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

Wasito Utomo1*, 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, Binas University of Informatics, Jakarta, Indonesia.
4 Civil Engineering Lecturer, Adikarya Technical Academy, Kerinci, Indonesia.
5 Lecturer in Media, Politeknik Negeri Media Kreatif, Jakarta, Indonesia.

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). Softe 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 (Fikriyati 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
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 & Demirbatr, 2023; Icsan et al., 2023; Konkus & 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 Fitriyana et al. (2021) the application of STEAM mapping can train students' creative and critical thinking skills in learning. In addition, research by Budiyono 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.

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 (dependent and independent). The results of data coding can be seen in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Data Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Code</td>
</tr>
<tr>
<td>P1</td>
</tr>
<tr>
<td>P2</td>
</tr>
<tr>
<td>P3</td>
</tr>
<tr>
<td>P4</td>
</tr>
<tr>
<td>P5</td>
</tr>
<tr>
<td>P6</td>
</tr>
<tr>
<td>P7</td>
</tr>
<tr>
<td>P8</td>
</tr>
<tr>
<td>P9</td>
</tr>
<tr>
<td>P10</td>
</tr>
<tr>
<td>P11</td>
</tr>
<tr>
<td>P12</td>
</tr>
<tr>
<td>P13</td>
</tr>
<tr>
<td>P14</td>
</tr>
</tbody>
</table>

**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:

\[
F = t^2 \\
\sqrt{F} = t \\
r = \frac{t}{\sqrt{t^2 + N - 2}}
\]

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>
<thead>
<tr>
<th>Table 2. Effect Size Criteria Values (Yusuf, 2023; Chamdani et al., 2022; Razak et al., 2021)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect Size</td>
</tr>
<tr>
<td>0 until 1.</td>
</tr>
<tr>
<td>&lt; .3</td>
</tr>
<tr>
<td>&lt; .5</td>
</tr>
<tr>
<td>&lt; .8</td>
</tr>
<tr>
<td>≥ .8</td>
</tr>
</tbody>
</table>

**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>
<thead>
<tr>
<th>Table 3. Research Heterogeneity Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omnibus test of Model Coefficients</td>
</tr>
<tr>
<td>Test of Residual Heterogeneity</td>
</tr>
</tbody>
</table>

Note: p value are approximate

<table>
<thead>
<tr>
<th>Table 4. The Residual Heterogeneity Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\tau^2)</td>
</tr>
<tr>
<td>0.510</td>
</tr>
<tr>
<td>(\tau)</td>
</tr>
<tr>
<td>(I^2)</td>
</tr>
<tr>
<td>(H^2)</td>
</tr>
</tbody>
</table>
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 \( r^2 > 0.00 \) 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**

<table>
<thead>
<tr>
<th>Intercept</th>
<th>Standard Error</th>
<th>z</th>
<th>p</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.052</td>
<td>0.072</td>
<td>7.173</td>
<td>0.01</td>
<td>0.872</td>
<td>1.324</td>
</tr>
</tbody>
</table>

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](image)

Based on Table 7 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**

<table>
<thead>
<tr>
<th>Sei</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.073</td>
<td>0.233</td>
<td></td>
</tr>
</tbody>
</table>

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.

**Table 7. Fail Safe N (FSN) Test Results**

<table>
<thead>
<tr>
<th>Fail Safe N</th>
<th>Sign.</th>
<th>Observed Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3940</td>
<td>0.05</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

**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 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 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


https://doi.org/10.1007/s40299-018-0410-5

https://doi.org/10.11591/edulearn.v13i3.13887

https://doi.org/10.30831/akukeg.1122136

https://doi.org/10.46966/ijae.v3i4.300

https://doi.org/10.24252/jppipa.v9i1.2555

https://doi.org/10.46328/ijres.3081

https://doi.org/10.18844/cjes.v17i1.6690

https://doi.org/10.24252/ip.v1i01.17642


http://dx.doi.org/10.52155/ijpsat.v27.2.3248


http://dx.doi.org/10.17977/jptpp.v3i1.10446


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

748


