Effectiveness of the Inquiry Based Learning Model Based on Mobile Learning on Students' Creative Thinking Skills: A Meta-Analysis

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Abstract: This study aims to determine the effect of the inquiry-based learning model based on Mobile Learning on Students' Creative Thinking Skills. This type of research is quantitative research with meta-analysis methods. The data source comes from analysis of national and international journals. The process of searching for data sources through the Google Scholar, ERIC, DOAJ, Wiley, Taylor of Francis and Plos ONE databases. Inclusion criteria are data sources from national and international journals indexed by SINTA; Scopus, WOS, DOAJ and EBSCO. Research must be related to inquiry models, mobile learning and critical thinking skills, Journals must be published in 2017-2023 and have a value (r), (t), or F N ≥ 25. Research results of 18 studies explains that the inquiry-based learning model based on mobile learning has a significant effect on students' creative thinking skills (z = 6.713; p < 0.001; CI 95% (0.784; 1.206). The effect size in this study is high criteria (rRE = 0.885). These findings show the application of mobile learning-based inquiry learning models has a major effect on students' creative thinking skills.

Keywords: Creative thinking; Inquiry learning model; Learning; Mobile learning

Introduction

Creative thinking is a thought process that students must have to generate new ideas in solving a problem (Ernawati & Maniarta, 2022; Kartikasari et al., 2022; Tabieh & Hamzeh, 2022; Li, 2021). Creative thinking skills have a role for students in solving a problem in the learning process (Made et al., 2020; Suwendra, 2023). Students who have creative thinking skills are able to encourage student creativity in learning (Ndiung et al., 2021; Yustiana et al., 2022; Hasancebi, 2021). Furthermore, creative thinking skills train students in providing new ideas in learning activities (Deswiana et al., 2019; Zainil et al., 2023; Pigza, 2015).

The reality is that in schools students' creative thinking skills are still low (Nurtamam et al., 2023; Suryandari et al., 2021; Fauziah et al., 2014). The low level of students' creative thinking skills can be seen from the lack of activeness and the difficulty of students in solving problems related to analysis (Elizabeth et al., 2018). Furthermore, teachers do not direct students to think at a higher level (Ernawati et al., 2022; Oktarina et al., 2021; Elfira et al., 2023; Ichsan et al., 2023). Teachers still use the lecture learning method so that learning is centered on the teacher (Supriyadi et al., 2023; Jamaludin et al., 2022; Supriyadi et al., 2023; Putra et al., 2023). Learning does not involve students to think creatively to solve a problem (Siburian et al., 2019; Suryono et al., 2023).
Furthermore, one way to develop students' creative thinking skills is with the inquiry-based learning model based on mobile learning. The inquiry-based learning model is a learning model that can encourage students to learn more actively to discover new things through experimentation (Susilowati, 2020; Fitri et al., 2022; Astalini et al., 2023). Research results of Asyari et al., (2019), the inquiry-based learning model can increase meta-cognitive knowledge so that students have creative thinking skills. Furthermore, the inquiry learning model can foster students' curiosity about something (Adnan et al., 2021). Inquiry-based learning model based on mobile learning can develop students' creative thinking skills through technology. Mobile learning is a learning that can be done online and offline through the internet network (Türker, 2022; Akkaya et al., 2021). Drolia et al. (2022) learning activities through mobile learning can be done through computers, laptops, cell phones and other electronic devices (Turan & Yaman, 2022; Shams et al., 2021). Mobile learning makes students learn more independently and creatively (Rahmawati & Mukminan, 2017). The use of mobile learning can foster student learning intentions (Rumengan et al., 2019). Therefore, the inquiry learning model based on mobile learning is one of the learning models to train creative thinking.

Previous research by Kılıç et al. (2022) stated that the inquiry-based learning model can improve students' thinking skills and attitude towards learning. Research results of Prameswari et al. (2018), the application of the inquiry learning model has a positive effect on students' critical thinking skills. Furthermore, the inquiry-based learning model has a major influence on improving student learning outcomes (Hosnah, 2010). Research results of Maknun (2020), the inquiry learning model is effective to encourage students' concept understanding and critical thinking skills. Therefore, based on the above problems, this study aims to influence the mobile learning-based model on students' creative thinking skills. inquiry based learning.

Method

Research Design

This research is quantitative research with a meta-analysis approach. Meta-analysis is a research approach that analyzes previous research that can be analyzed statistically (Diah et al., 2022; Öztürk et al., 2022; Santosa et al., 2021; Zulyusri et al., 2023; Gao et al., 2020). This meta-analysis aims to determine the effect of inquiry learning model based on mobile learning on students' creative thinking skills. In meta-analysis, research analysis is carried out systematically and structured, having rules in selecting and calculating the effect size value (Yusuf, 2023). Next, the method of data source selection is the PRISMA method, which can be seen in Figure 1.

Inclusion and Exclusion Criteria

In the process of searching for data sources, there are several inclusion criteria, namely: First, the research was searched through the google scholar database, ERIC, Wiley, ProQuest, ScienceDirect and Plos ONE. Second, the research must be published from 2016-2023. Third, the research must have a relationship with the inquiry learning model, mobile learning and creative thinking. Fourth, the research has an experimental class and a control class. Fifth, the research must have a value of \( t \), \( r \), or \( f \) and the sample size must be \( \geq 25 \). The exclusion criteria are research with incomplete data exposure and only a brief review or abstract. Furthermore, for overlapping studies, only studies with large sample sizes were included.

Data Coding

The data coding process in meta-analysis is essential for collecting and analyzing data (Yıldırım, 2022). Therefore, the data coding process in this study took into account aspects such as researcher name, year of publication, sample size \( N \), \( r \), \( t \), and \( f \) values, journal type and country of origin.

Variable

Three variables were coded from each study, namely: First, the type of publication in the form of journals and proceedings. Second, the level of education...
(elementary, junior high, high school and university). Third, the field of research (biology, physics, chemistry and mathematics) and fourth, the affected variable (creative thinking).

Data Analysis

Data analysis in meta-analysis was carried out by 1) analyzing data based on research characteristics; 2) coding data from each study; 3) converting t and f values into r values; 4) calculating the heterogeneity value of each study; 5) calculating the summary effect value or mean effect size; 6) making forest plots and funnel plots; 7) conducting hypothesis testing; 8) checking publication bias from each study. The effect size criteria in this study are based on Cohen (1988) which can be seen in table 1.

Table 1. Effect Size Criteria Based on Cohen’s (Cohen et al., 2007)

<table>
<thead>
<tr>
<th>Effect Size</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 until .1</td>
<td>Weak</td>
</tr>
<tr>
<td>&lt; 0.30</td>
<td>Modest</td>
</tr>
<tr>
<td>&lt; 0.50</td>
<td>Medium</td>
</tr>
<tr>
<td>&lt; 0.8</td>
<td>Strong</td>
</tr>
<tr>
<td>≥ 0.8</td>
<td>Very Strong</td>
</tr>
</tbody>
</table>

Result and Discussion

Results

From the analysis of 319 studies on the effect of mobile learning-based Inquiry Learning model on students’ creative thinking skills, there were only 8 studies that met the inclusion criteria. Furthermore, studies that have met the inclusion criteria are analyzed based on research characteristics consisting of the researcher’s name, sample size (N), value (t), (r) and (F), and publication type. The results of sample analysis based on research characteristics can be seen in Table 2.

Table 2. Sample Analysis Based on Research Characteristics

<table>
<thead>
<tr>
<th>Author</th>
<th>N</th>
<th>r</th>
<th>t</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulastri et al., (2019)</td>
<td>28</td>
<td>0.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ulandari et al., (2019)</td>
<td>87</td>
<td>1.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yolida &amp; Priadi, (2021)</td>
<td>28</td>
<td>2.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ernawati &amp; Maniarta, (2022)</td>
<td>130</td>
<td>4.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satriawati (2017)</td>
<td></td>
<td>0.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sabrina &amp; Kuswanto, (2018)</td>
<td>40</td>
<td>2.52</td>
<td>5.14</td>
<td></td>
</tr>
<tr>
<td>(Dewi, 2019)</td>
<td>36</td>
<td>1.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Zubaidah et al., 2017)</td>
<td>96</td>
<td>2.10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 explains the data analysis based on the characteristics of the researchers where the sample size (N) ranges from 28-130 students. Furthermore, before conducting hypothesis testing, we must first conduct a heterogeneity test of each research effect size. The results of the heterogeneity test can be seen in table 3 and table 4.

Table 3. Heterogeneity Test Results

<table>
<thead>
<tr>
<th>Q</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omnibus test of Model Coefficients</td>
<td>54.209</td>
<td>1</td>
</tr>
<tr>
<td>Test of Residual Heterogeneity</td>
<td>320.145</td>
<td>7</td>
</tr>
</tbody>
</table>

Note. p value is approximate

Table 4. The Residual Heterogeneity Test Result

<table>
<thead>
<tr>
<th>Estimates</th>
<th>Lower bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>τ²</td>
<td>0.3780</td>
<td>0.2441</td>
</tr>
<tr>
<td>τ</td>
<td>0.5147</td>
<td>0.4932</td>
</tr>
<tr>
<td>I² (%)</td>
<td>95.015</td>
<td>92.7110</td>
</tr>
<tr>
<td>H²</td>
<td>29.541</td>
<td>17.0082</td>
</tr>
</tbody>
</table>

Based on tables 3 and 4, it explains that the 8 studies are heterogeneously distributed. This can be seen from the p value <0.001; Q = 54.209; τ² or τ > 0 and 12 (%) = 95.015 close to 100%. The next step is to calculate the summary effect value or mean effect size of the entire research sample. The results of the summary effect size test or mean effect size can be seen in Table 5.

Table 5. Results of the Summary Effect Size or Mean Effect Size Test

<table>
<thead>
<tr>
<th>Estimates</th>
<th>SE</th>
<th>z</th>
<th>p</th>
<th>Lower bound</th>
<th>Upper bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.885</td>
<td>0.1728</td>
<td>6.713</td>
<td>&lt; 0.001</td>
<td>0.784</td>
</tr>
</tbody>
</table>

Based on table 5 explains that the value of Z = 6.713; p < 0.001. This result shows that the application of inquiry-based learning model based on mobile learning affects students’ creative thinking skills. Furthermore, the results can be categorized as having a large effect based on the estimated standard error value of 0.885 (0.784; 1.206). In addition, the effect size summary analysis test can be illustrated by the forest plot in Figure 2.

Figure 2. Forest Plot
Based on figure 2 explains that the overall effect size of the study has a significant effect. Furthermore, knowing the publication bias of each study. In this meta-analysis research, publication bias can be known by using funnel plot. Funnel plot effect size of the entire study can be seen in Figure 3.

**Figure 3.** Funnel plot standard error

Based on Figure 3 explains that the points of research that are widespread domina are in the middle of the curve. This shows the effect size but it is difficult to determine whether this meta-analysis is symmetrical or asymmetrical, so the Egger test is needed. The results of the Egger test can be seen in Table 6.

**Table 6.** Egger Test Results

<table>
<thead>
<tr>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.314</td>
<td>1.805</td>
</tr>
</tbody>
</table>

Table 6 explaining the p-value > 0.05, the funnel plot distribution is symmetrical. The funnel plot shows that there is no publication bias in this study. Furthermore, to increase the validity of publication bias, it is necessary to conduct the Fail-Safe N (FSN) test. The results of the fail-safe N test can be seen in table 7.

**Table 7.** Result Fail Safe N Test

<table>
<thead>
<tr>
<th>Fail safe N</th>
<th>Target Significance</th>
<th>Observed significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosenthal</td>
<td>146</td>
<td>0.050</td>
</tr>
</tbody>
</table>

Based on table 7, the fail-safe N (FSN) value is 146. Furthermore, the value of fail-safe N is compared with the value of k = (5.8) + 10 = 50. Therefore, the value of fail-safe N 146 / 50 = 1.2 > 0.05 means that in this meta-analysis study there is no publication bias.

**Discussion**

The application of the inquiry-based learning model based on mobile learning has a high effect on students’ critical thinking skills. This can be seen from the summary effect value and the overall mean effect size of 0.885 (0.784; 1.206) with strong effect size criteria. Research results Kılıç et al. (2022), the application of the inquiry-based learning model can improve students' thinking skills and learning attitudes. The inquiry-based learning model based on mobile learning trains students to learn more actively and creatively according to their learning interests (Korkman & Metin, 2021; Bird & Rice, 2021; Khasawneh et al., 2023). Furthermore, the inquiry-based learning model based on mobile learning helps students learn more creatively and innovatively through technology, thus training students to think creatively (Bacak & Byker, 2021).

Research results Liu et al. (2022) inquiry based learning is effective for students in finding new ideas in solving a problem. Inquiry based learning model can encourage student learning outcomes so that students are more active in the learning process (Öztürk et al., 2022). In addition, research results (Hwang et al., 2013) inquiry based learning model based on mobile learning effectively develops cognitive thinking skills and student learning achievement. Creative thinking is very important for students in providing solutions to problems in learning (Ichsan et al., 2023; Ramdani, 2016; Mursid et al., 2022). Not only that, creative thinking skills help students more easily find sources of information through technology (Kesici, 2022). This is due to inquiry based learning based on mobile learning, students can more quickly access learning information through internet media (Tabieh & Hamzeh, 2022; Syafrial et al., 2022).

Learning through mobile learning can make the learning atmosphere more interesting so that students are more creative in learning (Akкая et al., 2021; Özcan, 2022). According to Piillena et al. (2019), mobile learning is able to train students in developing their pre-science skills so that it helps them to think creatively. Not only that, mobile learning can help students learn independently and have high learning outcomes (Rahmawati & Mukminan, 2017). Therefore, the inquiry-based learning model based on mobile learning is very suitable to help students develop creative thinking skills in learning activities at school.

Furthermore, in this analytical research, we also analyzed the bias of research publications related to inquiry-based learning models and creative thinking skills. In table 7 Shows that the Fail Safe N test value > 0.05. This means that the research used in this study is resistant to publication bias. Calculation of publication bias is very important in meta-analysis research because...
it affects hypothesis testing (Kim et al., 2018; Gao et al., 2020). It can be seen that there is a significant effect of inquiry-based learning model based on mobile learning on creative thinking skills compared to conventional learning.

Conclusion

From this study it can be concluded that the inquiry-based learning model based on mobile learning has a significant effect on students' creative thinking skills ($z = 6.713; p < 0.001; CI 95\% (0.784; 1.206)$. Effect size in this study is high criteria ($r_{RE} = 0.885$). This finding shows that the application of inquiry learning model based on mobile learning has a great effect on students' creative thinking skills. The mobile-based inquiry-based learning model is able to train students to learn independently and creatively through technology. So, this model is very effective in helping teachers in encouraging students' creative thinking skills.

Acknowledgments

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Authors Contribution

The research consists of five researchers who have played an important role in completing this research. Suyatmo: collecting data from national and international journal databases Via Yustitia: conducting the data selection process Tomi Apra Santosa, Fajiriana, and Unan Unan Yusmaniar Oktiawati: Analysis and Interpretation of Research Data.

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Conflicts of Interest

The authors declare no conflict of interest.

References


Li, U. I. (2021). Creative Thinking Counseling Teaching Program can Improve the Creativity , Creative Tendency , and Self-Concept of Grade 7 Students : A Quasi-Experimental Study. The Journal of
Creative Behavior, 0, 1-20. https://doi.org/10.1002/jocb.491


