



Meta-Analysis Study: The Effect of Android-Based Learning Media on Student Learning Outcomes

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ABSTRACT

This research is motivated by the increasing number of users of android-based learning media it impacts the learning outcomes obtained. This study aims to determine the effect of android-based learning media on improving student learning outcomes. This research is a meta-analysis study. Data collection techniques are taken from indexing databases such as Google Scholar. The filtered data results from research that contains the value of the number of data (N), correlation test (r), and classification, then analyzed using meta-analysis through effect size and standard error to see the summary effect size. The results of data analysis research using JASP software show that the estimation of the summary effect or mean effect size and publication bias test uses a random effect approach. The results of the effect size analysis using the random effects model show that there is a significant positive correlation between the effect of android-based learning media to improve student learning outcomes ($z = 4.383$; $p < 0.001$; 95%CI [0.213; 0.559]). Therefore, the influence of android-based learning media on student learning outcomes is included in the low category ($r_{RE} = 0.386$). In this study, it can be concluded that there is an influence of android-based learning media to improve student learning outcomes where at the 95% confidence level, the p -value < 0.05 .

INTRODUCTION

The development of information and communication technology has an impact on the education aspect. The effect of the product is felt starting from the management aspect of the education management system to the process of teaching and learning activities utilizing this development. Educators who play more roles as facilitators must be able to use existing digital technology to design creative and innovative learning to make students active and think critically ([Rahmawati & Partana, 2019](#)). According to [Arsyad \(2014\)](#), it is used and managed for education needs to achieve the effectiveness and efficiency of the learning process. [Sadiman \(2011\)](#) defines media as all forms of objects used by teachers or presenters, or distributors of messages to students and recipients of messages to distribute information or letters so that the purpose of distributing messages or information is achieved. [Arsyad \(2011\)](#) argues that the media is also often called mediation, the cause or tool that intervenes in two parties and reconciles them. [Kustandi \(2011\)](#) argues that the media is the sender and intermediary messenger.

Based on this opinion, it can be interpreted that the media is a communication component that functions as an intermediary or messenger from the sender to the recipient. Based on the definition of

media in general, a different definition of learning media can be built. According to [Tafonao \(2018\)](#), media is a tool that can be used to channel information processes, while the role of media in learning is: (1) as a channel for messages from sender to receiver; (2) as a tool that helps students to explain something conveyed by educators; (3) as an intermediary between teachers and students in establishing a good relationship during the learning process; and (4) as a method to overcome student boredom during the learning process. Learning media can be linked to everything used to convey or distribute material from the teacher in a planned manner so students can learn effectively and efficiently. Everything must stimulate students' thoughts, feelings, attention, and abilities or process skills to encourage teaching and learning. The role of the media is very important in the learning process so that the material delivered by the teacher arrives quickly and is easily acceptable to the maximum by students ([Wicaksono, 2016](#)).

The lack of variety of learning media that attracts students to study independently becomes an obstacle to the distribution of knowledge from teachers to students. It takes a learning media that can be used to learn anywhere and anytime. So, students are not only fixated on learning that is in the classroom. Learning media, according to [Kamiana et al. \(2019\)](#), the media used in learning include teaching aids for teachers and means of carrying messages from learning sources to recipients of learning letters (students). In education in schools, few still use interesting learning media. When viewed from the learning media, it is sometimes less interesting for students to learn because the method used is felt to be less attractive. It makes students feel bored and gives the effect of being lazy to study. Lack of interest in learning students will affect their understanding of the material presented. According to [Mawaddah et al. \(2007\)](#), the era of rapid technological development changes the paradigm of the world of education, especially teachers as learning agents who must master and apply technology and communication in the learning process. Based on these dimensions, the role of the teacher is difficult to replace others.

In addition, motivation is a determinant of the intensity of students' learning efforts as a driving force and ensures the continuity of student learning so that the desired goals can be achieved ([Prasetyo et al., 2015](#)). This statement follows the opinion of [Yunus & Fransisca \(2006\)](#), which states that the field of education continues to move dynamically, especially to create more interactive and comprehensive educational media, methods, and materials. In addition, the one-way interaction learning pattern is the main sector teacher as the message's source. In this case, the teacher has the most important role and carries a heavy burden. The reason is that the teacher must position himself as best as possible in conveying the message.

This method has drawbacks, such as the learning process running tediously and students becoming passive because they do not have the opportunity to find the concepts being taught. The density of the ideas can result in students not being able to master the material being taught. Currently, students depend more on smartphones to find information in everyday life. Based on data from eMarketer, Android-based smartphone users in 2015 reached 55 million people and will continue to grow in 2016 and the following years. Technological developments are growing more creative and moving towards digital. Technological developments have a major impact on the learning process in schools ([Choirm & Abdullah, 2021](#)). Today's students are digital natives. They grow up with digital technology ([Choirm & Abdullah, 2021](#)). The smartphone is a technology that is currently developing ([Wahyono & Yumianta, 2018](#)). The use of smartphones in the school environment sees the bad impact of using smartphones which can damage the morale of students who easily access pornographic sites and become victims of crimes in cyberspace.

Unfortunately, students become addicted to smartphones without getting the benefits of the smartphone. So, the Android-based smartphone must be utilized in such a way as to support it. Seeing the problems above, it takes a new learning media that can provide learning motivation for students in a subject. In addition, [Arsyah et al. \(2019\)](#), one of the applications of android-based smartphones used in education is the creation of android-based learning media. Using mobile devices in android-based learning media can help students access material without being related to space and time and supports closer interactions between educators and students ([Baran, 2014](#)). However, the advantages of this mobile device make it challenging to develop and implement it in the learning process. Mobile learning provides various application programs that can be accessed by students, one of which is a smartphone. Therefore, smartphones can potentially be a learning media that can affect learning ([Sung et al., 2016](#)).

Meta-analysis uses research data from existing research sources (secondary data) ([Malicki et al., 2021](#)). Therefore, meta-analysis is a quantitative research method that analyzes quantitative data from the results of previous studies to accept or reject the hypotheses proposed in these studies. Meta-analysis is an increasingly popular research method used to summarize research results. Meta-analysis is widely used in the study of research theory. In addition, meta-analysis can be used as a reference source in policy making ([Borenstein et al., 2009](#)). In the meta-analysis, there is data that is then processed and used to make statistical conclusions. The data can be expressed in various measures that are calculated or searched in advance by formulas described by multiple mathematical equations, which are related to the purpose of the research theme of the meta-analysis studied ([Turner, Bird & Higgins, 2013](#)). This size is known as the effect size. The meta-analysis includes content analysis that encodes the characteristics of a study, such as age, place of research, or certain domains in a scientific field. Then, effect sizes with the same features are grouped and compared ([Mueller et al., 2018](#)).

Based on the above discussion, it can be concluded that the influence of android-based learning media is very important to determine the extent to which the achievement of the student learning process on learning outcomes. However, a meta-analysis study is needed to make a big picture of the influence between learning media and learning outcomes at the education level. So, this study aims to prove and determine the effect size of the impact of android-based learning media on student learning outcomes through a quantitative meta-analysis approach.

METHODS

Research Design

Meta-analysis is research that uses studies that already exist and have been used by other researchers that are carried out systematically and quantitatively to obtain accurate conclusions ([Retnawati et al., 2018](#)). The meta-analysis is a retrospective observational study in that the researcher recapitulates the data without performing experimental manipulation. This research data recapitulation comes from research publications on the effect of android-based learning media to improve student learning outcomes at the junior high and high school levels.

Eligibility Criteria

The research publications studied in this study have several criteria in their selection with the aim that the results of this broad analysis can be more centralized. The studies to be included in the meta-analysis depend on the intent of the meta-analysis ([Tawfik et al., 2019](#)). For this reason, the meta-analysis study hypothesis is very helpful in determining the inclusion and exclusion criteria that should be used from the outset to identify relevant studies ([Higgins et al., 2018](#)). The criteria for selecting the research publications studied are as follows: (1) publications that can be followed from online search databases such as Google Scholar; (2) publications on android learning media and learning outcomes; (3) publications must be in the 2016-2022 range; (4) publications have a value of (r), (t) or (F) which explains the effect of android learning media on learning outcomes; and (5) the sample in the published publications N 20.

Data Coding

Coding in meta-analysis is the most important requirement to facilitate data collection and analysis ([Malicki et al., 2021](#)). Therefore, the instrument in this meta-analysis was carried out with a coding category sheet. The coding of the data in this study clearly describes the characteristics of the publications used, such as the year of publication, the country of origin of the study, the sample of publications (N), the correlation value (r_{xy}), t value, F value, and remarks containing accreditation/reputation information journal.

Table 1. Comparison of 22 Studies Based on N, r, t, F Value

Authors	Year	Sample	N	R	T	F
Gutteres et al.	2018	High school student	38	0,730		
Arrobbani & Wulandari	2016	Colleger	20		2,900	

Authors	Year	Sample	N	R	T	F
Ramadhani et al.	2016	High school student	49		0,929	
Uma et al.	2022	Junior school student	40		0,824	
Rahmawati & Partana	2019	High school student	65		2,459	6,049
Putra et al.	2017	High school student	70		1,980	
Andriani & Suratman	2021	High school student	70		0,726	
Choirn et al.	2021	Junior school student	50		5,543	
Solehah	2018	High school student	75		3,038	
Mawaddah et al.	2021	Elementary school student	26		8,163	
Sau & Cahyani	2022	High school student	83		3,176	
Putri & Slamet	2019	High school student	44		0,069	
Putri, Farda & Umah	2021	Elementary school student	28	0,554		
Kartini & Putra	2020	High school student	70		1,870	
Saidah et al.	2021	Elementary school student	40		0,224	

Data Analysis Technique

The data analysis in this study was carried out through the following steps: (1) analysis of the characteristics of the research sample; (2) data coding; (3) convert the values of t and F to the value of r correlation (The formula used is $F = t^2$ or $t = \sqrt{F}$, or $r = t / \sqrt{t^2 + N - 2}$); (4) heterogeneity test of effect size; (5) calculate the summary effect or mean effect size; (6) create forest plots and funnel plots; (7) hypothesis testing and (8) check for publication bias. Analysis of the data used is a correlation meta-analysis. Effect sizes can be categorized starting from 0 – 1 based on Cohen's effect size criteria (Cohen et al., 2020). The software used in this research is JASP 0.8 4.0.

Table 2. Cohen’s Effect Size Criteria

Value	Criteria
< 0 + / -.1	Very weak effect
< 0 + / -.3	Weak effect
< 0 + / -.5	Medium effect
< 0 + / -.8	Strong effect
≥ + / -.8	Very strong effect

RESULTS

Based on 15 research publications with specific criteria analyzed, various values of r, t, and F were obtained for each study. Before entering the heterogeneity test, for all research publications that do not have an r value, the t or F values listed will be converted to r values first. The results of the heterogeneity test are presented in table 3 below.

Table 3. Heterogeneity Test Result

	Q	Df	P
<i>Omnibus test of Model Coefficients</i>	19.214	1	< .001
<i>Test of Residual Heterogeneity</i>	60.695	14	< .001

Note. p-values are approximate.

Note. The model was estimated using the Restricted ML method.

Table 4. Residual Heterogenitas Estimates

Estimate		95% Confidence Interval	
		Lower	Upper
τ^2	0.092	0.039	0.299
T	0.304	0.198	0.547
I ² (%)	81.480	65.215	93.452
H ²	5.400	2.875	15.271

The heterogeneity test results obtained from the JASP software above show that the value of $Q = 60,695$ with $p < 0.001$; τ^2 or > 0 ; and I^2 (%) is close to 100%, so it can be concluded that the 15 effect sizes of the analyzed studies are heterogeneous. Furthermore, an analysis of the estimated summary effect or mean effect size was carried out, and a publication bias test was carried out using a random effects approach. The analysis results of the summary effect or mean effect size is presented in table 5 below.

Table 5. Summary Effect or Mean Effect Size

	Estimate	Standard Error	Z	P	95% Confidence Interval	
					Lower	Upper
Intercept	0.386	0.088	4.383	<.001	0.213	0.559

Note. Wald test.

The results of the analysis using the Random Effect model showed that there was a significant positive correlation between reflective thinking and student achievement ($z = 4.383$; $p < 0.001$; 95%CI [0.213; 0.559]). The influence of android-based learning media on student learning outcomes is included in the low category ($r_{RE} = 0.386$). Furthermore, the analysis results in this study are also presented using a visually attractive graphical method and are commonly referred to as forest plots. Forest plots allow us to know the estimated combined effect depicted by actions (dots) at certain intervals simultaneously to make comparisons between studies clearer. The following is a chart of the forest plots of the 15 studies analyzed.

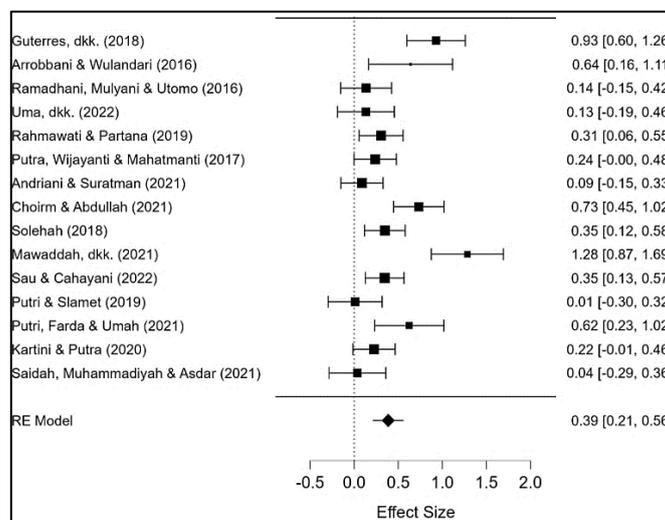


Figure 1. Forest Plot

Based on the Forest Plot graph above, it can be observed that the effects of the analyzed studies vary in magnitude from 0.01 to 1.28. Furthermore, the Funnel plot was made. The funnel plot is a scatter

diagram used in meta-analysis to visually detect the possibility of publication bias (symmetry or asymmetry of the study sample). The following is a funnel plot graph for the 15 studies analyzed.

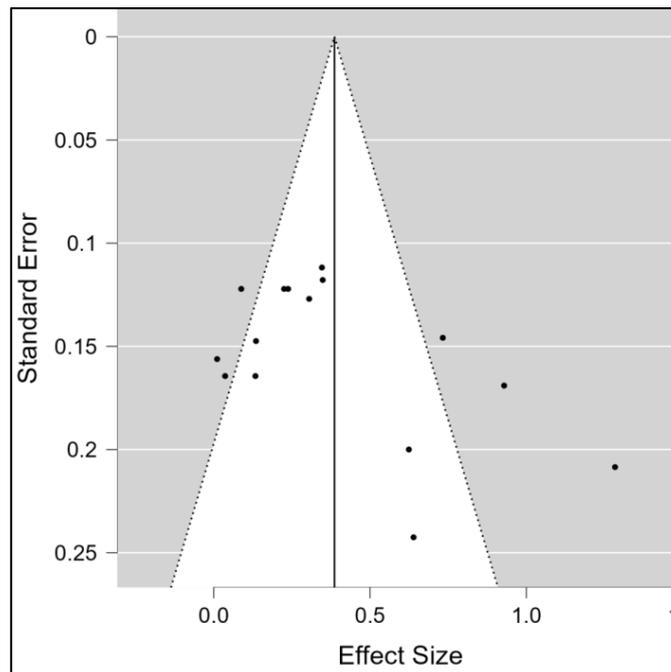


Figure 2. Funnel Plot

From the results of the funnel plot graph, there is no clear indication of publication bias because the model form can be said to be symmetrical or asymmetrical, so further analysis is needed using the Egger test. The Egger test results are shown in Table 6.

Table 6. Egger Test

	Z	P
Sei	2.316	0.021

Based on table 6, it is obtained information that $Z = 2.316$ with $P > 0.021$. It confirms that the Funnel Plot is symmetrical. Thus, it can be concluded that there is no publication bias problem in this meta-analysis study.

DISCUSSION

Based on 15 research results analyzed through this meta-analysis, a positive and significant relationship was found between the effect of android-based learning media to improve student learning outcomes (p -value < 0.05). It is supported because android is considered to have more diverse and interesting features with different functions and is equipped with elements in the form of learning applications (Branchais & Achmadi, 2019).

Furthermore, based on the results of the heterogeneity test analysis in Table 3. shows that the value of $Q = 60,695$. With $p < 0.001$; $I^2 > 0$; and I^2 (%) is close to 100%, it can be concluded that the 15 effect sizes of the analyzed studies are heterogeneous. Furthermore, in Table 4. an analysis of the estimation of the summary effect or mean effect size is carried out, and a publication bias test using a random effect approach is carried out. The results of the effect size analysis using the random effects model show that there is a significant positive correlation between the effect of android-based learning media to improve student learning outcomes ($z = 4.383$; $p < 0.001$; 95%CI [0.213; 0.559]). Therefore, the influence of android-based learning media on student learning outcomes is included in the low category ($I_{RE} = 0.386$).

Furthermore, based on Figure 1, the analysis results in this study are also presented using a visually attractive graphical method and are commonly referred to as forest plots. Forest plots allow us to know the estimated combined effect depicted by actions (dots) at certain intervals simultaneously to make comparisons between studies clearer. Based on the Forest Plot graph above, in Figure 1, the effect size of the analyzed studies varies from 0.01 to 1.28. [Arsyah et al. \(2019\)](#) state that one of the applications of android-based smartphones in education is the creation of android-based learning media. Smartphones can potentially be a learning media that can affect learning ([Sung et al., 2016](#)).

In addition, the learning media used must be quality, efficient and effective to improve learning achievement ([Asyar, 2012](#)). As stated by [Khodijah \(2014\)](#), learning motivation is an impulse that becomes a driving force in a person to achieve a goal, namely to achieve achievement. [Saefuddin & Berdiati \(2014\)](#), in education, learning can be interpreted as a positive process so that, in the end, new skills, skills, and knowledge are obtained, which can be seen from the accumulation of experience and learning. Therefore, learning media that affect learning outcomes appear as changes in behavior in students, which can be observed and measured in changes in attitudes, skills, and behavior. Changes can be interpreted as an increase and development that is better than before; for example, from no knowledge to knowing, a disrespectful attitude becomes polite ([Sudjana, 2015](#)). The results of this study follow research conducted by [Naffesa \(2021\)](#), which showed a negative relationship between the use of mobile phones on learning motivation in class XI students of SMA Negeri 1 Lintongnituha. This classification is based on the correlation value = -0.436 ; $\text{sig} < 0.05$. It means that the higher the use of mobile phones, the lower the motivation to learn.

On the contrary, the lower the use of mobile phones, the higher the motivation to learn. The use of cell phones includes factors from outside high school students that affect their learning motivation. Student's dependence on cell phones directly makes them lazy to study. It is because students who abuse cell phones are only used for games and scrolling on social media such as Instagram, TikTok, and more. Research conducted by [Utami & Kurniawati \(2019\)](#), Referring to the synthesis of research results from 10 studies, the negative effects on high school adolescents that are most often found from the emergence of the phenomenon of excessive smartphone use are decreased academic achievement, academic involvement, dissatisfaction with school, anxiety, depression, and other behavioral problems. These results were obtained from both quantitative studies and qualitative scientific studies.

This reality is reinforced by the research reviewed by [Kurniawati \(2020\)](#); dependence on smartphones causes students' lack of enthusiasm for learning, and learning concentration decreases so that achievement levels decrease. It is also seen in the average PS 60.98 and SA 56.01, showing a decline. Based on the analysis of 6 studies, the average gain result is 39.28%. It means that the use of smartphones affects student achievement. It is in line with research conducted by [Wahyu Rikha Rofiatul Ula \(2021\)](#). The impact of smartphone addiction experienced by the three research subjects is feeling restless, lonely, and confused when not playing with smartphones. Therefore, it appears that smartphones harm the learning achievements of the three research subjects.

Furthermore, based on the results of the publication test in Figure 2, a Funnel plot was made. The Begg funnel plot is a scatter diagram used in meta-analysis to visually detect the possibility of publication bias (symmetrical or asymmetrical research sample). Based on the funnel plot graph results, there is no clear indication of publication bias because the model form can be said to be symmetrical or asymmetrical, so further analysis is needed using egger's test. The results of egger's test are shown in Table 7. Based on Table 5, information is obtained that $Z = 2,316$ with $P > 0.001$. It confirms that the Funnel Plot is symmetrical. Furthermore, the test results for file drawer analysis or Fail safe-N are shown in Table 8 because $K = 33$, so $5K + 10 = 5(33) + 10 = 175$. The safe-N file value obtained is 503,000, with a significant target of 0.050 and $p < 0.001$. Because the value of the safe-N file is $> 5K + 10$, it can be concluded that there is no publication bias problem in this meta-analysis study. In this study, information was obtained that no publication bias was found. Many factors contribute to publication bias ([Borenstein et al., 2005](#)). For example, once scientific findings are well established, it may become newsworthy to publish reliable papers that fail to reject the null hypothesis ([Koolman & Luijendijk, 2012](#)). In addition, obtaining unpublished studies is difficult to prove and unsatisfactory ([Borenstein et al., 2005](#)). Efforts to see publication bias can be obtained by analyzing the funnel plot form test, proven to be asymmetrical. Based on the funnel plot graph results, there is no clear indication of publication bias because the model and the distribution of the points formed can be said to be symmetrical or

asymmetrical, so further analysis is needed using Egger's test. Based on Table 7. It is obtained that $Z = 2.316$ with $P > 0.001$. It confirms that the results of the Funnel Plot are symmetrical. Furthermore, to determine the number of studies that were not significant or not published, an effort should be added to the meta-analysis to reduce all statistically significant observations to non-statistical ones by using the approach suggested by Rosenthal, which aims to address the issue of publication bias. Based on the test results of file drawer analysis or Fail safe-N are shown in Table 8 because $K = 33$, so $5K + 10 = 5(33) + 10 = 175$. The safe-N file value obtained is 503,000, with a significant target of 0.050 and $p < 0.001$. Because the safe-N file value is $> 5K + 10$, it can be concluded that there is no publication bias problem in this meta-analysis study. In a published study, publication bias can occur when the research results decide to publish it biased. Efforts to obtain positive findings from publications containing only significant findings can result in a balance of data from a finding (Harvey et al., 2010). The publication bias analysis process is needed to measure the level of significance of the sources used, the results of accurate study conclusions, the different sample sizes of each study that affect the findings that are usually minimal, as well as the quality of the relevant research methods (Nair et al., 2019).

CONCLUSION

Based on the analysis of the results of the research and discussion above, it can be concluded that it is highly confirmed that there is an influence of android-based learning media on student learning outcomes. It can be shown based on the results of the heterogeneity test analysis in a show that the 15 effect sizes that the studies analyzed are heterogeneous. The calculation of effect size results from 15 publications has a strong significant relationship between learning media and learning outcomes that are proven to be heterogeneous, which has a positive correlation value and is in the low effect category. In addition, publication bias is proven to be non-existent. It indicates that the publications under review represent the actual situation. The characteristics of the research publications examined in this study showed the same sample, namely elementary high school, junior high schools, senior high school, madrasah aliyah, vocational high schools, and universities. It is intended that more theories show the interrelationship of the influence of android-based learning media to improve student learning outcomes so that especially educators can try to improve and look at this topic.

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The authors declare no funding and conflicts of interest for this research.

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