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The Effect of Self-Efficacy on Students' Mathematical Abilities: A Meta-Analysis Study

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Abstract: The Effect of Self-Efficacy on Students' Mathematical Abilities: A Meta-Analysis Study.
Objective: This study investigates the effect of diei efficacy on students' mathematical abilities. **Methods:** The research design used in this study is a meta-analysis by analyzing 16 studies published in journals indexed by SCOPUS with a sample of 73935 people in various countries. To support the accuracy of the analysis results, OpenMEE software is used. **Findings:** The results revealed that the combined effect size values generated using the random-effect model estimate were ($g = 0.518$; $p < 0.001$) with a standard error ($SE = 0.031$). This effect size belongs to the medium effect category. **Conclusion:** Thus, it can be concluded that self-efficacy has a positive and significant effect on students' mathematical abilities.

Keywords: Mathematics ability, self-efficacy, meta-analysis.

Abstrak: Dampak Efikasi Diri terhadap Kemampuan Matematika Siswa: Suatu Studi Meta Analysis.
Tujuan: *Penelitian ini menyelidiki pengaruh efikasi diri terhadap kemampuan matematika siswa.* ***Metode:*** *Desain penelitian yang digunakan dalam penelitian ini adalah meta-analisis dengan menganalisis 16 studi yang dipublikasikan pada jurnal terindeks SCOPUS dengan sampel sebanyak 73935 orang diberbagai negara. Untuk mendukung keakuratan hasil analisis digunakan software OpenMEE.* ***Temuan:*** *Hasil penelitian mengungkapkan bahwa nilai nilai effect size gabungan yang dihasilkan menggunakan estimasi model random-effect adalah ($g = 0.518$; $p < 0.001$) dengan standar error ($SE = 0.031$). Ukuran efek ini termasuk dalam kategori efek sedang.* ***Kesimpulan:*** *Dengan demikian dapat disimpulkan bahwa efikasi diri berpengaruh positif dan signifikan terhadap kemampuan matematika siswa.*

Kata kunci: *kemampuan Matematika, efikasi diri, meta-analisis.*

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INTRODUCTION

Mathematics is a universal science that has an important role in various disciplines and develops the power of human thought (Syahbana, 2012). The importance of mathematics cannot be separated from its role in various aspects of daily life such as trade, land measurement, construction, calculation of birth estimates and others. Mahmudi (2016) states that learning mathematics is functioned as a means to grow life skills. By learning mathematics, a person is trained to think creatively, critically, conceptually, and systematically so that they are expected to be able to apply mathematics in solving problems in everyday life and in other disciplines (Afrizon et al., 2012). This ability is certainly very necessary so that students can have the ability to obtain, manage, and utilize information to survive in conditions that are always changing, uncertain and competitive.

Mathematics is one of the subjects that becomes the main stressor in the learning process at school (Ghufron, 2013). This anxiety is because the students are worried that they do not have the ability to solve math problems and another reason is that they have negative emotional reactions to math problems, they are afraid and don't like math all the time. The high anxiety in learning mathematics leads to students' dislike of mathematics and a decreased understanding of mathematics. Previous research has described the factors that influence learning outcomes such as psychological, social and biological factors (Brezvscek, Jerebic, Rus, & Znidarsic, 2020). Although many studies have proven that the cognitive aspect is quite strong in influencing learning outcomes, it can be said that the affective aspect also has a positive effect (Abin et al., 2020; Gafoor & Sarabi., 2017; Recber et al., 2018).

Lipnevich et al in (Paramitha & Ajisukmo., 2021) reveal that although intelligence is a significant predictor of mathematics achievement, students' positive attitudes towards mathematics can explain why students can achieve higher. Students need to have a positive attitude because attitudes can lead students to like, enjoy, and show interest in learning mathematics (Wulanningtyas & Ate, 2020). Improving mathematical ability by obtaining good learning achievement will be more effective by increasing students' confidence in their own abilities in learning mathematics (Widyaninggar, 2014). Therefore, it is important to develop confidence in students' self-efficacy in learning mathematics so that students are able to obtain satisfactory learning achievements. An individual's belief in his ability to do or do something is known as self-efficacy (Bandura, 2001).

Self-efficacy is a person's belief in their ability to exercise a number of control measures over their own functioning and events in their environment so as to obtain positive results (Bandura, 2006; Santrock, 2007). According to Baron & Byrne (2004) self-efficacy is a person's belief in his ability or competence for the performance of a given task, achieving a goal or overcoming an obstacle. Bandura, et al (2008) explained that basically self-efficacy determines how people feel so they can think, motivate themselves, and behave. Students who doubt their abilities will tend to stay away from difficult tasks and it will be seen as a personal threat to themselves. On the other hand, students who have a high ability or self-efficacy will feel able to master a skill or carry out a task more readily to participate, work hard in the face of difficulties, and reach a higher level. A person who has good self-efficacy will feel that he is always ready and alert in solving problems without any doubts about his condition. A person will not think of himself with other people, but believes he is capable like other people (Putra et al., 2013). Self-efficacy is a person's evaluation of his ability and competition

to perform tasks, achieve goals, and overcome obstacles. When self-efficacy is high, students can feel they are doing certain responses to get reinforcement, otherwise if self-efficacy is low, students will feel anxious and unable to make that response (Wulanningtyas, 2020). Based on this description, self-efficacy can be expressed as a person's belief in doing something.

Previous research has revealed that there is a good positive correlation between self-efficacy and attitudes towards mathematics (Kundu & Ghose, 2016; Obedient & Rozario, 2014). This can be interpreted, the higher the level of student self-efficacy, the more positive students' attitudes towards mathematics. By improving students' attitudes, it will increase students' confidence and confidence in mathematics. Although there are many studies that prove that self-efficacy is positively correlated with students' math achievement, June and Eamoraphan (2019) reported that the correlation is low, different representations of findings on the same topic, of course, lead to subjective conclusions. Therefore, a research design with further analysis is needed to incorporate quantitative findings so as to provide accurate and useful conclusions for policy making (Higgins & Katsipataki, 2015). Thus, a suitable research design to be carried out is a meta-analysis.

Meta-analysis is a statistical analysis that combines the results of several scientific studies to produce the best approach (Nordmanna et al., 2012). Meta-analytical studies are needed with the aim of integrating and interpreting the findings to obtain in-depth and convincing conclusions (Schmidt & Hunter, 2015). Meta-analysis studies are the most important way of combining several studies, strengthening the level of validity of existing research results with similar findings and being able to explain these differences if there are differences in results (Kot et al., 2018; Siegel et al., 2021; Juandi). et al., 2021; Suparman et al., 2021). A meta-analysis was conducted to summarize the population evidence and then consider its implications (Lee, 2019;Tamur et al., 2020)

Meta-analytical research related to the effect of self-efficacy on academic performance has previously been carried out (Huang, 2016; Fun, 2021), however, these studies are not specifically focused on the variable of mathematical ability. -analysis that specifically focuses on the effect of self-efficacy on students' mathematical abilities. Based on the problems that have been described, it is necessary to conduct meta-analytical research related to the effect of self-efficacy on students' mathematical abilities by analyzing studies published in reputable journals. Therefore, this study aims to analyze, evaluate and examine the magnitude of the effect size between self-efficacy and students' mathematical abilities. The results of the meta-analysis are expected to be a solid theoretical foundation.

METHODS

Study Selection

The research design used in this study was a meta-analysis, where statistical analysis was used to calculate the effect size of each study and the combined effect. The articles analyzed in this study are studies published in journals indexed by SCOPUS. The first step to conduct a meta-analysis study is to collect data according to the specified inclusion criteria. The primary data in this research is research on the relationship between self-efficacy and students' mathematical abilities. Researchers search for relevant articles on online databases such as Scholar, Eric, Elsevier and Scopus websites. The keywords used in the research literature search were "relationship between self-efficacy and mathematical ability", "influence of self-efficacy and mathematical ability", and other standard words related to these two variables.

All study articles in the initial search were examined and assessed for further meta-analysis. The inclusion criteria used to screen publications of research results are:

1. The year of publication ranges from 2012 to 2022.
2. Articles containing research in SCOPUS indexed journals
3. Regression or correlation research related to self-efficacy and math ability
4. Articles are required to report the number of samples, the value of r, t, or F
5. Minimum sample of 50 respondents
6. Articles can be accessed online

Based on the search results that match the specified inclusion criteria, 16 independent studies were found for further evaluation. Hunter & Schmidt (2004), stated that if only 10 studies were studied, it was said to be small. Therefore, the number of studies used in this meta-analysis can be said to be large. Table 1 presents the search results data that match the inclusion criteria.

Table 1 . Search result data

Author	Region	Journal Name
Li, H et al (2020)	China	British Journal of Educational Psychology
Zhang & Wang (2020)	China	International Journal of Educational Research
Li, L et al (2020)	China	Children and Youth Services Review
Xu & Qi (2019)	China	EURASIA Journal of Mathematics, Science and Technology Education
Zakaria (2021)	Norwegian	Frontiers in Psychology
Nuruddin et al (2018) a	Malaysia	Journal of Physics: Conference Series
Nuruddin et al (2018) b	Malaysia	Journal of Physics: Conference Series
Nuruddin et al (2018) c	Malaysia	Journal of Physics: Conference Series
Nuruddin et al (2018) d	Malaysia	Journal of Physics: Conference Series
Özdemir et al (2021)	Turkey	Participatory Educational Research
Palestro & Jameson (2020)	Amerika Serikat	Cognition, Brain, Behavior. An Interdisciplinary Journal
Chema & Kitsantas (2013)	Amerika Serikat	International Journal of Science and Mathematics Education
Kalaycıoğlu (2015)	England	Educational Sciences: Theory and Practice
Hosein & Harle (2018)	England	Studies in Educational Evaluation
Miscevic (2015) a	Serbia	Revista Electrónica de Investigación Educativa
Miscevic (2015) b	Slovenia	Revista Electrónica de Investigación Educativa

Hypothesis

The hypothesis in this meta-analysis:

Ho: There is no significant effect between self-efficacy and students' mathematical ability

H_1: There is a significant effect beteen self-efficacy and students' mathematical ability

Data analysis

Data analysis was carried out with the help of JASP software. The meta-analysis scheme used in this article consists of several steps, namely: (1) calculating the effect size of each study; (2) heterogeneity test; (3) Calculate the Combined effect size; (4) Evaluation of publication bias. The effect size interpretation in this study uses the classification proposed by Thalheimer and Cook (2002). The size classification is presented in table 2 below.

Table 2. Effect size of experimental study

Klasifikasi	Interval
No Effect	-0.15 ≤ Effect Size ≤ 0.15
Low Effect	0.15 < Effect Size ≤ 0.40
Moderate Effect	0.40 < Effect Size ≤ 0.75
High Effect	0.75 < Effect Size ≤ 1.10
Very High Effect	1.10 < Effect Size ≤ 1.45
Excellent Effect	Effect Size > 1.45

The heterogeneity test in this study was carried out using the Q parameter approach. If the p-value < 0.05, the estimation model that is suitable for calculating the summary effect is the random effects model. If the p value > 0.05, then the estimation of the fixed effect model is used. The publication bias test used 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 justified.

■ RESULT AND DISCUSSIONS

Effect size of each study

The first step is to calculate the effect size of each study. For more accuracy, the effect size of each study in this study was calculated using the OpenMEE software. Table 3 presents a summary of the effect size and variance values for each country study. Effect size values range from 0.090 to 1,263. Of the total 16 effect sizes, one effect size (n = 1) is classified as very high effect, four effect sizes (n = 4) are classified as high effect, four effect sizes (n = 4) are classified as moderate effect, six effect sizes are classified as moderate effect. (n = 6) is classified as low effect, and one effect size (n = 1) is classified as no effect.

Effect size of each study

The first step is to calculate the effect size of each study. For more accuracy, the effect size of each study in this study was calculated using

Table 3. Effect size and variance for each study

Author	Country	Effect Size	Varians
Li, H et al (2020)	China	0.333	0.000
Zhang & Wang (2020)	China	0.375	0.008
Li, L et al (2020)	China	0.090	0.002
Xu & Qi (2019)	China	0.355	0.000
Zakaria (2021)	Norwegian	0.460	0.005
Nuruddin et al (2018) study 1	Malaysia	0.929	0.011

Nuruddin et al (2018) study 2	Malaysia	0.877	0.011
Nuruddin et al (2018) study 3	Malaysia	1.263	0.011
Nuruddin et al (2018) study 4	Malaysia	1.028	0.011
Özdemir et al (2021)	Turkey	0.703	0.005
Palestro & Jameson (2020)	Amerika Serikat	0.497	0.009
Chema & Kitsantas (2013)	Amerika Serikat	0.604	0.000
Kalaycıoğlu (2015)	England	0.297	0.000
Hosein & Harle (2018)	England	0.793	0.017
Miscevic (2015) study 1	Serbia	0.323	0.000
Miscevic (2015) study 2	Slovenia	0.393	0.000

the OpenMEE software. Table 3 presents a summary of the effect size and variance values for each country study. Effect size values range from 0.090 to 1,263. Of the total 16 effect sizes, one effect size (n = 1) is classified as very high effect, four effect sizes (n = 4) are classified as high effect, four effect sizes (n = 4) are classified as moderate effect, six effect sizes are classified as moderate effect. (n = 6) is classified as low effect, and one effect size (n = 1) is classified as no effect.

Table 4. Heterogeneity Test Data Summary

Q	df	p-value	I^2
553.270	15	< 0.001	97.289

The results of the analysis showed that the value of Q = 553,270 and p < 0.001. The degree of variation in effect size between studies is reflected in the I-Squared value (I^2 =95.905) which indicates that 97% of the observed effect sizes reflect the percentage variability due to true heterogeneity. So it can be concluded, the distribution of effect size in the research analyzed is heterogeneous. Because each effect size is heterogeneous, the model used to calculate the combined effect size is a random effect.

Overall Effect Size Using the Random Effects Model

The third step is to calculate the combined effect size of the experimental studies. Based on the search using the JASP software, the combined effect size was obtained (g=0.518; k = 16). The lower limit of the confidence interval (LLg = 0.457), while the upper limit value (ULg = 0.580). This combined effect size is included in the moderate effect classification.

Table 5. Presents the results of the combined effect size estimation

	Effect Size (g)	Std. Error	p-value	95% Confidence Interval	
				Lower Limit	Upper limit
Overall	0.518	0.031	< 0.001	0.457	0.580

Furthermore, to find out whether the hypothesis is accepted or not, it can be seen from the coefficient of the p value. Based on table 5, the p value was found to be less than 0.01. Because p value < 0.01, then the hypothesis Ho is rejected, so it can be concluded that there is a positive and significant influence between self-efficacy and students' mathematical abilities. The summary results of the effects can also be seen in the following forest plot image.

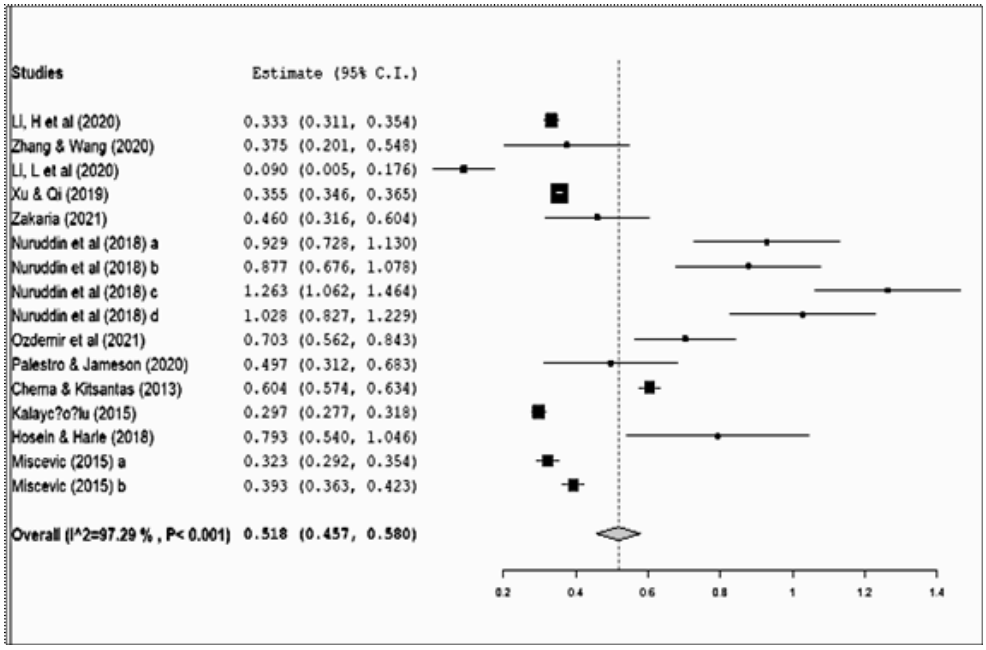

Figure 1. The results of the forest plot summary effect

Evaluation of Publication Bias

The final step in the meta-analysis is to detect 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 Rosenthal's fail-safe N-value diagnosis.

Based on the results of the analysis in table 6, because the value of K = 16 then 5K + 10 = 90. The Fail-Safe N value obtained is (FSN = 31199) with target significance (á = 0.05) and p < 0.001. Since the File-Safe N value is > (5K + 10), this indicates that the meta-analysis carried out has no problems of publication bias and is scientifically justified.

This study investigates the effect of self-efficacy on students' mathematical abilities using a meta-analysis approach. The results of the study found that the combined effect size value using a random effect approach was (d=0.518; p<0.001), this result proved that self-efficacy had a positive and significant effect on mathematical ability. The results of the publication bias test using the Fail-Safe N method were obtained (FSN=31199 < 5k + 1; k=16), thus the meta-analysis carried out in this study was completely objective and scientifically justified. In this regard, there have been no previous meta-analytical studies that reported the effect of self-efficacy on students' mathematical abilities, however, a

Table 6. File-Safe N

File Drawer Analysis			
	Fail-safe N	**Target Significance**	**Observed Significance**
Rosenthal	31199	0.05	< 0.001

meta-analysis conducted by (Fun, 2021) has reported that self-efficacy has a positive effect on academic performance of psychology faculty students. These results indicate that self-efficacy is one of the important determinants of the achievement of students' mathematical abilities. One's self-confidence in one's own abilities is the main mediating construct of goal achievement (Bandura, 2006; Baron & Byrne., 2004). Someone who has high self-efficacy, will feel that he is always ready and alert in solving problems without any doubts about his condition, they will not think about the differences between themselves and others, but believe that they are capable like other people (Pajares & Miller, 1994; Bandura, 2006; Eccles & Wigfield, 2002; Elias & Loomis, 2002; Linenbrink & Pintrich, 2002; Schunk & Pajares, 2002; Putra et al., 2013).

Reviewing the importance of self-efficacy that every student must have, teachers need to modify learning techniques so that they can increase students' self-efficacy (Bandura, 2006; Schunk 2002). Based on previous research, various learning models and strategies were reported to be able to increase students' self-efficacy, some of these learning models and strategies include; ARCS model (attention, relevance, confidence, and satisfaction) (Shin, 2018; Hasibuan, 2020), project-based learning model (Bilgin et al., 2015; Shin Myeong, 2018), realistic mathematics education (RME) approach (Purwati , 2016; Susanti, 2017; Rahman et al., 2018; Siregar & Prabawanto., 2021), Problem Based learning (Mahasneh & Alwan., 2018; Saepuloh et al., 2021). Regarding the aspect of self-efficacy, previous meta-analysis studies also reported other psychological aspects that also contributed to the improvement of mathematical abilities including self-concept (Suciati et al., 2020), self-confidence (Çiftçi & Yýldýz., 2019) and emotional intelligence (Martaputri et al., 2021). In addition to the application of the learning model above, the teacher must also improve the assessment process that can improve the psychological aspects of students. To achieve this target, teachers must have an understanding of (what, why, and how) affective-based learning is applied.

In addition, guidance and counseling services are needed related to the implications of guidance and counseling by counselor teachers in increasing self-efficacy. Information services can help individuals, especially students, in meeting the information needs they need in overcoming the problems they are experiencing, both personal, environmental and future problems (Firman, 2018). Through group guidance services, students feel free to express opinions, can develop feelings, thoughts, perceptions, insights, and attitudes that support behavior for self-control, tolerance, and brainstorming for fellow group members to actively participate and share experiences in development efforts. insights, attitudes, and skills needed in an effort to prevent problems or in personal development efforts (Nengsih, 2017; Firman, 2018). Individual counseling services can express personally all the problems faced by students (Karimah & Khairani, 2020). Through group counseling, they can develop communication skills so that they can provide mutual assistance to group members (Suryani & Khairani, 2017). The provision of guidance and counseling services is able to help students develop optimally so that educational goals can be achieved (Hidayat, Yusri, & Ilyas, 2015).

■ CONCLUSIONS

The results showed that there was a significant effect between self-efficacy and mathematical ability. This meta-analysis also did not find publication bias problems, so the results of this study can be justified scientifically. In

addition, problems related to different representations of students' self-efficacy and mathematical ability variables based on various literatures ranging from small, medium, large, and very large effects became clear after a meta-analysis was carried out, namely the medium category. These findings are based on only 16 studies published in the SCOPUS indexed journal. Therefore, it is recommended to conduct further research by collecting more data to obtain the necessary variables. The findings of the meta-analysis research show the consistency of publication of research results on the effect of self-efficacy and students' mathematical abilities.

Apart from the validation results that have been reported, this study has certain limitations. This research only does a meta on articles published in Scopus indexed journals, future research needs to expand the research sample by involving articles that are not only Scopus indexed, so that it is possible to find differences in findings. This study also did not analyze the moderator variables which were also possible to contribute to the influence between the self-efficacy variables and students' mathematical abilities. Therefore, future research is suggested to expand the research sample and analyze moderator variables.These findings are expected to be able to add to the literature review and obtain in-depth and complete information for use by mathematics teachers and policy makers.

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