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Reflective Thinking and Self-Efficacy: A Meta-Analysis and Its Implications for Mathematics Learning

Yoga Tegar Santosa[1]✉, Mutiara Hisda Mahmudah[2], Devi Yulindra[3], Akbar Waliyuddin Pakpahan[4]
[1,2]Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta, Indonesia
[3]Faculty of Teacher Training and Education, Universitas Lampung, Indonesia
[4]Faculty of Islamic Studies, Universitas Muhammadiyah Metro Lampung, Indonesia

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Abstract

Reflective thinking and self-efficacy are two crucial constructs in education, particularly in mathematics education, and both have been reported to share a positive relationship across various contexts. However, empirical findings regarding the strength of this relationship remain inconsistent. This study presents a meta-analysis to investigate the relationship between reflective thinking and self-efficacy by addressing four research questions: (1) What is the overall strength of the relationship between reflective thinking and self-efficacy? (2) Is there significant heterogeneity among the studies? (3) Do the year of study, country, participants, educational level, and sample size serve as moderators? (4) How can the findings of this meta-analysis be integrated into mathematics learning practices? A total of 28 articles meeting the inclusion criteria were synthesized from the Scopus, ScienceDirect, and ERIC databases, following the PRISMA search protocol. The analysis involved calculating effect sizes, estimating a random-effects model, testing for heterogeneity, analyzing moderator variables, and examining publication bias. The results revealed a positive and statistically significant relationship between reflective thinking and self-efficacy ($t(27) = 5.56$, $p < 0.001$). The heterogeneity analysis indicated substantial variation among the included studies. Moderator analysis indicated that participant characteristics were a significant source of this variability, with pre-service mathematics teachers representing one of the key contributing groups. These findings highlight the importance of integrating reflective activities into mathematics learning in ways that are responsive to learner characteristics across educational levels. The results also underscore the need for future research to examine theory-driven pedagogical moderators to further clarify the mechanisms linking reflective thinking and self-efficacy.

Keywords: mathematics learning, meta-analysis, self-efficacy, reflective thinking

✉***Corresponding Author:***
Yoga Tegar Santosa, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta, Indonesia
Email: a418240010@student.ums.ac.id

1. Introduction

Education in the 21st century demands that students possess strong problem-solving skills, making higher-order cognitive skills such as reflective thinking increasingly essential (Kholid et al., 2022 ; Sutama et al., 2022). In the context of mathematics learning, reflective thinking plays a crucial role as it helps students rationalize problems, establish connections among ideas, experiences, knowledge, perceptions, and reasoning, and select effective strategies to arrive at a solution (Akpur, 2020). Reflective thinking also mitigates students' difficulties when facing challenges and supports self-regulation during the problem-solving process (Maksimović & Osmanović, 2019). Furthermore, it encourages students to re-evaluate their strategies, enabling them to make more informed decisions when solving mathematical problems (Ngololo & Kanandjebo, 2021). In line with this, Şen (2013) asserts that the higher the students' reflective thinking ability, the higher their academic achievement. Thus, reflective thinking serves as a vital foundation for cognitive achievement and self-regulation in mathematics learning. On the other hand, students' reflective thinking abilities are inseparable from the psychological factors that influence how they perceive their own capabilities in tackling mathematical tasks, one of which is self-efficacy.

Self-efficacy is defined as an individual's belief in their capability to plan, regulate, and execute the actions necessary to attain specific goals (Hidayat et al., 2025). In the context of mathematics learning, self-efficacy is a critical psychological factor that influences how students respond to challenges, confront errors, and persist in the face of difficulties (Zakariya, 2022). Students with high levels of self-efficacy tend to set more challenging learning goals, demonstrate perseverance in completing tasks, manage academic stress and negative emotions, and are more active and purposeful in evaluating their thinking processes (Izzatunnisa et al., 2023; Putri & Hariyanti, 2022). Consequently, self-efficacy not only contributes to learning motivation and performance but also potentially strengthens the reflective thinking skills that play a pivotal role in enhancing mathematics learning achievement.

Theoretically, a close link exists between reflective thinking and self-efficacy in the learning process. According to Jurs et al. (2023), the process of reflective thinking enables students to re-examine their employed strategies, analyze both successes and failures, and identify areas for improvement (Putri et al., 2025). This mechanism can strengthen students' belief in their own abilities, as positive reflective experiences contribute to the formation of mastery experiences, which Bandura (1997) identifies as the most powerful source of self-efficacy. Furthermore, students with high self-efficacy are more inclined to engage in deep reflection because they believe their efforts will impact the successful completion of tasks (Wei et al., 2024). Thus, reflective thinking and self-efficacy influence each other reciprocally: reflective thinking helps build students' academic confidence, while self-efficacy supports their engagement in more meaningful reflection processes. Nevertheless, empirical research shows varied results regarding the strength and consistency of the relationship between these two variables.

Several studies have reported a strong relationship between reflective thinking and self-efficacy. Research by Safari et al. (2020) and Nuryadi et al. (2025) showed that the standardized regression coefficient (β) between the two variables in a Structural Equation Modeling (SEM) model exceeded 0.70. Similar findings were presented by Santosa et al. (2025), who, through path analysis, reported a β value of 0.748. However, other studies have reported different relationship strengths. For instance, Yilmaz & Baş (2021) found a β value of 0.24, while Asakereh & Yousofi (2018) reported a Pearson correlation coefficient (r) of only 0.146, indicating a weak relationship. This variation in findings indicates heterogeneity among studies, which may be influenced by differences in research context, participant characteristics, educational level, research sample, or year of study (Borenstein et al., 2021; Lipsey & Wilson, 2001).

This inconsistency underscores the need for a more comprehensive empirical synthesis through meta-analysis to obtain a more accurate estimate of the relationship and to identify the factors that moderate the link between reflective thinking and self-efficacy.

Previous meta-analyses have been conducted on both reflective thinking and self-efficacy, but separately. Meta-analyses on reflective thinking include those by Chamdani et al. (2022) and Gürbüztürk & Ünal (2022), who examined the relationship between reflective thinking and academic achievement. Yelbuz et al. (2022) investigated the link between reflective thinking and lower conspiracy beliefs, and Yanto et al. (2025) evaluated the effect of Problem-Based Learning on mathematical reflective thinking skills. Meanwhile, meta-analyses on self-efficacy were conducted by Huang (2016) on the relationship between self-efficacy and achievement goals, Livinţi et al. (2021) on self-efficacy as a predictor of engagement in research activities, and Liao et al. (2021) on the association between self-efficacy and self-comparison. Additionally, studies linking the variables of reflective thinking and self-efficacy have been limited to correlational research (Nuryadi et al., 2025; Safari et al., 2020; Santosa et al., 2025) and systematic literature review (Izzatunnisa et al., 2023). To date, no meta-analytical study has specifically examined the relationship between reflective thinking and self-efficacy. Although the empirical studies included in this meta-analysis span diverse educational domains, including language education, mathematics learning is emphasized in the interpretation of findings due to its distinctive cognitive and metacognitive demands, where reflective thinking and self-efficacy play a central role (Thahir et al., 2019). Therefore, this study aims to fill this gap. This research is important as it can provide a more precise estimate of the relationship while offering a more integrated understanding of the factors influencing the association between the two variables.

1.1 Research Question

Based on the background outlined, this study aims to investigate the relationship between reflective thinking and self-efficacy through a meta-analytic approach. Given the limited number of mathematics-specific empirical studies examining both variables, this meta-analysis synthesizes evidence from the broader field of education. The findings are then interpreted with particular attention to mathematics learning, where reflective thinking and self-efficacy are theoretically central due to the abstract and problem-solving-oriented nature of the subject (Thahir et al., 2019). Specifically, this study is designed to answer the following research questions:

1. What is the overall strength of the relationship between reflective thinking and self-efficacy? (RQ1)
2. Is there significant heterogeneity among the studies? (RQ2)
3. Do the year of study, analytical methods, country, participants, educational level, and sample size serve as moderators in the relationship between reflective thinking and self-efficacy? (RQ3)
4. How can the findings on the relationship between reflective thinking and self-efficacy be integrated into the practice of mathematics learning? (RQ4)

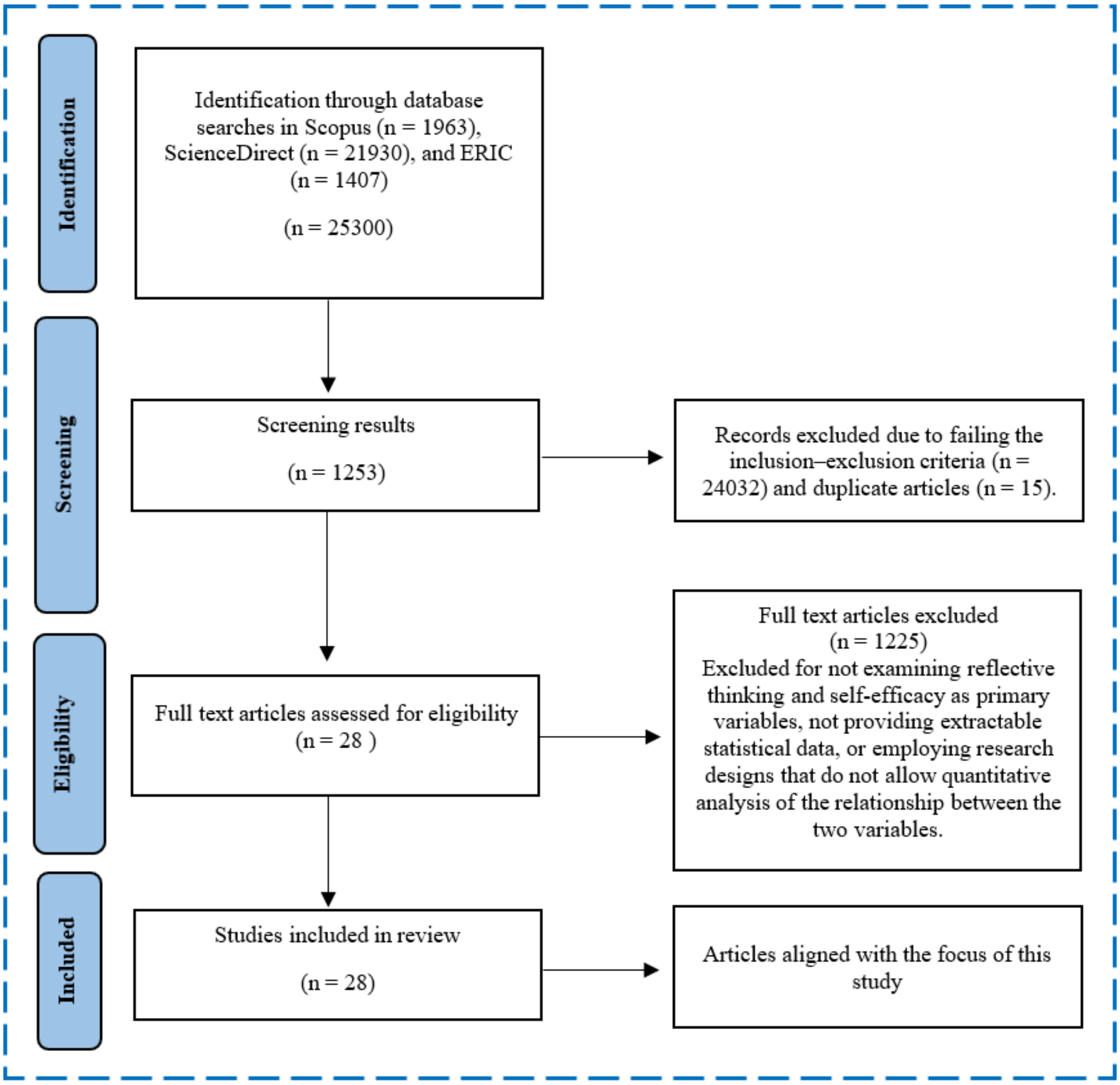

Figure 1. Article Selection Process using PRISMA

2. Method/Approach

2.1 Research Design

This study employs a meta-analytic design. Meta-analysis is a research approach that quantitatively combines and analyzes the results of previous independent studies to estimate the average effect, the strength of a relationship, or differences between groups based on the totality of available findings (Borenstein et al., 2021). In this research, meta-analysis was utilized to synthesize the effect sizes from studies examining the relationship between reflective thinking and self-efficacy, enabling the testing of heterogeneity and the identification of moderator variables that influence the variation in findings across studies.

2.2 Search Procedure

To ensure the meta-analysis was conducted systematically and transparently, the article search process in this study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, as recommended by Moher et al. (2009). PRISMA guides researchers through four main stages: (1) identification, (2) screening, (3) eligibility, and (4) inclusion. These four stages ensure that the process of searching, selecting, and reporting articles is conducted in a structured and replicable manner. Figure 1 presents the article selection flow using the PRISMA framework in this study.

Table 1. PECO Framework

PECO Framework	Categories	Keywords
E (Exposure)	Reflective Thinking	"reflective thinking", "reflection"
C (Comparison)	Self-Efficacy	"self-efficacy"

Table 2. Search Strings and Boolean Combinations Used in SCOPUS, ScienceDirect, and ERIC Databases

Database	String
Scopus	("reflective thinking" OR "reflection") AND ("self-efficacy")
ScienceDirect	("reflective thinking" OR "reflection") AND ("self-efficacy")
ERIC	("reflective thinking" OR "reflection") AND ("self-efficacy")

2.2.1 Identification

The identification step began with determining the databases for the systematic review. In this case, the SCOPUS, ScienceDirect, and ERIC databases were used. After determining the databases, the next step was to establish the keywords used to search for research articles in these three databases. In this study, the keywords were determined using the PECO (Population, Exposure, Comparison, and Outcomes) framework, as recommended by Morgan et al. (2018). The PECO framework assists researchers in identifying and formulating relevant keywords based on the study population, the exposure of interest, the comparison condition, and the expected outcomes (Littlewood & Kloukos, 2019). However, in this study, the Population aspect was not detailed because the primary focus of the literature search was not directed at specific participant characteristics. Likewise, the Outcome component was not incorporated into the search strings to avoid excluding potentially relevant studies that reported statistical associations without explicitly labeling them in the title or abstract. Table 1

Furthermore, for the Exposure aspect, the researchers focused on reflective thinking, and the Comparison aspect referred to self-efficacy. Based on the Exposure and Comparison components, the keywords were combined using the Boolean operators "AND" and "OR" to facilitate the literature search (see Table 1). The same search string was applied consistently across the SCOPUS, ScienceDirect, and ERIC databases. Table 2 presents the search strategy used in each database.

Based on the identification stage procedures described previously, the researchers obtained 1963 articles from the SCOPUS database, 21930 from the ScienceDirect database, and 1407 from the ERIC database. Thus, the total number of articles identified at this stage was 25300. Subsequently, all of these articles proceeded to the screening stage for further filtering based on the predetermined inclusion and exclusion criteria.

2.2.2 Screening

The screening stage began with the selection of articles obtained in the previous phase. These articles were filtered based on the established inclusion and exclusion criteria, as presented in Table 3. Based on the established inclusion and exclusion criteria, 1571 articles from the SCOPUS database, 21365 from ScienceDirect, and 1096 from ERIC were eliminated. In total, 24032 articles that did not meet the criteria were removed from the selection process, leaving 1268 articles remaining in this stage. Furthermore, searching across multiple databases

Table 3. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Publication Year	Articles published between 2006 and 2025	Articles published outside the specified range
Type of Publication	Only peer-reviewed journal articles	Conference papers, book chapters, reviews, books, conference reviews, notes, editorials, retracted papers, short surveys, and errata.
Language	Only articles written in English	Articles not written in English
Subject Area	Education	Other subject areas
Accessibility	Full-text articles or Open Access publications	Preview-only articles or those requiring payment for access

can result in duplicate articles. Therefore, duplicate articles were eliminated. Consequently, 1253 articles remained and were deemed eligible to proceed to the eligibility stage. See Table 3

2.2.3 Eligibility

The eligibility stage was conducted by reviewing the full texts of the articles that had passed the screening process. At this stage, the inclusion-exclusion criteria were applied more stringently, particularly concerning the availability of the statistical data required to calculate the effect size. Articles were eliminated if they: 1) did not investigate reflective thinking and self-efficacy as two main variables; 2) did not provide statistical data that could be used to calculate the effect size; 3) did not empirically analyze the relationship between the two variables, for instance, by only describing them without a correlation test; and 4) employed a research design that did not allow for the extraction of a quantitative relationship between the two variables, such as purely qualitative studies, literature reviews, or experimental studies that did not report correlational values. Based on these criteria, 1225 articles were eliminated, leaving 28 articles to proceed to the inclusion stage.

2.2.4 Inclusion

At the inclusion stage, all articles that had passed the eligibility process were re-examined to ensure the completeness of statistical data and the suitability of the research design for the meta-analysis. The 28 articles that met all criteria were deemed suitable and included as the final studies in the effect size calculation. Furthermore, according to Lipsey & Wilson (2001) and Borenstein et al. (2021), meta-analytic methodology does not impose a fixed minimum number of studies; rather, the adequacy of a meta-analysis depends on the availability of comparable effect size data and the appropriateness of the analytical model. In this regard, the inclusion of 28 studies can be considered methodologically adequate for estimating pooled effect sizes in educational research.

2.3 Data Extraction and Coding

Data were extracted from all articles that passed the selection process according to the PRISMA procedure. The extraction process was conducted using a coding sheet developed based on the objectives of the meta-analysis and the research variables. The information collected from each study included: (1) author names and year of publication, (2) country where the research was conducted, (3) participant characteristics, (4) educational level, (5) sample size (N), and (6) the correlational statistics between reflective thinking and self-efficacy. The extracted correlational statistics consisted of Pearson correlation coefficients (r) and/or standardized regression coefficients (β), which were subsequently converted into correlation effect sizes according to meta-analytic procedures. Furthermore, Table 4 presents a summary of the data extraction results from all analyzed studies.

Table 4. Summary of Data Extracted from the Included Studies

(Author's Year)	Country	Participants	Educational Level	N	r	β	F
(Phan, 2007)	Republic of Fiji	Educational Psychology Students	Higher Education	254		0.38	
(Uzun et al., 2013)	Turkey	Pre-service Mathematics Teachers	Higher Education	125		0.248	
(Noormohammadi, 2014)	Iran	Teachers	High School	172	0.4		
(Phan, 2014)	Australia	Pre-service Science Teachers	Higher Education	269		0.25	
(Beverborg et al., 2015)	Netherlands	Teachers	Higher Education	655		0.117	
(Seggelen-Damen & Dam, 2016)	Netherlands	Junior High School Students	Middle School	506		0.15	
(Sagir et al., 2016)	Turkey	Pre-service Science Teachers	Higher Education	619	0.582		
(Asakereh and Yousofi, 2018)	Iran	EFL Students	Higher Education	132	0.146		
(Thahir et al., 2019)	Indonesia	Junior High School Students	Middle School	64			0.063
(Loo et al., 2019)	Netherlands	Pre-service Science Teachers	Higher Education	111	0.241		
(Ghasemzadeh et al., 2019)	Iran	Teachers	High School	171		0.27	
(Agustina et al., 2020)	Indonesia	Teachers	Higher Education	637		0.22	
(Safari et al. 2020)	Iran	EFL Teachers	Higher Education	212		0.72	
(Yilmaz and Baş, 2021)	Turkey	Pre-service Mathematics Teachers	Higher Education	226		0.24	
(Huang et al., 2023)	China	Teachers	Middle School	510		0.2	
(López-Crespo et al., 2022)	Spain	Educational Psychology Students	Higher Education	73	0.31		
(Saracoglu, 2022)	Turkey	Pre-service Primary School Teachers	Higher Education	304		0.73	
(Ali and Ali, 2022)	Saudi Arabia	Teachers	Kindergarten	191	0.275		
(Zarrin et al., 2023)	Iran	Nursing Students	Higher Education	240	0.48		
(Karaoglan-Yilmaz et al., 2023)	Turkey	Pre-service Mathematics Teachers	Higher Education	217		0.263	

(Author's Year)	Country	Participants	Educational Level	N	r	β	F
(Ariany et al., 2023)	Indonesia	Pre-service Mathematics Teachers	Higher Education	78	0.6		
(Tao & Yu, 2024)	China	EFL Students	Higher Education	563	0.25		
(Xu et al., 2024)	China	Senior High School Students	High School	704		0.179	
(Jiang et al., 2025)	China	Junior High School Students	Middle School	479		0.031	
(Mensah et al., 2025)	Ghana	Pre-service Religious Teachers	Higher Education	146		0.752	
(Barkhordari-Sharifabad et al., 2025)	Iran	Nursing Students	Higher Education	199		0.92	
(Heydarnejad, 2025)	Iran	EFL Students	Higher Education	318	0.601	0.57	
(Nuryadi et al., 2025)	Indonesia	Middle School Students	Middle School	332		0.68	

2.4 Data Analysis

The data analysis in this study was conducted through several main stages, from the calculation of effect sizes to the assessment of publication bias. All analytical procedures were performed using a meta-analytic approach (Borenstein et al., 2021; Quintana, 2015) with the assistance of Jeffreys's Amazing Statistics Program (JASP) software, version 0.95.4, released in October 2025, the latest version of the platform. JASP was chosen because it is open-source software that is freely accessible, thereby facilitating replication and broadening the accessibility of the analysis for researchers. This platform also provides a comprehensive meta-analysis module, featuring effect size calculation, random- and mixed-effects model analysis, heterogeneity assessment, and publication bias detection.

2.4.1 Effect Size Calculation

The effect size of the relationship between reflective thinking and mathematics self-efficacy in each study was represented using the Pearson correlation coefficient (r). Studies that directly reported the correlation value were used as is. For studies that only provided a standardized regression coefficient (β), the value was converted to an equivalent correlation following the recommendation of Peterson & Brown (2005) using the formula:

$$r = \beta + 0.05\lambda$$

where $\lambda = 1$ if $\beta \geq 0$ and $\lambda = -1$ if $\beta < 0$.

In addition, for studies reporting F statistics with one degree of freedom in the numerator ($df_1 = 1$), the F values were converted into Pearson's correlation coefficients using the following formula:

$$r = \sqrt{\frac{F}{F + df_2}}$$

while F represents the reported F statistic and df_2 denotes the denominator degrees of freedom (Lipsey & Wilson, 2001).

Subsequently, all r values were transformed into Fisher's z to stabilize the variance, using the formula:

Table 5. Cohen's Effect Size Criteria

Value	Criteria
< 0 + / -.1	Weak
< 0 + / -.3	Modest
< 0 + / -.5	Moderate
< 0 + / -.8	Strong
≥ + / -.8	Very Strong

Table 6. Moderator Variables Included in the Study

Moderator Variable	Group	Frequency
Year of Study	2006-2009	1
	2010-2013	1
	2014-2017	5
	2018-2021	6
	2022-2025	15
Analytical Methods	SEM	15
	Path Analysis	2
	Linear Regression	11
Country	Iran	7
	Netherlands	3
	Turkey	5
	Republic of Fiji	1
	Australia	1
	Spain	1
	Ghana	1
	Saudi Arabia	1
	Indonesia	4
	China	4
Participants	Pre-service Science Teachers	3
	EFL Students	4
	Teachers	7
	Pre-service Mathematics Teachers	4
	High School	1
	Pre-service Primary School Teachers	1
	Educational Psychology Students	2
	Nursing Students	2
	Middle School Students	3
Educational Level	Kindergarten	1
	Junior High School	5
	Senior High School	4
	Higher Education	18
Sample Size	≤ 300	18
	> 300	10

$$z = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right)$$

Furthermore, the standard error of Fisher's z was calculated using the formula:

$$SE = \frac{1}{\sqrt{N-3}}$$

Effect size can be categorized into the values of 0–1 based on Cohen's effect size criteria (Cohen et al., 2000). Cohen's effect size criteria are presented in Table 5.

2.4.2 Random Effects Model

Because the synthesized studies originated from different research contexts, sample characteristics, and regions, a random-effects model was used. This model allows for the estimation of a true effect that varies between studies and is more appropriate for psychological and educational meta-analyses. To answer RQ1, the average effect was calculated based on the mean effect size in Fisher's z.

2.4.3 Test for Heterogeneity

To answer RQ2, heterogeneity among studies was tested using: 1) the Q statistic to detect significant heterogeneity, 2) the I^2 statistic to determine the proportion of variance due to differences between studies, and 3) tau-squared (τ^2) as an estimate of the variance of the true effect in the population. An I^2 value of $\geq 50\%$ was considered to reflect moderate-to-high heterogeneity (Higgins et al., 2003).

2.4.4 Moderator Analysis

To answer RQ3, a moderator analysis was conducted to evaluate whether specific variables influenced the strength of the relationship between reflective thinking and mathematics self-efficacy. The moderators analyzed are presented in Table 6. The analysis was performed using mixed-effects meta-regression for continuous moderators (year of study and sample size) and subgroup analysis for categorical moderators (analytical methods, country, participants, and educational level).

2.4.5 Publication Bias Assessment

To ensure the integrity of the meta-analysis results, an evaluation of potential publication bias was conducted through: 1) a Funnel plot, 2) Egger's test, and 3) the Trim-and-fill method if bias was detected (Higgins et al., 2019).

3. Result and Discussion

3.1 Result

The selection process yielded 28 studies that met all criteria and were included in the meta-analysis. These studies were published between 2006 and 2025, originated from 10 countries (Turkey, Iran, Indonesia, Saudi Arabia, Ghana, Australia, Spain, the Netherlands, the Republic of Fiji, and China), and involved a total of 8507 participants with sample sizes ranging from 64 to 704. The majority of the studies were conducted at the higher education level, with a smaller portion at the senior high school and kindergarten education levels (see Table 4). The correlation coefficients reported in each study showed considerable variation, ranging from $r = 0.0318$ to $r = 0.97$, indicating potential heterogeneity among the studies. All meta-analytic analyses were conducted using a random-effects model to accommodate differences in methodological characteristics and research contexts.

3.1.1 The Strength of the Relationship Between Reflective Thinking and Self-Efficacy

This analysis aimed to determine the strength of the relationship between reflective thinking and self-efficacy based on the 28 studies that met the inclusion criteria. Each study reported an effect size in the form of a Pearson correlation coefficient (r) or other statistics that were subsequently converted to r. All r values were transformed into Fisher's z to obtain an unbiased estimate in the random-effects model. Table 7 presents the effect size values (Fisher's z) along with their standard errors (SE), which served as the basis for calculating the combined effect in this meta-analysis.

Based on Table 8, the results of the estimation using the random-effects model indicate that reflective thinking is positively and significantly associated with self-efficacy. The pooled effect size indicated a statistically significant association, with a 95% Confidence Interval (CI) of [0.271, 0.589] and a significance test result of $t(27) = 5.56$, $p < 0.001$. This finding suggests that, on average, individuals with higher levels of reflective thinking tend to exhibit higher self-efficacy.

Table 7. Effect Sizes (Fisher's z) and Standard Errors Extracted from the Included Studies

Study	N	r	Effect Size	SE
Phan (2007)	254	0.43	0.459896681	0.06311944
Uzun et al. (2013)	125	0.298	0.307323247	0.090535746
Noormohammadi (2014)	172	0.4	0.42364893	0.076923077
Phan (2014)	269	0.3	0.309519604	0.061313934
Beverborg et al. (2015)	655	0.167	0.168578995	0.039163022
Sagir et al. (2016)	619	0.582	0.665481858	0.040291148
Asakereh & Yousofi (2018)	132	0.146	0.147050852	0.088045091
Thahir et al. (2019)	64	0.0318	0.031810726	0.12803688
Loo et al. (2019)	111	0.241	0.245835504	0.096225045
(Ghasemzadeh et al. (2019)	171	0.32	0.331647109	0.077151675
Agustina et al. (2020)	637	0.27	0.276863823	0.039715074
Safari et al. (2020)	212	0.77	1.020327758	0.069171446
Yilmaz & Baş (2021)	226	0.29	0.298566264	0.066964953
Huang et al. (2023)	510	0.25	0.255412812	0.044411559
López-Crespo et al. (2022)	73	0.31	0.320545409	0.119522861
Saracoglu (2022)	304	0.78	1.045370548	0.057639042
Ali & Ali (2022)	191	0.275	0.282264901	0.072932496
Zarrin et al. (2023)	240	0.48	0.522984278	0.06495698
Karaoglan-Yilmaz et al. (2023)	217	0.313	0.323867791	0.068358593
Ariany et al. (2023)	78	0.6	0.693147181	0.115470054
Tao & Yu (2024)	563	0.25	0.255412812	0.042257713
Xu et al. (2024)	704	0.229	0.233133868	0.037769479
Jiang et al. (2025)	479	0.081	0.081177848	0.045834925
Mensah et al. (2025)	146	0.802	1.104192704	0.083624201
Barkhordari-Sharifabad et al. (2025)	199	0.97	2.09229572	0.071428571
Heydarnejad (2025)	318	0.601	0.694711148	0.056343617
Nuryadi et al. (2025)	332	0.73	0.928727364	0.055131785

Table 8. Random-Effects Model Summary for the Relationship Between Reflective Thinking and Self-Efficacy

	Test	Estimate	95% Confidence Interval Lower	95% Confidence Interval Upper	p
Pooled Effect	t(27) = 5.56	0.430	0.271	0.589	< .001

Furthermore, the forest plot (see Figure 2) illustrates that nearly all studies reported a positive relationship, although the magnitude of the effect sizes varied substantially across studies. This variation suggests that the strength of the association between reflective thinking and self-efficacy is not uniform across all research contexts, necessitating that further interpretations account for the degree of between-study heterogeneity.

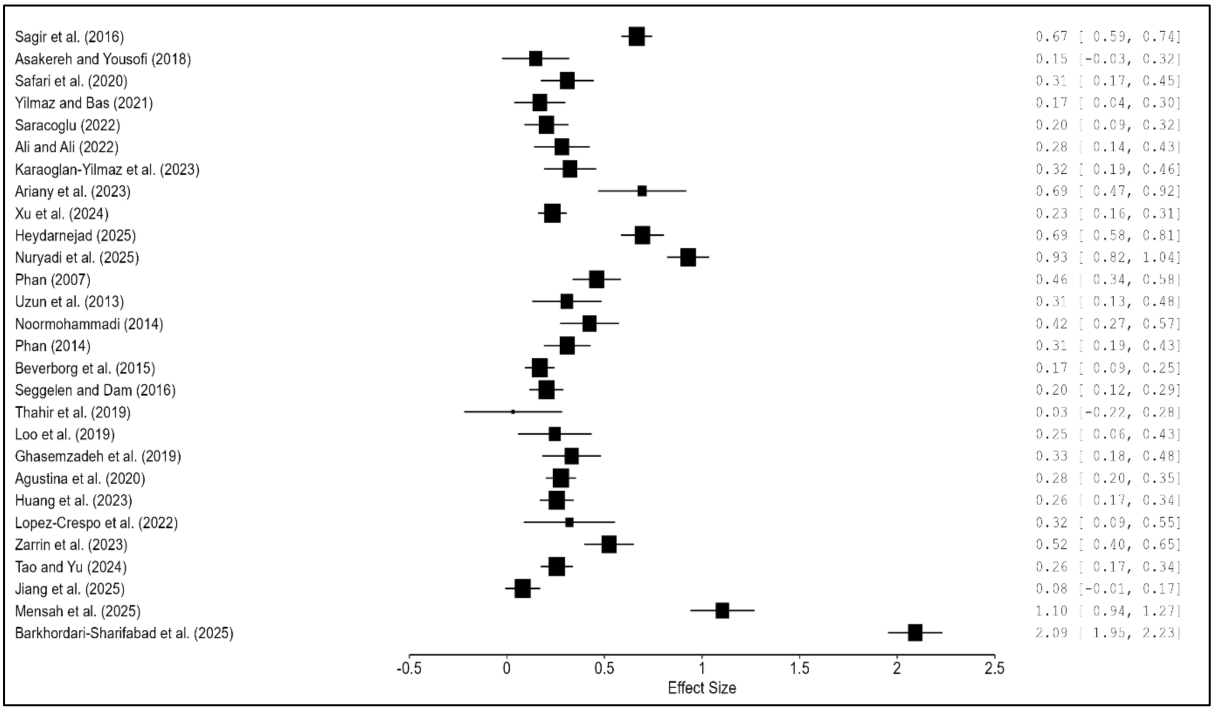

Figure 2. Forest Plot of the Individual Study Effect Sizes and the Overall Random-Effects Estimate

Table 9. **Heterogeneity Statistics of the Meta-Analysis**

	Parameter	Symbol	Estimate
Heterogeneity	Cochran's Q	Q	1011.62
	Degrees of freedom	df	27
	p-value (Q-test)	p	< .001
	Between-study variance	τ	0.403
	Heterogeneity Index	H^2	49.02
	Between-study variance	τ^2	0.162
	Proportion of variance due to heterogeneity	I^2	97.96

3.1.2 Evidence of Significant Between-Study Heterogeneity

Between-study heterogeneity was assessed using Cochran's Q, τ^2, and I^2 statistics to determine if significant variation in effect sizes existed beyond what would be expected by sampling error alone. The meta-analytic results, presented in Table 9, indicate the presence of very high heterogeneity among the included studies. The Q statistic was significant, $Q(27) = 1011.62$, $p < 0.001$, indicating that the variation in effect sizes could not be explained solely by sampling error, but instead reflected genuine differences among the studies. See Table 9

Furthermore, an I^2 value of 97.96% indicates that almost all of the variance in effect sizes is due to differences in characteristics between studies, falling into the category of substantial to considerable heterogeneity. The estimate of between-study variance, indicated by $\tau^2 = 0.162$ and its standard deviation $\tau = 0.403$, further reinforces the presence of substantial variation in the magnitude of the relationship between reflective thinking and self-efficacy across different research contexts. Additionally, an H^2 value of 49.02 suggests that the total variance in effect sizes is substantially greater than the expected variance under a homogeneity assumption (i.e., if all studies shared a common true effect).

Overall, these findings confirm that the relationship between reflective thinking and self-efficacy varies significantly across studies, thus justifying the use of the random-effects model

Table 10. Results of the Moderator Analysis

Moderator	Group	F-value	df1	df2	p	p-value
Year of Study	2006-2009	0.798	4	23.00	0.278	0.539
	2010-2013				0.798	
	2014-2017				0.817	
	2018-2021				0.579	
	2022-2025				0.837	
Methods	SEM	0.464	2	25.00	0.349	0.634
	Path Analysis				0.685	
	Linear Regression				0.001	
Country	Iran	0.759	9	18.000	0.467	0.654
	Netherlands				0.834	
	Turkey				0.958	
	Republic of Fiji				0.805	
	Australia				0.476	
	Spain				0.986	
	Ghana				0.205	
	Saudi Arabia				0.964	
	Indonesia				0.713	
	China				0.830	
Participants	Pre-service Science Teachers	3.061	9	18.000	0.883	0.042
	EFL Students				0.045	
	Teachers				0.756	
	Pre-service Mathematics Teachers				0.048	
	High School				0.741	
	Pre-service Primary School Teachers				0.687	
	Pre-service Religious Teachers				0.990	
	Educational Psychology Students				0.939	
	Nursing Students				0.009	
	Middle School Students				0.853	
Educational Level	Kindergarten	0.256	3	24.000	0.774	0.857
	Junior High School				0.685	
	Senior High School				0.060	
	Higher Education				0.817	
Sample Size	≤ 300	0.724	1	26.000	0.001	0.403
	> 300				0.403	

in this meta-analysis. The high degree of heterogeneity also suggests the influence of contextual factors or specific study characteristics that may moderate the strength of the association between these two variables. Consequently, a moderator analysis was conducted to identify potential factors explaining the variance in effect sizes across studies.

3.1.3 Analysis of Moderator Variables

To address RQ3, a mixed-effects meta-regression analysis was conducted to examine whether specific study characteristics acted as moderator variables in the relationship between reflective thinking and self-efficacy. The six moderator variables analyzed were: year of publication, analytical method, country, participant characteristics, educational level, and sample size. The significance level was set at $\alpha = 0.05$. The complete results of the moderator analysis are presented in Table 10.

Based on the moderator analysis results in Table 10, the participant variable was the sole significant moderator of the variance in effect sizes for the relationship between reflective thinking and self-efficacy ($F(9,18) = 3.061$; $p = 0.042$). This finding indicates that the strength of the relationship between these two variables differs significantly depending on the participant characteristics involved in the studies, such as school students, university students, teachers, and pre-service teachers. Further analysis at the subgroup level revealed that several participant categories showed significant differences compared to the reference category, specifically pre-service mathematics teachers ($p = 0.048$), nursing students ($p = 0.009$), and EFL students ($p = 0.045$). The significance within these subgroups is not interpreted as a standalone moderation effect, but rather as the primary contributors to the overall significance of the participant moderator.

Furthermore, the other five moderator variables did not show a significant effect on the variance in effect sizes ($p > 0.05$). The 'Year of Study' variable was not significant ($F(4,23) = 0.798$; $p = 0.539$), indicating that the publication period did not influence the strength of the relationship between reflective thinking and self-efficacy. Similarly, the analytical methods used in the studies (SEM, path analysis, and linear regression) did not act as significant moderators ($F(2,25) = 0.464$; $p = 0.634$), suggesting that the observed relationship was relatively consistent across different analytical approaches.

The 'Country' variable also did not show a significant moderation effect ($F(9,18) = 0.759$; $p = 0.654$), indicating that geographical and cultural contexts did not systematically influence the magnitude of the relationship between reflective thinking and self-efficacy. Subsequently, educational level (kindergarten, junior high school, senior high school, and higher education) did not serve as a significant moderator ($F(3,24) = 0.256$; $p = 0.857$). The sample size variable (≤ 300 and > 300) also did not show a significant moderation effect ($F(1,26) = 0.724$; $p = 0.403$).

Overall, although high between-study heterogeneity was identified in RQ2, the meta-regression results indicate that this heterogeneity can be partially explained by differences in participant characteristics, while other study characteristics failed to account for the observed variance in effect sizes. This finding suggests that the relationship between reflective thinking and self-efficacy is relatively stable across methodological and geographical contexts but varies depending on the population under study.

3.1.4 Publication Bias Assessment

To ensure the reliability of the meta-analytic findings, the potential for publication bias was assessed through a visual inspection of a funnel plot and a test for asymmetry using Egger's regression test. The funnel plot in Figure 3 displays a distribution that is not perfectly symmetrical, with a concentration of studies on the side of positive effects. However, this pattern cannot be directly interpreted as an indication of publication bias.

It is crucial to note that all effect sizes from the 28 included studies were positive (see Table 7). Under such conditions, a funnel plot is geometrically unlikely to exhibit perfect symmetry, as there are no studies with negative effects on the opposite side of the distribution for comparison. Moreover, the interpretation of this asymmetry must consider the substantial between-study heterogeneity ($I^2 = 97.96\%$) reported in this analysis. High heterogeneity, which reflects a distribution of true effects rather than a single common effect, is a primary driver of asymmetry in funnel plots. Therefore, the observed visual asymmetry is more likely a consequence of two methodological factors: the consistent direction of the effects and the high degree of true variation between studies. This makes the presence of systematic publication bias a less probable explanation for the observed pattern.

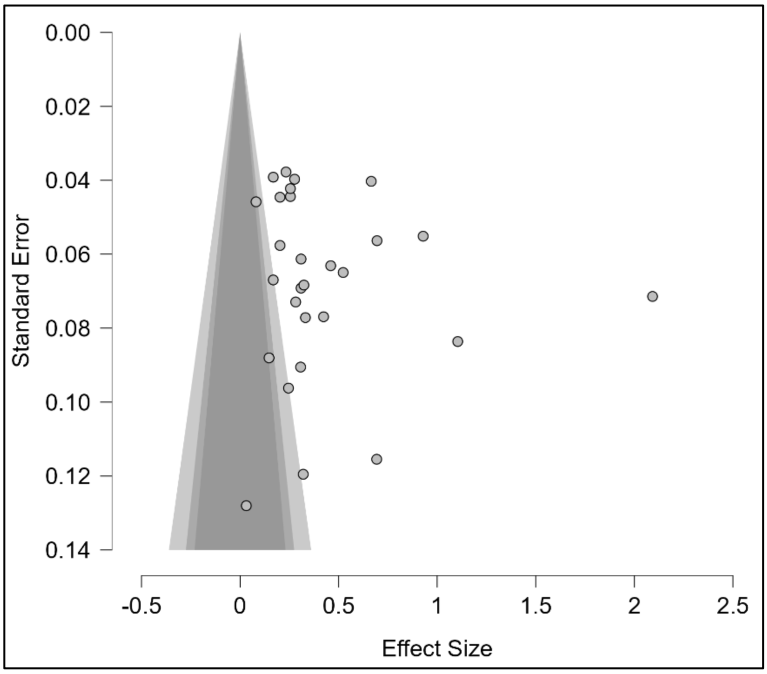

Figure 3. Funnel Plot

Table 11. Regression Test for Funnel Plot Asymmetry (Egger's test)

Estimates	Asymmetry Test			Limit Estimate µ		
	t	df	p	Estimate	Lower 95% CI	Upper 95% CI
28	1.120	26	0.273	0.492	– 0.265	0.594

Furthermore, the results of Egger's regression test, presented in Table 11, indicated no significant asymmetry (t = 1.120; df = 26; p = 0.273), thus revealing no statistical evidence of small-study effects. This finding reinforces our interpretation that the visual asymmetry is not caused by publication bias, but rather by the unidirectional distribution of effect sizes and, more importantly, the substantial true heterogeneity among the studies.

Based on the visual inspection and statistical tests, there is insufficient evidence to conclude the presence of meaningful publication bias in this meta-analysis. Consequently, the trim-and-fill method was not applied, and the results of this meta-analysis can be considered substantially unaffected by publication bias.

3.1.5 Implications for Mathematics Learning

Based on the findings of this meta-analysis, the researchers propose several important implications for the development of mathematics learning practices across various educational levels. The primary finding indicates that reflective thinking has a positive and statistically significant relationship with self-efficacy. The consistency of this relationship's direction, observed across all studies despite originating from different countries, educational levels, and participant types, affirms that reflective thinking is a critical cognitive and metacognitive aspect in the development of students' self-efficacy in learning mathematics.

1. Strengthening Mathematics Self-Efficacy through Reflective Activities
   The pooled effect size indicates that instructional practices fostering reflective thinking can meaningfully contribute to enhancing students' mathematics self-efficacy. In learning practice, mathematics teachers can integrate structured reflection activities (e.g., self-explanation, error analysis, reflective journaling, or metacognitive prompts) to help students

monitor their thinking processes, assess problem-solving strategies, and evaluate the validity of their reasoning. Such activities can strengthen perceptions of competence and self-control, which are the primary foundations of self-efficacy according to Bandura (1997)

2. Differential Effects Based on Participant Characteristics
   The results of the moderator analysis indicate that participant characteristics are the sole significant moderator of the variance in the strength of the relationship between reflective thinking and self-efficacy. This finding implies that reflection-based mathematics learning strategies cannot be applied uniformly, but must be tailored to the characteristics of the learning group. Specifically, the pre-service mathematics teachers group, which was one of the primary contributors to the significance of the participant moderator, indicates that reflective activities in pre-service mathematics teacher education should be directed towards problem-solving strategy analysis, conceptual understanding evaluation, and pedagogical reflection on the mathematics learning process. Meanwhile, for other levels or groups, such as school students, a reflective approach can be facilitated through structured questions and concrete activities appropriate to their cognitive development level.
3. Addressing Heterogeneity Through Evidence-Based Instructional Design
   The high level of between-study heterogeneity indicates that the effectiveness of reflective thinking in enhancing self-efficacy is strongly influenced by the context in which learning is implemented. Therefore, reflection in mathematics education should not be applied as a generic activity or one that is separate from the main learning process; rather, it needs to be systematically integrated into evidence-based instructional design. Instructional models such as Problem-Based Learning (PBL), Realistic Mathematics Education (RME), or guided discovery provide a clearer framework for students to reflect on mathematical problem-solving strategies, evaluate their mathematical thinking processes, and assess the accuracy of their solutions. Effective reflection needs to be directed not only towards describing the steps of a solution but also towards the critical evaluation of strategic choices and conceptual understanding. Thus, reflective activities can function as a mechanism that bridges conceptual understanding and the strengthening of self-efficacy in mathematics education.
4. Implications for Curriculum Development and Teacher Training
   Given that reflective thinking contributes to self-efficacy, the integration of reflective activities should be an explicit component of the mathematics curriculum. Furthermore, teacher training programs need to emphasize the importance of reflection-based instructional design, including how to provide scaffolding that encourages students to identify misconceptions, reformulate strategies, and build self-confidence grounded in mathematical understanding.

Furthermore, the implications derived from this meta-analysis are summarized in Table 12 to provide a concise overview that can guide mathematics educators, curriculum designers, and researchers in applying these findings to instructional practice.

Table 12. Concise Summary of Implications for Mathematics Education

Implication Area	Core Insight	Practical Direction
Strengthening Mathematics Self-Efficacy	Reflective thinking shows a positive and statistically significant association with self-efficacy	Embed structured reflective tasks in mathematics instruction (e.g., self-explanation, error analysis) to strengthen students' mathematical confidence and self-regulation.
Differential Effects Based on Participant Characteristics	The relationship between reflective thinking and self-efficacy varies significantly among participant groups, with pre-service mathematics teachers being a primary contributor to this difference.	Reflection-based mathematics instruction needs to be designed adaptively; specifically, in pre-service mathematics teacher education, reflection should be directed towards strategy analysis, conceptual understanding, and pedagogical reflection to enhance self-efficacy.
Responding to Study Heterogeneity	High heterogeneity indicates sensitivity to instructional context.	Employ evidence-based reflective models in mathematics learning (e.g., PBL, RME, guided discovery) that cultivate deep mathematical reasoning.
Curriculum and Teacher Training Implications	Reflective thinking contributes meaningfully to self-efficacy formation.	Integrate reflective components explicitly into mathematics curricula and emphasize reflective pedagogy in mathematics teacher training programs.

3.2 Discussion

The findings of this meta-analysis indicate that reflective thinking is positively and significantly associated with self-efficacy. This result is consistent with Bandura's (1997) theoretical framework, which emphasizes the role of cognitive-metacognitive processes in shaping self-perceived competence through mastery experiences, self-regulation, and internal evaluation. In this context, reflective thinking serves as a cognitive mechanism that fosters the development of adaptive self-assessment in the learning process, aligning with the metacognitive concept that positions reflection as the foundation for self-regulation and perceived competence (Thingbak et al., 2024; Wyatt, 2021). The consistency of this positive relationship across various study contexts in this research (Heydarnejad, 2025; Nuryadi et al., 2025; Safari et al., 2020; Sagir et al., 2016; Saracoglu, 2022) demonstrates that students' ability to review strategies, evaluate their thinking processes, and derive meaning from their learning experiences contributes significantly to the development of self-efficacy. This is supported by research from Torres et al. (2020) and Radović et al. (2021), who highlight the role of reflection in strengthening perceptions of academic capability. Therefore, the consistent relationship between reflective thinking and self-efficacy reflects a theoretically meaningful and empirically supported association between higher-order cognitive processes and the formation of learning self-belief across various educational levels.

Furthermore, the high between-study heterogeneity in this meta-analysis indicates that the relationship between reflective thinking and self-efficacy does not unfold uniformly across all research contexts. This variation aligns with the arguments of Closs et al. (2022) and Clark et al. (2023), who suggest that metacognitive and affective constructs are highly influenced by differences in instructional design, learning environments, and cultural dynamics that shape students' reflective experiences. Within the social-cognitive theory framework, repeated mastery experiences and their accompanying reflective processes are the foundation for forming competence beliefs, and both are highly sensitive to pedagogical settings (Wille et al., 2025). Consequently, the substantial heterogeneity observed in the analyzed studies suggests that there are contextual factors, such as the quality of reflective activity implementation, the nature of academic tasks, or the intensity of student engagement, that may contribute to variability in the observed relationship between reflective thinking and self-efficacy but were not explicitly documented in the articles sampled for this meta-analysis.

The moderator analysis revealed that differences in participant characteristics are a relevant factor in explaining the variation in the strength of the relationship between reflective thinking and self-efficacy. This finding aligns with the view of Guo (2022), who stated that the reflective process does not operate uniformly across all learner populations but is instead influenced by cognitive developmental stages, learning experiences, and the academic demands inherent to specific participant groups. Specifically, the significant contribution of the pre-service mathematics teachers group indicates that reflective thinking is potentially more effective in learning contexts that demand high-level mathematical reasoning, complex problem-solving, and pedagogical reflection. Consistent with the perspectives of Calkins et al. (2020) and Radović et al. (2021), directed reflection allows individuals to evaluate their thinking strategies and academic performance, which in turn strengthens their self-belief in their ability to solve challenging mathematical tasks.

Meanwhile, the non-significance of other moderators, such as year of publication, geographical context, educational level, analytical method, and sample size, indicates that the variation in the relationship between reflective thinking and self-efficacy is not primarily determined by the methodological or administrative characteristics of the research. This finding aligns with the research by Li et al. (2023), which found that metacognitive and affective constructs are more sensitive to the quality of learning experiences and instructional design than to solely demographic or structural factors. Therefore, although participant characteristics can explain some of the between-study heterogeneity, a residual variance remains, likely influenced by other substantive factors not accounted for, such as the form of reflective scaffolding, the complexity of mathematical tasks, and the validity and sensitivity of the measurement instruments.

This meta-analysis did not yield statistical evidence of publication bias. The result of Egger's regression test did not indicate significant asymmetry, suggesting that no small-study effects were detected in the corpus of studies analyzed. Nevertheless, interpreting the funnel plot has its limitations in the context of high between-study heterogeneity and a distribution of effect sizes concentrated in a single direction. Higgins et al. (2019) and Borenstein et al. (2021) assert that under conditions of substantial heterogeneity, funnel plot asymmetry cannot be conclusively interpreted as an indication of publication bias, as the pattern may also reflect contextual variations in effects. Furthermore, this finding is consistent with the meta-analysis by Chamdani et al. (2022), which reported a high level of heterogeneity ($I^2 = 94.707\%$) with no indication of publication bias based on Egger's regression test, thereby strengthening the argument that funnel plot asymmetry under such conditions does not always reflect publication bias. Consequently, the findings of this meta-analysis are interpreted as indicating no evidence of publication bias.

The lack of evidence for publication bias bolsters the credibility of these findings as a foundation for developing mathematics instruction that positions the reflective process as a key component of learning. Research indicates that reflective thinking functions as a metacognitive mechanism that helps students control the problem-solving process, manage errors, and assess the effectiveness of strategies (Kholid et al., 2020; Sa'dijah et al., 2020; Santosa, Antara, Sukimin, et al., 2025), while Bandura's (1997) social-cognitive theory asserts that such reflective experiences are the foundation for forming academic self-efficacy. In line with this framework, mathematics learning practices can utilize structured reflection activities, such as self-explanation, error analysis, reflective journaling, or metacognitive prompts, to strengthen students' perceptions of competence and self-belief (Amal & Mahmudi, 2020). However, consistent with the moderator analysis, the effectiveness of these reflective approaches may vary depending on learner characteristics. In particular, the more pronounced effects observed among pre-service mathematics teachers suggest that structured reflection is most impactful when learners are cognitively prepared to evaluate mathematical problem-solving strategies, conceptual understanding, and instructional decisions.

Furthermore, learning models such as PBL, RME, and guided discovery can provide space for deep reflection, facilitating students in evaluating their mathematical reasoning (Kirilova, 2024; Simamora et al., 2018). Therefore, the explicit integration of reflective activities into the curriculum, coupled with strengthening teacher competence in providing reflective scaffolding, is are strategic step for enhancing students' mathematical self-efficacy through more meaningful conceptual understanding.

Overall, this meta-analysis confirms the significant role of reflective thinking as a predictor of self-efficacy and underscores the need for future research that explores instructional contexts and content domains. These findings support the necessity of designing reflection-based learning that not only enhances cognitive abilities but also students' self-confidence in various learning contexts, including mathematics.

3.2.1 Limitations of the Study

Although this meta-analysis encompassed 28 primary studies and employed a random-effects model, several limitations warrant acknowledgment. The moderator analysis indicated that only participant characteristics were identified as a significant moderator, suggesting that while some of the between-study heterogeneity could be explained, a portion of the effect variability remains unaccounted for. The high degree of remaining heterogeneity reflects the complexity of contexts and practices in educational research, as well as limitations in the availability, clarity, and consistency of reporting for moderator variables in the primary studies. Furthermore, the moderators analyzed were general in nature and dependent on the information reported, thereby precluding an in-depth analysis of more specific contextual and pedagogical factors, such as instructional characteristics, measurement quality, and implementation context. Therefore, future research is recommended to expand the exploration of moderators and enhance the consistency of reporting in primary studies to gain a more comprehensive understanding of the sources of effect heterogeneity.

4. Conclusion

The results of this meta-analysis demonstrate that reflective thinking has a positive and significant relationship with self-efficacy, thereby affirming the crucial role of the reflection process in shaping learners' beliefs of competence in mathematics education. Nevertheless, the heterogeneity analysis revealed substantial variation among studies, indicating that the relationship between reflective thinking and self-efficacy does not manifest uniformly across all research contexts. Subsequent moderator analysis showed that participant characteristics were the sole significant moderator, suggesting that the strength of this relationship may differ depending on the profile and educational level of the learners, while other study characteristics were unable to explain the remaining variance. In practical terms, these findings imply that mathematics education needs to integrate reflective activities both systematically and adaptively, considering learner characteristics across various educational levels to more effectively support the development of self-efficacy. Despite these insights, the study is not without limitations, particularly concerning the limited availability of theory-based moderators and the variability in reporting quality among the primary studies. Therefore, future research is advised to explore more specific reflection mechanisms, incorporate moderators related to instructional design and reflective scaffolding, and employ more standardized methodological reporting to obtain a more comprehensive understanding of the role of reflective thinking on self-efficacy in mathematics education.

Declarations

Author Contribution	: Author 1: Conceptualization, Methodology, Data Curation, Screening and Coding of Studies, Formal Analysis, Visualization, Writing – Original Draft, Project Administration, Supervision, Correspondence and Submission Management; Author 2: Methodology, Software, Statistical Support, Validation; Writing – Review & Editing, Formal Analysis; Author 3: Investigation, Resources, Verification of Coding Consistency, Writing – Review & Editing; Author 4: Conceptualization; Writing – Review & Editing; Oversight of Research Quality)
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