

The Effect of STEAM-Based Hybrid Based Learning Model on Students' Critical Thinking Skills

Wasito Utomo^{1*}, Wiwid Suryono², Jimmi³, Tomi Apra Santosa⁴, Ika Agustina⁵

¹ Lecturer of Air Traffic, Aviation Polytechnic Surabaya, Surabaya, Indonesia.

² Lecturer at Aviation Polytechnic Surabaya, Surabaya, Indonesia.

³ English Lecturer, Faculty of Communication and Languages, Binus University of Informatics, Jakarta, Indonesia.

⁴ Civil Engineering Lecturer, Adikarya Technical Academy, Kerinci, Indonesia.

⁵ Lecturer in Media, Politeknik Negeri Media Kreatif, Jakarta, Indonesia.

Received: July 5, 2023

Revised: September 16, 2023

Accepted: September 25, 2023

Published: September 30, 2023

Corresponding Author:

Wasito Utomo

wasitoutomo@gmail.com

DOI: [10.29303/jppipa.v9i9.5147](https://doi.org/10.29303/jppipa.v9i9.5147)

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



Abstract: The purpose of the study was to determine the effect of STEAM-based hybrid based learning model on students' critical thinking skills. This research is a type of meta-analysis research. The research data came from 15 national and international journals. The process of searching for data sources through the google scholar database, Science Direct, Eric, Plos ONE and Wiley. The data selection method is the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. The inclusion criteria for this meta-analysis research are that the research must be published in the last 5 years 2018-2023, the research must use experimental or quasi-experimental methods, the research must have an experimental class that applies a hybrid-based learning model and a control class, the research comes from journals indexed by SINTA and Scopus, and the research has complete data to calculate the effect size. The data analysis technique is quantitative analysis by calculating the effect size value, research heterogeneity and publication bias with the help of the Comprehensive Meta-analysis (CMA) version.3 application. The results of the study concluded that the summary effect size or average effect size ($p < 0.01$; $ES = 1.052$) criteria were strong. This finding explains that the hybrid-based learning model has a significant effect on students' critical thinking skills. This STEAM-based hybrid-based learning model has a higher effect on students' critical thinking skills than the conventional model. Model has a high influence on students' critical thinking skills than conventional models.

Keywords: Critical thinking; Education; Hybrid based learning model; Meta-analysis

Introduction

Critical thinking is a skill that students must have in order to face the 21st century (Jamaludin et al., 2022; Elfira et al., 2023; Amin et al., 2020; Dakabesi et al., 2019). Soffe et al. (2015) critical thinking is a process of students thinking deeply and in detail about information. Critical thinking skills encourage students to think deeply and carefully in solving a problem (Ariani, 2020; Supratman et al., 2021; Wan et al., 2018). Furthermore, critical thinking skills train students to be more active and easy to explore the subject matter (Fikriyatii et al., 2022; Aloisi & Callaghan, 2018; Jeanne & Green, 2011; Rahman et al., 2023). Students who have critical thinking skills find it

easier to analyze and solve a phenomenon in life (Herzon et al., 2018; Temel, 2022).

However, the reality in schools is that critical thinking skills in learning activities are still relatively low (Ichsan et al., 2019; Nurtamam et al., 2023; Zulkifli et al., 2022; Nur et al., 2023; Prihono et al., 2020). Low student interest and motivation to learn, making them less active in learning (Phasa, 2020; Suryono et al., 2023). The learning process does not involve students to think critically in solving a problem (Hamengkubuwono et al., 2016; Wahyuni, 2021; Ichsan et al., 2023). Furthermore, the results of the Trends in International Mathematics and Science Study (TIMSS) survey in 2018 showed that the critical thinking skills of Indonesian students only scored 396, much lower than the average international

How to Cite:

Utomo, W., Suryono, W., Jimmi, J., Santosa, T.A., & Agustina, I. (2023). The Effect of STEAM-Based Hybrid Based Learning Model on Students' Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 9(9), 742-750. <https://doi.org/10.29303/jppipa.v9i9.5147>

score of 500 (Luciana et al., 2023; Nurlaeli et al., 2018; Putra et al., 2023). Research results Listiqowati (2022) The low level of students' critical thinking skills in learning is influenced by the selection of inappropriate learning models and methods.

Hybrid based learning is a digital-based learning model that can be done by students online (Cheerapakorn & Chatwattana, 2023; Fitriyana et al., 2021; Strehl et al., 2022; Yalcin, 2022). Hybrid based learning helps make learning easier and more effective through the internet (Essa, 2023; Bastos et al., 2021; Rukayah et al., 2022). Research results Suwandi et al. (2021) Hybrid based learning model can encourage students' thinking skills in facing the industrial revolution 4.0. Hybrid based learning helps students learn independently using technology so as to encourage students to think and be creative in learning (Hutasuhut et al., 2022; Santosa et al., 2021; Mccann et al., 2010).

Furthermore, STEAM-based hybrid based learning is one of the learning models that effectively improves students' higher order thinking skills (Rahardjanto et al., 2019; Masalimova et al., 2021; Sigit et al., 2022). STEAM is a learning approach that combines Science Technology Engineering Arts and Mathematics in learning activities (Özer & Demirbatır, 2023; Ichsan et al., 2023; Konuş & Topsakal, 2022; Houghton et al., 2022). This STEAM approach encourages students to be more creative and independent in learning so as to train their critical thinking skills (Frediana et al., 2021; Cobos et al., 2023). Research results Fitriyah et al. (2021) the application of STEAM mapping can train students' creative and critical thinking skills in learning. In addition, research by Budiyo et al. (2020) stated that the application of STEAM in the learning process fosters creativity and understanding of learning concepts in students to develop their cognitive knowledge.

Previous research by Hidayat et al. (2019) the application of hybrid based learning model can improve students' motivation and learning outcomes. Research results Nurdiansah et al. (2021) hybrid based learning influences students' science process skills. Furthermore, STEAM-based hybrid based learning supports offline and online learning activities to achieve learning objectives (Lugthart & Dartel, 2021; Lii et al., 2022). But in reality, there are still few studies on hybrid based learning that describe the effect size of STEAM-based hybrid based learning models. Therefore, this research needs to be done to find out how much the effect size of the hybrid based learning model is in the learning process. Based on the above problems, this study aims to determine the effectiveness of the STEAM-based hybrid based learning model on students' critical thinking skills.

Method

Design Research

This research is a type of meta-analysis research. Meta-analysis is a research method that analyzes previous research that can be analyzed statistically quantitatively (Zulyusri et al., 2023; Chamdani et al., 2022; Rahman et al., 2023; Supriyadi et al., 2023; Diah et al., 2022). Meta-analysis research is used to determine the effectiveness of STEAM-based hybrid based learning model on students' critical thinking skills. This research data comes from journals that have relevance to the research variables.

Data Collection Procedures

The data collection process in this study came from national and international journals. Data sources were searched through google scholar, ScienceDirect, ProQuest, Wiley and ERIC databases. The keywords for searching data sources are "hybrid based learning, STEAM and critical thinking skills". The process of selecting data sources using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method can be seen in Figure 1.

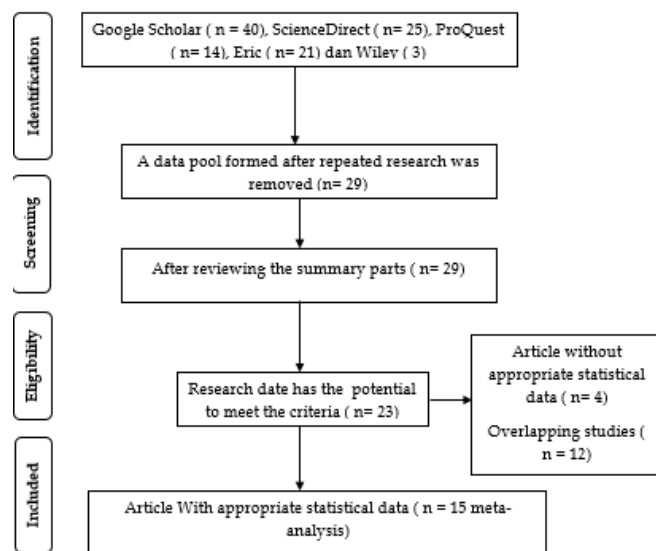


Figure 1. Data selection with PRISMA

Eligibility Criteria

In this meta-analysis research has criteria that aim to produce a broader analysis. For hypothesis testing in meta-analysis research, it is very helpful in determining the inclusion and exclusion criteria from the beginning of relevant research (Higgins et al., 2019). As for the publication criteria in this study, namely research from national and international journals published in 2015-2023; research comes from various countries; research journals in Indonesian and English; has an experimental class with a hybrid based learning model and a control

class; Research samples come from elementary, junior high, high school and university students; research must be indexed by SINTA and Scopus and have a value (r), (f) and (t).

Data Coding

Data coding in meta-analysis plays an important role in data collection and analysis (Demir & Kaya, 2022;

Harun et al., 2021). For information in coding data in this meta-analysis consists of research code, publication year, publication type, sample size (N) and correlation coefficient (r) and research variables (depended and independent). The results of data coding can be seen in Table 1.

Table 1. Data Coding

Research Code	Year	N	r	t	F	Variable
P1	2016	26	0.790	12.019		Critical Thinking
P2	2023	40	0.617			Critical Thinking
P3	2020	60	0.912	3.056		Critical Thinking
P4	2020	200	0.821			Critical Thinking
P5	2021	98	0.772			Critical Thinking
P6	2023	24	0.65	9.230		Critical Thinking
P7	2021	42	0.918	2.173		Critical Thinking
P8	2021	38	0.716	8.076		Critical Thinking
P9	2021	45	1.29			Critical Thinking
P10	2023	130	0.870			Critical Thinking
P10	2021	76	0.816	9.324		Critical Thinking
P11	2017	88	0.702	7.862		Critical Thinking
P12	2018	50	0.903	2.720		Critical Thinking
P13	2018	62	0.962	14.313		Critical Thinking
P14	2015	57	0.815			Critical Thinking

Data Analysis

For data analysis in this meta-analysis research, the steps consisted of: analyze the characteristics of the research sample, code the research data; convert the t and f values to the correlation value r with the formula:

$$F = t^2 \tag{1}$$

$$t = \sqrt{F} \tag{2}$$

$$r = \frac{t}{\sqrt{t^2 + N - 2}} \tag{3}$$

Furthermore, 4) calculate the effect size heterogeneity test; 5) accumulate the average effect size; 5) conduct hypothesis testing; 6) calculate the publication bias with Trim fills. In the hypothesis testing process by looking at the p-value. Statistical data analysis with the help of the Comprehensive Meta-Analysis (CMA) version 3.0 application. Cohen's (1988) Effect Size criteria values can be seen in Table 2.

Table 2. Effect Size Criteria Values (Yusuf, 2023; Chamdani et al., 2022; Razak et al., 2021)

Effect Size	Criteria
0 until 1.	Weak Effect Size
< .3	Modest Effect Size
< .5	Medium Effect Size
< .8	Strong Effect Size
≥ .8	Very Strong Effect Size

Result and Discussion

Results

Based on the inclusion criteria that have been determined above, there are 14 studies that meet the inclusion criteria regarding the STEAM-based hybrid based learning model on students' critical thinking skills. Research journals were used from 2015-2023 publications. The smallest research sample size (N = 40) and the largest research sample (N = 120). The research data were analyzed to obtain the r, t and F values of each study. To calculate the value of heterogeneity, it is necessary to convert the value of t or f from all studies to the value of r. The results of the heterogeneity test can be seen in Table 3 and Table 4.

Table 3. Research Heterogeneity Test Results

	Q	df	P
Omnibus test of Model Coefficients	69.130	1	< 0.001
Test of Residual Heterogeneity	452.108	13	< 0.001

Note: p value are approximate

Table 4. The Residual Heterogeneity Test Result

	Estimate	Lower	Upper
τ^2	0.510	0.218	0.945
τ	0.684	0.584	0.872
I^2 (%)	94.442	9.997	99.543
H^2	29.907	16.116	43.079

Tables 3 and 4 show that the effect size values of 14 national and international studies analyzed are heterogeneously distributed. The p value < 0.001 ; $Q = 69.130$ or $\tau^2 > 0.00$ and I^2 (%) = 94.442 close to 100%. Furthermore, the Summary effect value or average effect size can be seen in Table 5.

Table 5. Summary Effect Size Test Values

	Estimate	Standard Error	z	p	Lower	Upper
Intercept	1.052	0.072	7.173	0.01	0.872	1.324

Table 5 shows that the p value is < 0.01 , so there is an influence of the STEAM-based hybrid based learning model on students' critical thinking skills. In this analysis, it is known that this influence is strong criteria with a value of 1.052. Furthermore, calculating publication bias with funnel plot, Trim and Fills Test. A total of 14 studies analyzed to determine publication bias can be depicted in Figure 2.

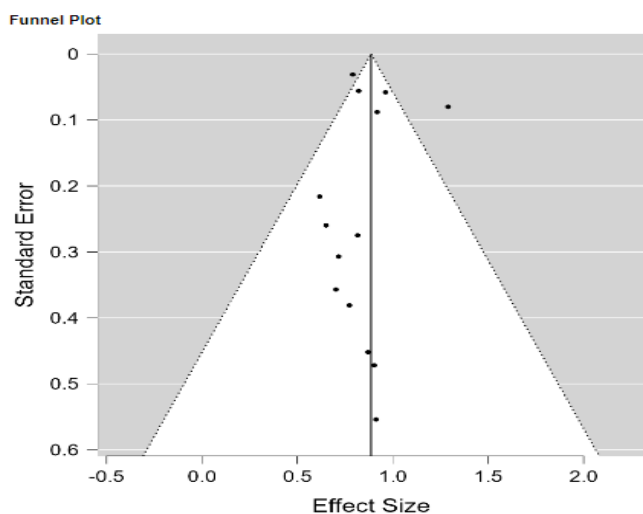


Figure 2. Funnel plot

Based on Table 1 Shows that the study points are in the vertical line. This illustrates an accurate effect size. Furthermore, the study points are difficult to describe symmetrically or asymmetrically so it is necessary to do the Egger test to determine publication bias. The results of the Eggers test can be seen in Table 6.

Table 6. Eggers Test Results

	z	p
Sei	1.073	0.233

Table 6 Shows the p -value < 0.05 so that the research in the funnel plot is symmetrical. This result explains that in this study there is no publication bias. Furthermore, to increase valid data in publication bias, it is necessary to conduct the Fail Safe N (FSN) test. The

results of the Fail Safe N (FSN) test can be seen in Table 7.

Based on table 7 shows the value of fail safe N (FSN = 3940) so that it is entered in the formula $5k + 10 = (5.14) + 10 = 3940/80 = 49.25$. These results explain that research in meta-analysis is resistant to publication bias.

Table 7. Fail Safe N (FSN) Test Results

	Fail Safe N	Sign.	Observed Significance
Roshental	3940	0.05	< 0.001

Discussion

The application of STEAM-based hybrid-based learning model has a strong influence on students' critical thinking skills. This can be seen in Table 5 summary effect size or average effect size value ($p < 0.01$; $ES = 1.052$). The results of this study are in line with (Montafej et al., 2022) the hybrid based learning model can encourage students' critical thinking skills. Hybrid based learning trains students to learn actively and creatively so that it can train critical thinking in students (Thamrin et al., 2022; Sujanem et al., 2018; Trisnowati et al., 2022). In addition, the STEAM-based hybrid based learning model helps teachers more easily carry out the learning process both offline and during. The STEAM-based hybrid-based learning model can be done online and face-to-face so that the learning process can be accessed at any time (Yani, 2018; Purba, 2022).

Furthermore, the STEAM-based hybrid based learning model increases students' understanding of technology-based learning (Muñoz et al., 2020). STEAM-based hybrid-based learning model students can develop knowledge competencies so as to foster critical thinking skills. Ali et al. (2018) the application of STEAM-based hybrid-based learning models can foster student interest and motivation that helps students learn actively and creatively. This is because the STEAM approach fosters students' creative and critical thinking in learning (Bedar & Al-shboul, 2021; Smith et al., 2021). Not only that, the research results Harahap et al. (2021) Science Technology Engineering Arts and Mathematics (STEAM) based learning can develop students' concept understanding compared to conventional learning.

The STEAM-based hybrid based learning model is very effective in helping students gather learning information online which encourages students' critical thinking skills in learning (Ardiansyah & Wasan, 2022). Critical thinking skills are very important for students in solving a problem (Que et al., 2022; Suharyat et al., 2022; Fradila et al., 2021; Makhmudah et al., 2021). Research results Bassachs et al. (2020) Critical thinking skills help students more easily analyze and synthesize a phenomenon that occurs in life. In addition, students who have critical thinking skills have high motivation and interest in learning (Ariani, 2020; Yaki, 2022;

Dahyeon et al., 2018). So, the existence of a STEAM-based hybrid based learning model is an effective model to improve students' critical thinking skills.

Conclusion

From this meta-analysis research, it can be concluded that the summary effect size or average effect size ($p < 0.01$; $ES = 1.052$) criteria are strong. This finding explains that the hybrid-based learning model has a significant effect on students' critical thinking skills. This STEAM-based hybrid-based learning model has a higher effect on students' critical thinking skills than the conventional model.

Acknowledgments

The researcher would like to thank all the authors who have been involved directly or indirectly in completing this research, and we would like to thank the editorial board of JPPIPA for being willing to publish this research.

Author Contributions

This research consists of five researchers who have their own contributions. Wasito and Wiwid suryono contributed in collecting research data from the journal database. Jimmi and Ika Agustina contributed in selecting and filtering data from the journal database. Tomi Apra santosa contributed in analysing and presenting the research data with JSAP application.

Funding

This Research Received external funding.

Conflicts of Interest

The authors declare no conflict of interest.

References

- Ali, M., & Kassem, M. (2018). Improving EFL Students' Speaking Proficiency and Motivation: A Hybrid Problem-based Learning Approach. *Theory and Practice in Language Studies*, 8(7), 848-859. <https://doi.org/10.17507/tpls.0807.17>
- Aloisi, C., & Callaghan, A. (2018). Threats to the validity of the Collegiate Learning Assessment (CLA+) as a measure of critical thinking skills and implications for Learning Gain. *Higher Education Pedagogies*, 3(1), 137-162. <https://doi.org/10.1080/23752696.2018.1449128>
- 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>
- Ardiansyah, A., & Wasan, A. (2022). Pengaruh model teaching personal and social responsibility (TPSR) berbasis hybrid dan online learning serta tanggung jawab terhadap aktivitas fisik The effect of teaching personal and social responsibility (TPSR) model based on hybrid and online learn. *Jurnal Olahraga Pendidikan Indonesia (JOPI)*, 1(2), 139-153. Retrieved from <https://jopi.kemenpora.go.id/index.php/jopi/article/view/96>
- Ariani, R. F. (2020). Pengaruh Model Pembelajaran Problem Based Learning Terhadap Kemampuan Berpikir Kritis Siswa SD. *Jurnal Imiah Pendidikan Dan Pembelajaran*, 4(3), 422-432. <https://doi.org/10.23887/jipp.v4i3.28165>
- Bassachs, M., Cañabate, D., Serra, T., & Bubnys, R. (2020). education sciences Fostering Critical Reflection in Primary Education through STEAM Approaches. *Educ. Sci.* 2020, 10(384), 1-14. <https://doi.org/10.3390/educsci10120384>
- Bastos, M., & Pp, I. C. (2021). Cypriot Journal of Educational Hybrid model in accounting education: The experience of management simulation course. *Cypriot Journal of Educational Sciences* Volume, 16(5), 2402-2411. <https://doi.org/10.18844/cjes.v16i5.6345>
- Bedar, R. W. A., & Al-shboul, M. A. (2020). The Effect of Using STEAM Approach on Motivation Towards Learning Among High School Students in Jordan. *International Education Studies*, 13(9), 48-57. <https://doi.org/10.5539/ies.v13n9p48>
- Budiyono, A., Husna, H., & Wildani, A. (2020). Pengaruh penerapan model pbl terintegrasi steam terhadap kemampuan berpikir kreatif ditinjau dari pemahaman konsep siswa. *Edusains*, 12(2), 166-176. Retrieved from <https://journal.uinjkt.ac.id/index.php/edusains/article/view/13248/pdf>
- Cahaya Phasa, K. (2020). Meta Analisis Pengaruh Model Pembelajaran Problem Based Learning Terhadap Kemampuan Berpikir Kritis Dalam Pembelajaran Matematika. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 4(2), 711-723. <https://doi.org/10.31004/cendekia.v4i2.296>
- Chamdani, M., Yusuf, F. A., Salimi, M., & Fajari, L. E. W. (2022). Meta-Analysis Study: The Relationship between Reflective Thinking and Learning Achievement. *Journal on Efficiency and Responsibility in Education and Science*, 15(3), 181-188. <http://dx.doi.org/10.7160/eriesj.2022.150305>
- Cheerapakorn, P., & Chatwattana, P. (2023). *The Virtual Learning Environment Model on Cloud using Hybrid Learning*. 13(1), 42-49. <https://doi.org/10.5539/hes.v13n1p42>
- Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences Second Edition*. Lawrence Erlbaum Associates.

- Dahyeon, H. S., Hyunjin, R., & Hyungshin, P. (2018). What Constitutes Korean Pre-service Teachers' Competency in STEAM Education : Examining the Multi-functional Structure. *The Asia-Pacific Education Researcher*.
<https://doi.org/10.1007/s40299-018-0410-5>
- 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>
- 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>
- Essa, E. K. (2023). The Effectiveness of Hybrid Learning in Enhancing Academic Mindfulness and Deeper Learning of University Students To cite this article : Essa, E. K. (2023). The effectiveness of hybrid learning in enhancing academic mindfulness The Effectiveness of H. *International Journal of Research in Education and Science (IJRES)*, 9(1), 188-202.
<https://doi.org/10.46328/ijres.3081>
- Fikriyatii, A., Surabaya, U. N., Agustini, R., Surabaya, U. N., Sutoyo, S., Surabaya, U. N., Planning, H. E., & Board, C. (2022).ritical thinking cycle model to promote critical thinking disposition and critical thinking skills of pre-service science teache. *Cypriot Journal of Educational Sciences*, 17(1), 120-133.
<https://doi.org/10.18844/cjes.v17i1.6690>
- Fitriyah, A., & Ramadani, S. D. (2021). Pengaruh Pembelajaran Steam Berbasis Pjbl (Project-Based Learning) Terhadap Keterampilan. *Journal of Chemistry And Education (JCAE)*, X(1), 209-226.
<https://doi.org/10.24252/ip.v10i1.17642>
- Fitriyana, N., Wiyarsi, A., Sugiyarto, K. H., & Ikhsan, J. (2021). The Influences of Hybrid Learning with Video Conference and Learning , and Achievement toward Chemistry. *Journal of Turkish Science Education*, 18(2), 233-248. Retrieved from <https://www.tused.org/index.php/tused/article/view/703/665>
- Fradila, E., Razak, A., Santosa, T. A., Arsih, F., & Chatri, M. (2021). Development Of E-Module-Based Problem Based Learning (PBL) Applications Using Sigil The Course Ecology And Environmental Education Students Master Of Biology. *International Journal of Progressive Sciences and Technologies (IJPSAT)*, 27(2), 673-682.
<http://dx.doi.org/10.52155/ijpsat.v27.2.3248>
- Frediana, E., Kartika, R., Vh, E. S., & Indriyanti, N. Y. (2021). Development And Validation Of Web-Based Steam Online Platform To Improve Learning Quality In Pre-Service. *Journal of Technology and Science Education*, 11(2), 513-525. Retrieved from <https://dialnet.unirioja.es/servlet/articulo?codigo=8302410>
- Hamengkubuwono, Asha, L., Warsah, I., Ruly, M., & Adhrianti, L. (2016). The Effect of Teacher Collaboration as the Embodiment of Teacher Leadership on Educational Management Students' Critical Thinking Skills. *European Journal of Educational Research*, 11(3), 1315-1326.
<https://doi.org/10.12973/eu-jer.11.3.1315>
- Harahap, M. S., Nasution, F. H., & Nasution, N. F. (2021). Efektivitas pendekatan pembelajaran science technology engineering art mathematic (STEAM) terhadap kemampuan komunikasi matematis. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 10(2), 1053-1062.
<https://doi.org/10.24127/ajpm.v10i2.3633>
- Harun, Kartowagiran, B., & Manaf, A. (2021). Student Attitude and Mathematics Learning Success : A Meta-Analysis. *International Journal of Instruction*, 14(4), 209-222. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1319617.pdf>
- Herzon, H. H., Budijanto, & Utomo, H. D. (2018). Pengaruh Problem-Based Learning (PBL) terhadap Keterampilan Berpikir Kritis. *Jurnal Pendidikan*, 3(1), 42-46.
<http://dx.doi.org/10.17977/jptpp.v3i1.10446>
- Hidayat, M. Y., & Andira, A. (2019). Pengaruh model pembelajaran hybrid learning berbantuan media schoology terhadap hasil belajar. *JPF (Jurnal Pendidikan Fisika) Universitas Islam Negeri Alauddin Makassar*, 7(2), 140-148.
<https://doi.org/10.24252/jpf.v7i2.9442>
- Higgins, J. P. T., López-, J. A., Becker, B. J., Davies, S. R., Dawson, S., Grimshaw, J. M., Mcguinness, L. A., Moore, T. H. M., Rehfuess, E. A., Thomas, J., & Caldwell, D. M. (2019). *Synthesising quantitative evidence in systematic reviews of complex health interventions*. 1-15.
<https://doi.org/10.1136/bmjgh-2018-000858>
- Houghton, T., Houghton, T., Lavicza, Z., Rahmadi, I. F., & Fenyvesi, K. (2022). STEAMTEACH Austria : Towards a STEAM Professional Development

- Program To cite this article: STEAMTEACH Austria: Towards a STEAM Professional Development Program. *International Journal of Research in Education and Science (IJRES)*, 8(3), 502–512. <https://doi.org/10.46328/ijres.2747>
- Ichsan, I., Suharyat, Y., Santosa, T. A., & Satria, E. (2023). The Effectiveness of STEM-Based Learning in Teaching 21 st Century Skills in Generation Z Student in Science Learning: A Meta-Analysis. *Jurnal Penelitian Pendidikan IPA*, 9(1), 150-166. <https://doi.org/10.29303/jppipa.v9i1.2517>
- Ichsan, I. Z., Sigit, D. V., Miarsyah, M., Ali, A., Arif, W. P., & Prayitno, T. A. (2019). HOTS-AEP: Higher order thinking skills from elementary to master students in environmental learning. *European Journal of Educational Research*, 8(4), 935–942. <https://doi.org/10.12973/eu-jer.8.4.935>
- Iii, J. W. H., King-corken, A., & Devaney, T. (2022). The Future Of Teaching And Learning : Face To Face , Hybrid , And Online Instructional Delivery Models. *International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2022)*, 308–312. Retrieved from <https://files.eric.ed.gov/fulltext/ED626884.pdf>
- Jamaludin, J., Kakaly, S., & Batlolona, J. R. (2022). Critical thinking skills and concepts mastery on the topic of temperature and heat. *Journal of Education and Learning (EduLearn)*, 16(1), 51–57. <https://doi.org/10.11591/edulearn.v16i1.20344>
- Jeanne, S., & Green, W. (2011). Critical thinking in a first year management unit : the relationship between disciplinary learning , academic literacy and. *Higher Education Research & Development*, 30(3), 303–315. <https://doi.org/10.1080/07294360.2010.501075>
- Konuş, Ö. C., & Topsakal, Ü. U. (2022). The Effects of STEAM-Based Activities on Gifted Students ' STEAM Attitudes , Cooperative Working Skills and Career Choices. *Journal of Science Learning Way*, 5(3), 398–410. <https://doi.org/10.17509/jsl.v5i3.46215>
- Listiqowati, I., & Ruja, I. N. (2022). The Impact of Project-Based Flipped Classroom (PjBFC) on Critical Thinking Skills. *International Journal of Instruction*, 15(3), 853–868. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1355340.pdf>
- Luciana, O., Santosa, T. A., Rofi'i, A., Taqiyuddin, T., & Nasution, B. (2023). Meta-Analysis: The Effect of E-Learning-Based Mind Mapping on Students' Critical Thinking Skills. *Edumaspul: Jurnal Pendidikan*, 7(2), 2058-2068. <https://doi.org/10.1063/1.5139796>
- Lugthart, S., & Dartel, M. Van. (2021). Simulating Professional Practice in STEAM Education : A Case Study. *European Journal of STEM Education*, 6(1), 1–8. <https://doi.org/10.20897/ejsteme/11393>
- Lupión-cobos, T., Crespo-gómez, J. I., & García-ruiz, C. (2023). Challenges and Opportunities to Teaching Inquiry Approaches By STE (A) M Projects in the Primary Education. *Journal of Baltic Science Education*, 22(3), 1–16. <https://doi.org/10.33225/jbse/23.22.454>
- Makhmudah, S., Suyitno, H., & Rusilowati, A. (2021). Mathematics Critical Thinking Ability Reviewing from Gender and Independent Learning Students in Stem Problem-Based Learning Assisted by Web E Learning School. *Unnes Journal of Mathematics Education Research*, 10(2), 211–219. Retrieved from <https://journal.unnes.ac.id/sju/index.php/ujmer/article/download/49310/20022>
- Masalimova, A. R., Ryazanova, E. L., Tararina, L. I., Sokolova, E. G., Ikrennikova, Y. B., Efimushkina, S. V., Shulga, T. I., Masalimova, A. R., Ryazanova, E. L., Tararina, L. I., Sokolova, E. G., Ikrennikova, Y. B., Efimushkina, S. V., Planning, H. E., & Board, C. (2021). Cypriot Journal of Educational pandemic perspective: Collaborative technologies aspect. *Cypriot Journal of Educational Sciences*, 16(1), 389–395. <https://doi.org/10.18844/cjes.v16i1.5536>
- Mccann, A. L., Schneiderman, E. D., & Babler, W. J. (2010). Application of Basic Science to Clinical Problems: Traditional vs. Hybrid Problem-Based Learning. *Educational Methodologies*, 74(10), 1114–1124. <https://doi.org/10.1002/j.0022-0337.2010.74.10.tb04966.x>
- Montafej, J., Lotf, A. R., & Chalak, A. (2022). The Effectiveness of Hybrid and Pure Problem-Based Learning in the Productive Skills and Critical Thinking of Iranian Undergraduate Students through MALL Application. *Education Research International*, 1–11. <https://doi.org/10.1155/2022/1531210>
- Nur, T. D. , Corebima, A. D. , Zubaidah, S. , Ibrohim, I. & Saefi, M. (2023). Learning Biology through Thinking Empowerment by Questioning: The Effect on Conceptual Knowledge and Critical Thinking. *Participatory Educational Research*, 10 (1), 122-139. <https://doi.org/10.29333/ejmste/13651>
- Nurdiansah, I., & Makiyah, Y. S. (2021). Efektivitas Modul Hybrid Project Based Learning (H-Pjbl) Berbasis Laboratorium Untuk Meningkatkan Keterampilan Proses Sains Siswa. *Jurnal Pendidikan Fisika dan Teknologi*, 7(2), 104-110. <http://dx.doi.org/10.29303/jpft.v7i2.2750>
- Nurlaeli, N., Noornia, A., & Wiraningsih, E. D. (2018). Pengaruh Model Pembelajaran Problem Based Learning terhadap Kemampuan Berpikir Kritis Matematis Siswa ditinjau dari Adversity Quotient. *FIBONACCI: Jurnal Pendidikan Matematika dan Matematika*, 4(2), 145-154. <https://doi.org/10.24853/fbc.4.2.145-154>

- 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>
- Özer, Z., & Demirbatır, R. E. (2023). Examination of STEAM-based Digital Learning Applications in Music Education. *European Journal of STEM Education*, 8(1), 1-11. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1377876.pdf>
- Prihono, E. W., Khasanah, F., Konvensional, P., Berpikir, K., & Matematis, K. (2020). Pengaruh Model Problem Based Learning Terhadap Kemampuan Berpikir Kritis Matematis Siswa Kelas VIII SMP. *EDU-MAT: Jurnal Pendidikan Matematika*, 8(1), 74-87. <https://doi.org/10.20527/edumat.v8i1.7078>
- Purba, R. A. (2022). Hybrid Models with Technology : Is it Effective for Learning in Abnormal Situations ? *Journal of Educational Research and Evaluation*, 6(1), 1-9. <https://doi.org/10.23887/jere.v6i1.41546>
- 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>
- Rahardjanto, A., & Malang, U. M. (2019). Hybrid-PjBL: Learning Outcomes , Creative Thinking Skills , and Learning Motivation of Preservice Teacher. *International Journal of Instruction*, 12(2), 179-192. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1211050.pdf>
- 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>
- 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>
- Rukayah, & Andayani, A. S. (2022). Learner ' s needs of interactive multimedia based on hybrid learning for TISOL program. *Journal of Language and Linguistic Studies*, 18(1), 619-632. <https://doi.org/10.52462/jlls.207>
- Sanchez-muñoz, R., Carrió, M., Rodríguez, G., Pérez, N., Carrió, M., Rodríguez, G., Pérez, N., Sanchez-muñoz, R., Carrió, M., Rodríguez, G., Pérez, N., & Moyano, E. (2020). A hybrid strategy to develop real-life competences combining flipped classroom , jigsaw method and project-based learning . flipped classroom , jigsaw method and project-based learning. *Journal of Biological Education*, 00(00), 1-12. <https://doi.org/10.1080/00219266.2020.1858928>
- Santosa, T. A., Sepriyani, E. M., & Razak, A. (2021). Analisis E-Learning Dalam Pembelajaran Evolusi Mahasiswa Pendidikan Biologi Selama Pandemi Covid-19. *Jurnal Edumaspul*, 5(1), 66-70. <https://doi.org/10.33487/edumaspul.v5i1.1027>
- Sigit, D. V. (2022). Integration of Project-Based E-Learning with STEAM : An Innovative Solution to Learn Ecological Concept. *International Journal of Instruction*, 15(3), 23-40. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1355590.pdf>
- Smith, T., Sunday, K., Gray, C., & Li, D. (2021). Issues-Based STEAM Education: A Case Study in a Hong Kong Secondary School. *International Journal of Education & the Arts*, 22(3), 1-23. <http://doi.org/10.26209/ijea22n3>
- Soffe, S. M., Marquardt, M. J., & Hale, E. (2015). Action learning and critical thinking: A synthesis of two models. *Action Learning: Research and Practice*, 8(3), 211-230. <https://doi.org/10.1080/14767333.2011.614927>
- Strehl, E. A., Arbor, A., Loweth, R. P., Lafayette, W., & Daly, S. R. (2022). Evaluation of a Hybrid Learning Block Model for Engineering Design Interview Skill Building. *Advances in Engineering Education*, 10(4), 57-80. <https://doi.org/10.18260/3-1-1153-36037>
- Suharyat, Y., Ichsan, Satria, E., Santosa, T. A., & Amalia, K. N. (2022). Meta-Analysis Penerapan Model Pembelajaran Problem Based Learning Untuk Meningkatkan Ketrampilan Abad-21 Siswa Dalam Pembelajaran IPA. *Jurnal Pendidikan Dan Konseling*, 4(5), 5081-5088. <https://doi.org/10.31004/jpdk.v4i5.7455>
- Sujanem, R., Poedjiastuti, S., & Jatmiko, B. (2018, June). The Effectiveness of problem-based hybrid learning model in physics teaching to enhance critical thinking of the students of SMAN. In *Journal of Physics: Conference Series* (Vol. 1040, No. 1, p. 012040). IOP Publishing. <https://doi.org/10.1088/1742-6596/1040/1/012040>
- Supratman, Zubaidah, S., & Corebima, A. D. (2021). The Effect Size of Different Learning on Critical and Creative Thinking Skills of Biology Students.

- International Journal of Instruction*, 14(3), 187–206. <https://doi.org/10.29333/iji.2021.14311a>
- 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>
- Suwandi, A. M., & Prisma, I. G. L. E. (2021). Pengembangan Hybrid Based Learning Berbasis Steam Menggunakan Learning Management System Berdasarkan Lembar Kerja Siswa untuk Meningkatkan Kemampuan Siswa dalam Menghadapi Tuntutan Revolusi Industri 4.0. *IT-Edu: Jurnal Information Technology and Education*, 6(2), 13–31. Retrieved from <https://ejournal.unesa.ac.id/index.php/it-edu/article/view/43430>
- Temel, H. (2022). The Effect of Critical Thinking Course Carry Out with Distance Education on Critical Thinking Skills and Dispositions. *International Journal of Psychology and Educational Studies*, 9(3), 792–808. <https://doi.org/10.52380/ijpes.2022.9.3.894>
- Thamrin, T., Hutasuhut, S., Aditia, R., & Putri, F. R. (2022). The Effectiveness of the Hybrid Learning Materials with the Application of Problem Based Learning Model (Hybrid-PBL) to Improve Learning Outcomes during the COVID-19 Pandemic. *IJORER: International Journal of Recent Educational Research*, 3(1), 124–134. <https://doi.org/10.46245/ijorer.v3i1.178>
- Trisnowati, E., Ismawati, R., Dewantari, N., Tidar, U., & Tengah, J. (2022). Indonesian Journal of Science and Education. *Indonesian Journal of Science and Education Volume*, 06(1), 29–35. <https://doi.org/10.31002/ijose.v6i1.92>
- Wahyuni, A. (2021). The Effect of Concept Attainment Model on Mathematical Critical Thinking Ability. *International Journal of Instruction*, 14(1), 727–742. Retrieved from <https://repository.uir.ac.id/2277/>
- Wan, Z. H., Hung, M., & Cheng, M. (2018). Classroom learning environment, critical thinking and achievement in an interdisciplinary subject: a study of Hong Kong secondary school graduates. *Educational Studies*, 5698, 1–21. <https://doi.org/10.1080/03055698.2018.1446331>
- Yaki, A. A. (2022). Fostering Critical Thinking Skills Using Integrated STEM Approach among Secondary School Biology Students. *European Journal of STEM Education*, 7(1), 06. <https://doi.org/10.20897/ejsteme/12481>
- Yalcin, K. (2022). Investigation of the Effectiveness of Hybrid Learning on Academic Achievement: A Meta-Analysis Study. *International Journal of Progressive Education*, 18(1), 1–17. <https://doi.org/10.29329/ijpe.2022.426.14>
- Yani, A. (2018). Pengaruh Media Model Hybrid Berbasis Web Whanced Course Terhadap Hasil Belajar Fisika. *Jurnal Sains Dan Pendidikan Fisika (JSPF)*, 13(3), 224–230. <https://dx.doi.org/10.35580/jspf.v13i3.6191>
- Yusuf, F. A. (2023). 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. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1378720.pdf>
- 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/10.33292/petier.v5i1.144>
- 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>