacognition Ability. *International Electronic Journal of Mathematics Education*, *14*(2). https://doi.org/10.29333/iejme/5717

Singh, I. S., & Chibuye, B. (2016). Effect of Ethnochemistry Practices on Secondary School Students' Attitude Towards Chemistry. *Journal of Education and Practice*. Retrieved from http://files.eric.ed.gov/fulltext/EJ1105254.pdf

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 Studentsâ€™ Thinking Skills. *Jurnal Pendidikan IPA Indonesia*, *8*(4). https://doi.org/10.15294/jpii.v8i4.17546

Tessema, G., Michael, K., & Areaya, S. (2024a). Realist hands-on learning approach and its contributions to learners' conceptual understanding and problem-solving skills on solid geometry. *Pedagogical Research*, *9*(1), em0186. https://doi.org/10.29333/pr/14096

Treepob, H., Hemtasin, C., & Thongsuk, T. (2023). Development of Scientific Problem-Solving Skills in Grade 9 Students by Applying Problem-Based Learning. *International Education Studies*, *16*(4), 29. https://doi.org/10.5539/ies.v16n4p29

Valdez, J., & Bungihan, M. (2019). Problem-based learning approach enhances the problem solving skills in Chemistry of high school students. *Journal of Technology and Science Education*, *9*(3), 282. https://doi.org/10.3926/jotse.631

Winarto, W., Sarwi, S., Cahyono, E., & Sumarni, W. (2022). Developing a Problem-Solving Essay Test Instrument (PSETI) in the Instruction of Basic Science Concepts in Ethnoscience Context. *Journal of Turkish Science Education*. https://doi.org/10.36681/tused.2022.108

Wynn, C. (2022). Facilitating Postformal Thinking Through Problem-Based Learning in the History Survey Course: An Empirically Tested PBL Model. *Journal of Problem Based Learning in Higher Education*. https://doi.org/10.54337/ojs.jpblhe.v10i1.7288

Yanto, F., Diliarosta, S., Azhar, A., Primasari, M., & Syukri, D. (2023). Development of Science Learning E-Modules Using the Pbl Model with Ethnoscience Approach. *Journal for ReAttach Therapy and Developmental Diversities*, *6*(9s). Retrieved from https://jrtdd.com/index.php/journal/article/view/1669

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*, *21*(92). https://doi.org/10.14689/ejer.2021.92.16

Zeng, Y., Chi, S., Wang, Z., & Zhuang, X. (2023). Developing and Validating an Instrument to Assess Ninth-Grade Students' Online Metacognitive Skills in Solving Chemistry Problems. *Journal of Baltic Science Education*, *22*(3), 520–537. https://doi.org/10.33225/jbse/23.22.520