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The Effect of Learning Videos on Students' Mathematical Abilities: A Meta-Analysis Study

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This study aims to determine the influence of learning videos on mathematical ability. The design used to test the research questions is a meta-analysis. Based on searches on the ERIC, SAGE, SpringerLink, and Google Scholar Databases, 28 measures of effect were found that met the specified inclusion criteria. Data analysis was carried out with the help of JASP 0.16.1.0 software. The results of the analysis showed that the use of learning video media had a major effect on mathematical ability when compared to conventional learning media ($d = 1.12$; $p < 0.01$). The results of the analysis based on moderator variables found that the influence of the flipped classroom model compared to conventional teaching on mathematics ability differed according to the level of education ($Qb = 36.25$; $p < 0.05$), and the measured ability ($Qb = 15.7$; $p < 0.05$), but did not differ according to the sample size group ($Qb = 0.98$; $p > 0.05$) and the year of study ($Qb = 2.31$; $p < 0.05$)

K e y w o r d s :
Mathematics Ability, Learning Videos, Meta-Analysis.

INTRODUCTION

Mathematical ability has long been recognized as important, not only for academic success but also for efficient functioning in everyday life (Carey et al., 2017). By studying mathematics, we practice accuracy, consistency and mental discipline, which are essential skills necessary for problem solving and effective and responsible decision-making in everyday life (Brezavšcek et al., 2020). This result clearly shows that the mastery of mathematical skills has far-reaching consequences for students. Mathematics has abstract characteristics, so to make students understand well the mathematical material requires the use of appropriate media from the teacher.

In this era Technology has developed rapidly and influenced many aspects, including the education sector over the past few decades. As a result, in this era demands that teachers must be active, creative in mastering learning systems and technology. A learning environment equipped with the use of technology can improve the understanding and quality of the education system (NCTM, 2000; Savec et al., 2018; Attard & Holmes, 2020). The use of technology in assertive and creative mathematics learning helps individuals develop the skills and knowledge needed to meet the educational and societal expectations of the 21st century (Adelabu et al., 2019; Tamur et al., 2018; Chen et al. al., 2020). The integration of technology gives students additional exercises and the opportunity to examine their problems and to express their findings with different alternative answers (Gonzalez & Birch, 2018; Juandi & Priatna, 2018; Sung et al., 2016; Nurjanah et al., 2020).

The combination of technology-based learning media and the right learning model also has a significant effect on the learning process based on the 2013 Revised Edition curriculum, which requires students to be active and learn independently (Bariyah, 2019; Wirasatriya et al., 2020). One alternative solution offered to integrate learning strategies with technology is *video based learning*. According to the cognitive theory of multimedia learning, video, face-to-face classes, and video conferencing can all maximize the use of our cognitive infrastructure (Mayer, 2008). Our minds have different but connected neurological systems to process auditory and visual information. Some media present content in one format or another: for example, books present visual information; podcasts and radios present auditory information. These systems are connected, so visual activities, such as reading, will activate the auditory system when we 'hear' the words in our heads. While listening to a podcast, our visual system can create an 'image' of what is being explained. However, the cognitive theory of multimedia learning proposes that learning is more effective when complementary information is presented for both systems (Mayer, 2008). Meta-analysis of multimedia effects confirms this proposition, showing that people learn better when both channels are used, not just one or the other (Mayer, 2008; Rolfe & Gray, 2011). Video serves this purpose, communicating information through both channels. Videos facilitate students to learn independently, adjusting to the time and place that is right for them, as well as providing opportunities for students to repeat until students fully understand the material (Bustanil et al., 2019).

Many studies have identified that the use of learning videos makes a positive contribution to mathematical ability, but there are some studies that the use of learning videos has no effect on mathematical achievement. Research results by (Ali et al., 2019; Ambarwati & Kurniasih, 2019; Goddess, 2016; Dewi & Napitupulu, 2020; Huda et al., 2020; Imron et al., 2019 Isfayani, 2020; Prasetia, 2017; Prastica et al., 2020; Salsabila & Pradipta, 2020; Saputra & Mujib, 2018) reported that the use of learning videos had a positive effect on mathematics ability, different results were found by Muzini et al. (2020) showing that learning videos had no effect on students' mathematics achievement. In addition, research conducted by Twozia (2019) and Pambudi et al. (2021) revealed that learning videos have a small effect on mathematical achievement. Different results on the same topic certainly provide subjective conclusions, so it is necessary to carry out further evaluations to summarize the results of the study so that the research findings become more accurate. In this regard, meta-analytical studies can be used to combine coherently and consistently the findings of different research results on the same topic to expand the sample and obtain reliable results (Borenstei et al., 2009; Hunter & Schmit, 2004; Juandi et al., 2009). al., 2020; Retnawati et al., 2018).

So far, there has been no meta-analysis research that specifically examines the effect of learning videos on mathematical ability. Therefore, the purpose of this study is to determine the effect of the use of learning videos on students' mathematical abilities, Besides that, it will also be studied whether the effect of using the flipped classroom differs according to the moderator variable.This study seeks answers to the following questions:

RQ1: Does the use of learning videos affect math skills?
RQ2: Does the effect of the use of learning videos on mathematics ability differ according to education level, sample size, measured ability, and year of study?

METHOD

Research Design

In this study, the meta-analysis method was used to review the results of research that examined the effectiveness of videos on mathematics learning. In general, the stages in metaanalysis are; determining inclusion criteria, study search, data collection and variable coding, statistical analysis (Borenstein et al.,2009; Retnawati et al., 2018; Juandi & Tamur., 2020).

Inclusion Criteria

Determination of inclusion criteria to facilitate the search for studies at the next stage. All studies collected in the initial search were then examined and assessed using the inclusion criteria set out for inclusion in the meta-analysis and further evaluation. The inclusion criteria set out in this meta-analysis include:

1. The year of publication ranges from 2016 to 2021;
2. Indonesian studies in the form of articles published in national or international journals;
3. Studies using experimental or quasi-experimental research methods;

4. There is at least 1 experimental group with video media and its dressing group as a control group with conventional media;
5. Studies must report mean values, standard deviations and sample sizes of each experimental group and control group.

Data Collection and Coding

The relevant stage of collecting studies uses online databases such as Google Scholar, ERIC, Elsevier, and others. The keywords used in literature searches are "*Video effectiveness*" and "*Mathematics*" in Indonesian and English. From the search for studies based on the specified criteria, 28 studies were obtained that met the inclusion criteria for further evaluation. Hunter & Schmidt (2004), states that if only 10 studies are studied then it is said to be small. Therefore, the amount of research used in this meta-analysis can be said to be large.

After obtaining an article that has been eligible (meets the inclusion criteria) then identify the characteristics of the literature by coding. Coding in this study was carried out by two people (raters) so that errors of a subjectivity nature could be avoided. The coding content includes information; 1) Education Level; 2) Sample Size; 3) Measured ability; 4) Year; 5) Frequency; and 6) Percentages. Table 1 presents a summary of the coding results.

Table 1. Studies included in the Meta-analysis

Education Level	**Frequency**	**Percentage**
Primary School	8	28.57%
Junior High School	13	46.43%
Senior High School	3	10.71%
University	4	14.29%
Sample Size	**N**	**Percentage**
Large (> 30)	10	35.71%
Small (≤ 30)	18	64.29%
Measured Skills	**N**	**Percentage**
Learning Outcomes	13	35.71%
Concept Understanding	3	46.43%
Problem Solving	4	10.71%
Critical Thinking	2	14.29%
Other	6	7.14%
Year	**N**	**Percentage**
2016-2018	7	25.00%
2019-2021	21	75.00%

Data Analysis

Data analysis is carried out with the help *of JASP* software. The meta-analysis scheme used in this article consists of several steps, namely: (1) calculating the size of the effect of each study; (2) heterogeneity test; (3) Calculate the combined effect size and moderator variable analysis; (4) Evaluation of publication bias. The interpretation of the size of the effect in this study uses the classification proposed by Cohen et al (2018). The size classification is presented in the following table 2:

Table 2. Category of effect size groups using Cohen's interpretation

Classification	Interval
Ignored	0.00 < Effect Size ≤ 0.19
Small	0.19 < Effect Size ≤ 0.49
Medium	0.49 < Effect Size ≤ 0.79
Large	0.79 < Effect Size ≤ 1.29
Very Large	Effect Size > 1.29

The heterogeneity test in this study was carried out using the Q parameter approach. If the p-value < 0.05, the estimation model suitable for calculating the summary effect is a random effect model. If the p-value > 0.05, then fixed effect model estimates are used (Borenstein et al., 2009; Retnawati et al., 2018; Juandi & Tamur., 2020). Studies containing statistics needed in meta-analysis are required publication bias tests (Retnawati et al., 2018; Juandi & Tamur, 2020; Yunita et al., 2020; Martaputri et al., 2021; Setiawan et al., 2022). The publication bias test uses the File-Safe N (FSN) approach. If the File-Safe N value > (5K+10), where k is the number of studies included in the meta-analysis, then this study has no publication bias problem and is scientifically justifiable (Mulen et al., 2001; Rothstein, 2008).

RESULT AND DISCUSSION

Effect Measures of Each Study

The main purpose of this study is to reveal the magnitude of the overall influence of the use of video media on mathematics learning. The effect size of each study was calculated with the help of *JASP* software. Table 3 presents a summary of the value of the measure of the effects, each study.

Table 3. Effect Measures of Each Study

Study	Effect Size	Variance	Std. Error	Description
Ali et al	1.272	0.127	0.353	Large
Ambarwati & Kurniasih	0.778	0.060	0.243	Medium
Goddess	1.075	0.059	0.241	Large
Goddess & Napitupulu	1.525	0.172	0.412	Very Large
Huda et al. study 1	1.462	0.084	0.290	Very Large
Huda et al. study 2	1.631	0.089	0.297	Very Large
Imron et al	0.944	0.099	0.312	Large
Isfayani	1.075	0.129	0.356	Large
Jusmiana et al	0.631	0.079	0.280	Medium
Kurniawati	0.641	0.070	0.263	Medium
Muziani et al	-0.200	0.100	0.314	Ignored
Nurdin et al	2.628	0.102	0.320	Very Large
Pambudi et al	0.473	0.059	0.241	Small
Partayasa et al	0.936	0.082	0.285	Large
Pinontoan & Walean, Study 1	0.996	0.107	0.325	Large
Prasetia	1.266	0.120	0.344	Large

Prastica et al	2.190	0.103	0.321	Very Large
Salsabila & Pradipta	0.987	0.071	0.266	Large
Saputra & Mujib	1.041	0.068	0.260	Large
Shinta	0.684	0.071	0.264	Medium
Sudiarta & Sadra. study 1	1.438	0.067	0.258	Very Large
Sudiarta & Sadra. study 2	1.271	0.086	0.292	Large
Suliawati et al	1.447	0.084	0.289	Very Large
Twozia	0.326	0.127	0.351	Small
Wulandari et al	1.256	0.068	0.261	Large
Yanti et al	0.844	0.107	0.324	Large
Yenti	0.634	0.058	0.240	Medium
Yuliani et al	2.615	0.166	0.407	Very Large

Based on table 3 above, the effect size ranges from -0.200-2.615. out of a total of 28 effect sizes, eight effect sizes (n = 8) are included in the very large effect category, twelve effect sizes (n = 12) are in the large effect category, five effect sizes (n = 5) are in the medium effect category. , two effect sizes (n = 2) were included in the small effect category, and one effect size (n = 1) was included in the neglected category. These results indicate that the effect size representations of the above studies are different.

Heterogeneity Test

The second stage is to test heterogeneity to select a suitable estimation model. Heterogeneity tests were performed to determine the model to be used in calculating the size of the effects of the 28 studies to be analyzed. The heterogeneity test in this study was carried out using the Q parameter approach with a degree of freedom (df = 28-1 = 27). Table 4 presents the results of heterogeneity tests for fixed and random effects.

Table 4. Heterogeneity Test Summary

	Q	Df	p-value
Test of Residual Heterogeneity	101.53	27	< 0.001

The results of the heterogeneity test (see table 4) show that (Q = 101.53, p < 0.001). Therefore it can be concluded, the variance between the measures of effects used in this study is heterogeneous. Based on these results, because the study is very heterogeneous, a random effect model is used in calculating the size of the combined effect. The confirmed heterogeneous study also implies that a moderator variable analysis is carried out to determine the contribution of each moderator variable to the difference in variance between effects.

Combined Effect Size and Moderator Variable Analysis

The third stage is to calculate the size of the combined effect and analyze the moderator variables. The moderator variables identified in this study are (level of education, sample size, skills measured, and years,). Table 5 presents a summary of the combined effect size using random effect model estimation and moderator variable analysis.

Table 5. Combined effect size results and moderator variable analysis

Moderator Variables	k	d	[95% CI]	p	Heterogeneity			
					Q	Df	Qb	p
Overalls	28	1.12	[0.907, 1.331]	< 0.01	101.53	28		
Education Level								
Primary	8	1.36	[0.878, 1.832]	< 0.01	29.11	3	36.25	0.000
Junior High School	13	0.98	[0.730, 1.231]	< 0.01	33.76			
Senior High School	3	1.38	[0.072, 2.696]	0.039	29.06			
University	4	0.96	[0.683, 1.246]	< 0.01	2.46			
Sample Size								
Small (≤ 30)	18	1.06	[0.799, 1.310]	< 0.01	51.93	1	0.98	0.320
Large (> 30)	10	1.23	[0.846, 1.604]	< 0.01	48.62			
Measured Skills								
Learning Outcomes	13	0.90	[0.620, 1.189]	< 0.01	38.12	4	15.7	0.000
Concept Understanding	3	1.34	[0.078, 2.593]	0.037	25.67			
Problem Solving	4	1.24	[0.969, 1.506]	< 0.01	1.73			
Critical Thinking	2	1.55	[1.137, 1.952]	< 0.01	0.17			
Other	6	1.26	[0.757, 1.758]	< 0.01	20.14			
Year								
2016-2018	7	1.28	[0.920, 1.648]	< 0.01	17.35	1	2.31	1.000
2019-2021	21	1.06	[0.803, 1.317]	< 0.01	81.87			

Note. k = the number of studies; CI = Confidence Interval; Qw = Q within; Qb = Q between.

The results of the analysis showed that the overall effect size of the study was (d = 1.12; k = 29). The size of this effect is in the large category. These results indicate that the overall use of learning videos has a major effect on students' mathematical abilities when compared to conventional learning. This finding is in line with the results of a previous meta-analysis conducted by Noetel et al. (2021) which revealed that the use of instructional videos can increase learning achievement with an effect size of 0.80. Videos that affect math skills are supported by several factors, namely videos can facilitate students to study independently, adjust to the right time and place for them, and provide opportunities for students to be repeated until students really understand the material (Syah et al., 2019). Video facilitates information through both the eyes and ears so that students will find it easier to capture information. This is in accordance with the cognitive theory of multimedia learning proposed by Mayer (2008) which states that learning will be more effective when information is presented through both systems. Video can reduce students' cognitive load (Schneider et al., 2018). Specifically, videos allow students to manage their own cognitive load by pausing to take notes, replaying difficult passages, or speeding up easy passages. Thus we can conclude that learning videos can have a positive effect in learning. Although the results of this study may be subject to some experimental and publication bias, they suggest that instructional videos are unlikely to be detrimental and typically enhance student learning.

Based on the moderator variable for education level, the use of instructional video media has proven to be effective at all levels of education (elementary, junior high, high school, and university). The results of the heterogeneity test also found that the mean effect sizes of the four levels were significantly different (Qb = 36.25; p < 0.05). These results indicate that the effect of video media compared to conventional media on mathematics learning is different according to education level. Of the four groups, the use of video media was most effective at the high school level, followed by elementary, junior high, and university levels. This finding is in contrast to our assumption that higher levels will have a higher effect, which is in line with the findings of Ahlfeldt et al. (2005) and Tamur et al. (2020) that higher grades have higher engagement rates. The difference in the results of this study became the basic idea for future research involving more primary studies, and expanded inclusion criteria. Although there were significant differences, the four groups were proven to reveal that video media was more effective than conventional teaching media or without using video.

Based on the sample size moderator variable, the use of instructional video media proved to be effective in small sample sizes (≤ 30) and large samples (≥ 31). The results of the heterogeneity test found that the mean effect sizes of the two sample size groups were not significantly different (Qb = 0.98; $p > 0.05$). These results indicate that the effect of instructional video media compared to conventional media on mathematics learning does not differ according to sample size. This means that the use of instructional video media in small and large sample sizes is equally effective on mathematical ability. This result is different from the findings (Yakar, 2021; Karagol & Esen, 2019; Juandi et al., 2021). Their findings show that small sample sizes produce larger effect sizes.

Furthermore, based on the measured ability moderator variable, the use of instructional video media proved to be effective on all measured mathematical abilities (learning outcomes, concept understanding, problem solving, critical thinking and others). The results of the heterogeneity test also found that the mean effect sizes of the five groups were significantly different (Qb = 15.70; $p < 0.05$). These results indicate that the effect of video media compared to conventional media on mathematics learning is different according to the measured ability. Although there were significant differences, the five groups were proven to reveal that video media was more effective than conventional teaching media or without using video.

The moderator variables of the year measured consisted of two groups, namely 2016-2018 and 2019-2021. The results of the analysis (see Table 5) found that the mean effect sizes of the four groups were not significantly different (Qb = 2.31; $p > 0.05$). These results indicate that the effectiveness of the flipped classroom model compared to conventional teaching in mathematics learning does not differ according to the year of the study. Of the four groups, the use of the flipped classroom model was most effective in the 2021-2022 group (d= 1.11; $p < 0.01$), followed by 2017-2018 (d= 0.84; $p < 0.01$), 2019-2020 (d= 0.74; $p < 0.01$), and 2015-2016 (d= 0.41; $p < 0.05$). Although the average effect size of the 2016-2018 group (d = 1.28; $p < 0.01$) was higher than the group in 2019-2021 (d = 1.06; $p < 0.01$), the difference in the average effect size of the two was confirmed. not significant.

Based on the moderator variable in the year of the study, the use of instructional video media proved to be effective in the size of the group in the study year (2016-2018 and 2019-2021). The results of the heterogeneity test found that the mean effect sizes of the two study years were not significantly different (Qb = 2.31; $p > 0.05$). These results indicate that the effect of instructional video media compared to conventional media on mathematics learning is not different according to the research year group. This means that the use of instructional video media in 2016 to 2018 and 2019 to 2021. This finding is different from our assumption that the latest year will have a higher effect because we speculate that in the current year of research it may have gone through a development process from previous years. , so the results obtained will be better than the previous year.

Publication Bias Evaluation

The final step in the meta-analysis is the evaluation of publication bias. The evaluation of publication bias was carried out to show that the meta-analysis carried out was truly objective, in the sense that the articles that were the material for the meta-analysis were correct and showed results that were in accordance with the reality in the field. There are many methods that can be used to analyze publication bias. In this study, publication bias was evaluated using the File-Safe N method. Table 6 presents the results of the diagnosis of Fail-Safe N values.

Table 6. Fail-Safe N

File Drawer Analysis				
	k	**Fail-safe N**	**Target Significance**	**Observed Significance**
Rosenthal	28	4037	0.05	< 0.001

Based on the analysis of the results of the FSN test (see table 6) the value of k = 28 then 5k + 10 = 150. The Fail-Safe N value obtained is (FSN = 4037) with a target significance of 0.05 and $p < 0.001$. Since the FSN value is > (5k + 10), this indicates that the meta-analysis conducted has no problem of publication bias and is scientifically justified (Mullen et al., 2001; Borenstein et al., 2009; Retnawati et al., 2018)

CONCLUSION

The results of the analysis show that the use of learning videos has an effect on mathematical ability compared to conventional media. Based on the analysis of the moderator variables, it is known that the effect of instructional videos on mathematical abilities differs according to the groups, levels of education, and the measured mathematical abilities, but does not differ according to the sample size group and the year of research.

Apart from the reported validation results, this study also has limitations. This study only analyzed 28 effect sizes. This study also only analyzes mathematical abilities in general. Further research needs to expand the research sample and analyze mathematical abilities more specifically, for example: critical thinking skills, mathematical communication, and others. In addition, it is also recommended to be more specific in reviewing the analysis of moderator variables in this study by involving more research so that research findings become more accurate.

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