

Achievement Emotion in Mathematics Learning: Meta-Regression

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Abstrak

Penelitian yang mensintesis temuan empiris mengenai hubungan pencapaian emosi dengan hasil belajar matematika masih terbatas. Penelitian ini bertujuan untuk meninjau literatur dan melakukan meta-regresi mengenai pencapaian emosi terkait aktivitas (senang, marah, putus asa, dan bosan), emosi prospektif (cemas dan malu), dan emosi retrospektif (bangga) terhadap hasil belajar matematika. Pemahaman hubungan ini penting untuk mengoptimalkan proses pembelajaran matematika. Metode Systematic Literature Review dan meta-analisis (PRISMA) digunakan dalam penelitian ini. Dari hasil identifikasi, penyaringan, dan penilaian kelayakan, diperoleh 18 artikel yang dipublikasikan pada jurnal Database Scopus (Q1-Q4) antara tahun 2014 dan 2024. Sampel independen mencakup emosi marah (6 sampel, N = 4376), cemas (13 sampel, N = 10006), bosan (18 sampel, N = 11311), putus asa (6 sampel, N = 3423), malu (5 sampel, N = 2204), senang (19 sampel, N = 13536), dan bangga (8 sampel, N = 5003). Analisis meta-regresi dilakukan untuk menghitung ukuran efek setiap emosi terhadap hasil belajar matematika. Hasil penelitian menyimpulkan bahwa emosi marah, malu, putus asa, dan bosan menunjukkan efek sedang ($0.3 \leq |r| < 0.5$) terhadap hasil belajar matematika, sedangkan emosi senang, cemas, dan bangga menunjukkan efek kuat ($|r| \geq 0.5$). Temuan ini mengimplikasikan pentingnya pengendalian emosi dalam pembelajaran matematika untuk meningkatkan pencapaian akademik siswa.

Kata Kunci: aktivitas emosi; emosi prospektif; emosi retrospektif; control-value; pencapaian emosi.

Abstract

Limited research synthesizes empirical findings on the relationship between achievement emotions and mathematics learning outcomes. This study aims to review literature and conduct a meta-regression on achievement emotions related to activity emotions (joy, anger, hopelessness, and boredom), prospective emotions (anxiety and Embarrassed), and retrospective emotions (pride) in mathematics learning outcomes. Understanding these relationships is crucial for optimizing mathematics learning processes. A Systematic Literature Review and meta-analysis (PRISMA) were employed. From identification, screening, and eligibility assessment, 18 articles published in Scopus Database journals (Q1-Q4) between 2014 and 2024 were obtained. Independent samples included anger (6 samples, N = 4376), anxiety (13 samples, N = 10006), boredom (18 samples, N = 11311), hopelessness (6 samples, N = 3423), Embarrassed (5 samples, N = 2204), joy (19 samples, N = 13536), and pride (8 samples, N = 5003). Meta-regression analysis was conducted to calculate the effect size of each emotion on mathematics learning outcomes. The results concluded that anger, Embarrassed, hopelessness, and boredom showed moderate effects ($0.3 \leq |r| < 0.5$) on mathematics learning outcomes, while joy, anxiety, and pride exhibited strong effects ($|r| \geq 0.5$). These findings imply the importance of emotion regulation in mathematics learning to enhance students' academic achievement.

Keywords: Activity emotion; Prospective emotion; Retrospective; control-value; achievement emotions.

I. INTRODUCTION

Emotions play a crucial role in mathematics learning, affecting students' motivation, learning strategies, and academic performance (Acosta-Gonzaga & Ramirez-Arellano, 2021; Vistorte et al., 2024). A deep understanding of different types of emotions in the context of mathematics can provide valuable insights into improving the teaching and learning of this subject. Pekrun (2006) explained that students' achievement emotions are influenced by their subjective appraisal of control and value in academic activities. According to the control-value theory, students' self-concept, which reflects their self-assessment of their abilities, serves as an important mediator between learning outcomes and emotions. Furthermore, students' emotions arise in various situations, such as learning, attending classes, completing assignments, or taking exams (Pekrun & Linnenbrink-Garcia, 2014).

Achievement emotions in the perspective of control-value theory (Pekrun & Perry, 2014) are divided into three dimensions: (1) the object focus of emotions is either activity emotions in learning (e.g., enjoyment in a learning activity) or emotions resulting from learning activities (e.g., pride in receiving a good grade); (2) emotional valence, which can be positive (e.g., hope) or negative (e.g., hopelessness); and (3) emotion activation (activated or deactivated emotions).

McCulloch (2011) described those emotions arising during mathematical activities, both in class and at home, are stored in students' emotional memory, which later influences their behavior when solving mathematical problems or learning mathematics. Students' emotions in mathematics learning can stem from various factors, including stimuli from the mathematics content, difficulty in understanding the material, negative impacts of teaching methods, students' learning experiences, and social norms (Goldin et al., 2011; Quintanilla & Gallardo, 2022).

A meta-analysis conducted by Camacho-Morles et al. (2021) concluded that there is a positive correlation between enjoyment in learning and academic performance ($\rho = 0.27$), while the relationship was negative for emotions such as anger ($\rho = -0.35$) and boredom ($\rho = -0.25$). The correlation between emotions causing frustration and academic performance was nearly non-existent ($\rho = -0.02$). Moderator tests showed that the relationship between activity-related emotions and academic performance was stronger in secondary school students than in elementary and university students, particularly when emotions were measured using the Achievement Emotions Questionnaire Mathematics (AEQ-M).

Research on achievement emotions in mathematics learning is crucial, given the significant role emotions play in influencing students' learning experiences, motivation,

and academic outcomes. Although previous studies have explored the relationship between emotions such as joy, anger, frustration, and boredom with academic performance (Sharp, Sharp, & Young, 2020; Camacho-Morles et al., 2021), research on a broader spectrum of emotions, such as anxiety, hopelessness, Embarrassed, and pride, remains limited. A deeper understanding of diverse emotions is needed to help educators create emotionally supportive learning environments and improve students' mathematics learning outcomes.

Additionally, this study aims to address gaps related to variations in the influence of emotions based on education levels and evaluation methods, such as exam scores and report card grades. Using the control-value theory approach, this study provides not only theoretical insights into the relationship between emotions and mathematics learning but also practical recommendations for educators in designing more effective, emotion-oriented teaching strategies. Therefore, this systematic review is essential to provide a stronger empirical foundation for understanding the impact of emotions on mathematics learning outcomes and optimizing students' learning experiences.

II. METHOD

This study employed a Systematic Literature Review and meta-analysis (PRISMA) approach to answer the research questions. Only journal publications

indexed in the Scopus database (Q1-Q4) published between 2014 and 2024 were analyzed; older articles were excluded. PRISMA consists of four steps: identification, screening, eligibility assessment, and inclusion. Figure 1 illustrates the PRISMA flowchart for selecting articles used in the meta-analysis.

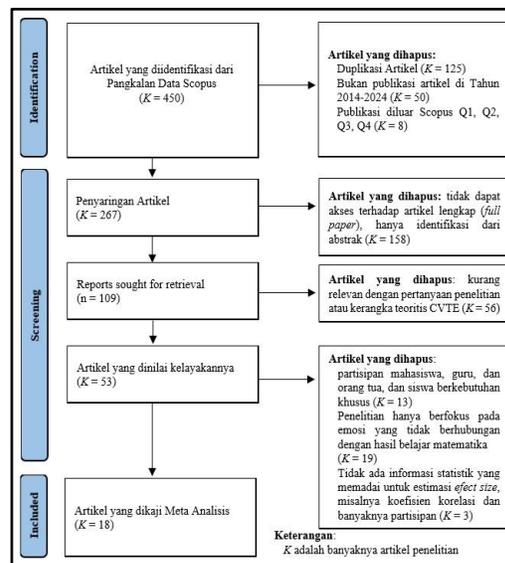


Figure 1. PRISMA Flowchart

The identification stage

The identification stage involved searching fundamental research topics such as "achievement emotion" and "control-value theory." The search strategy expanded by incorporating terms like "achievement emotion OR control-value theory OR 'enjoyment' OR 'pride' OR 'joy' OR 'relief' OR 'boredom' OR 'anger' OR 'anxiety' OR 'frustration' OR 'sad' OR 'Embarrassed' OR 'hopelessness' AND mathematics achievement." The search was conducted in the Scopus database,

excluding systematic reviews, books, and conference proceedings.

A total of 450 journal articles were identified using this search strategy. After removing 125 duplicate records and 50 articles deemed ineligible by automation tools [2014-2024], and excluding 8 articles outside Q1-Q4, 267 journal articles remained for classification in this process.

Screening Stage

As illustrated in Figure 1, the selection process followed PRISMA principles (Moher et al., 2009). This study applied various inclusion and exclusion criteria, resulting in the identification of 214 articles that did not meet the research criteria, leaving only 53 eligible articles. To ensure the final selection aligned with the study's objectives, titles, abstracts, methodologies, results, and discussions were thoroughly reviewed. Ultimately, 18 articles were included in the final analysis.

Inclusion Criteria

Six inclusion criteria were applied for the meta-analysis:

1. The study must involve elementary or secondary school students, excluding studies with university students, teachers, or parents.
2. Participants must not be students with special educational needs.
3. The study must examine the relationship between achievement emotions and mathematics learning outcomes or the effects of specific emotions (e.g., pride, anxiety, and

boredom) on mathematics achievement.

4. The article must include objective measures of achievement emotions (e.g., Achievement Emotion Questionnaire) or learning outcomes (e.g., exam scores or report card grades).
5. The study must report sufficient statistical information for effect size estimation (e.g., correlation coefficients and sample size).
6. The theoretical framework must be based on the control-value theory of achievement emotions (Pekrun & Stephens, 2010).

Data Extraction

Selected articles were extracted for key information, including authors, measured emotions (anger, anxiety, boredom, hopelessness, Embarrassed, joy, and pride), education levels (elementary or secondary), learning outcome measurements (exam scores or report card grades), correlation coefficients, and sample sizes.

Meta-Analysis

A correlation-based meta-analysis was conducted using JASP software. The meta-analysis steps included: transforming each correlation value into effect size, heterogeneity testing, summary effect size estimation, and publication bias evaluation. Effect size interpretation followed Cohen's scale (Retnawati et al., 2018):

- Effect size ≤ 0.10 (Small)

- $0.10 < \text{Effect size} < 0.40$ (Moderate)
- $\text{Effect size} \geq 0.40$ (Strong)

Heterogeneity testing used the Q parameter and p-value approach. If p-value < 0.05 , the random effects model was applied for summary effect size estimation. If p-value > 0.05 , the fixed effects model was used.

Publication bias was assessed using Rosenthal's File-Safe N (FSN) approach. If $\text{FSN} > (5K+10)$, where K is the number of studies included in the meta-analysis, the findings were considered robust against publication bias (Mullen et al., 2001).

III. RESULT AND DISCUSSION

From the filtering and eligibility assessment, 18 journal articles met the inclusion criteria and were analyzed further. A total of 75 independent data samples were extracted, categorized into the following emotions: anger (K = 6), anxiety (K = 13), boredom (K = 18), hopelessness (K = 6), Embarrassed (K = 5), joy (K = 19), and pride (K = 8). The transformation of each study's correlation value into effect size and determination of standard error were conducted. The results of data extraction are presented in Table 1.

Table 1.

Data Extraction that Meets Inclusion Criteria

Authors	Emotion	TP	NHBM	r	N	M	SE	BB	BA
Ganotice et al. (2016)-2	Proud	SM	NR	0,26	341	0,85	0,05	0,75	0,95
Hanin & Catherine (2019)-6	Proud	SD	NU	-0,01	354	0,49	0,05	0,39	0,59
Hanin & Nieuwenhoven (2016)-2	Proud	SM	NU	0,04	115	0,54	0,09	0,36	0,72
Holm et al. (2020)-2	Proud	SM	NU	0,54	1322	1,67	0,03	1,61	1,73
Kim et al. (2014)-6	Proud	SM	NU	0,30	72	0,93	0,12	0,69	1,17
Luo et al. (2014)-2	Proud	SM	NR	0,41	273	1,19	0,06	1,07	1,31
Parr et al. (2019)-2	Proud	SD	NU	0,28	1307	0,89	0,03	0,83	0,95
Peixoto et al. (2016)-6	Proud	SM	NR	0,02	1219	0,52	0,03	0,46	0,58
Bailey et al. (2014)-2	Bored	SM	NU	-0,10	102	0,41	0,10	0,21	0,61
Di Leo et al. (2019)-3	Bored	SD	NU	-0,19	138	0,34	0,09	0,16	0,52
Ganotice et al. (2016)-4	Bored	SM	NR	-0,25	341	0,30	0,05	0,20	0,40
Hanin & Catherine (2019)-4	Bored	SD	NU	-0,05	354	0,45	0,05	0,35	0,55
Hanin & Nieuwenhoven (2016)-6	Bored	SM	NU	-0,23	115	0,31	0,09	0,13	0,49
Holm et al. (2020)-7	Bored	SM	NU	-0,19	1322	0,34	0,03	0,28	0,40
Kim et al. (2014)-2	Bored	SM	NU	-0,19	72	0,34	0,12	0,10	0,58
Luo et al. (2014)-3	Bored	SM	NR	-0,25	273	0,30	0,06	0,18	0,42
Muis et al. (2015)-3	Bored	SD	NU	0,14	79	0,66	0,11	0,44	0,88
Parr et al. (2019)-4	Bored	SD	NU	-0,24	1307	0,31	0,03	0,25	0,35
Peixoto et al. (2016)-4	Bored	SM	NR	-0,06	1219	0,44	0,03	0,38	0,50

Authors	Emotion	TP	NHBM	r	N	M	SE	BB	BA
Putwain et al. (2018)-2	Bored	SD	NU	-0,40	1057	0,21	0,03	0,15	0,27
Putwain et al. (2021)-3	Bored	SD	NU	-0,31	1298	0,26	0,03	0,20	0,32
Raccanello et al. (2019)-3	Bored	SD	NR	-0,27	767	0,29	0,04	0,21	0,37
Reindl et al. (2018)-2	Bored	SM	NR	-0,24	700	0,31	0,04	0,23	0,39
Schukajlow & Rakoczy (2016)-2	Bored	SM	NU	-0,16	144	0,36	0,08	0,20	0,52
Schukajlow et al. (2021)-2	Bored	SM	NU	-0,34	220	0,25	0,07	0,11	0,39
Westphal et al. (2018)-3	Bored	SM	NU	-0,24	1803	0,31	0,02	0,27	0,35
Chen et al. (2020)-2	Worried	SM	NU	-0,34	2225	0,25	0,02	0,21	0,29
Di Leo et al. (2019)-2	Worried	SD	NU	-0,06	138	0,44	0,09	0,26	0,62
Ganotice et al. (2016)-3	Worried	SM	NR	-0,35	341	0,24	0,05	0,14	0,34
Hanin & Catherine (2019)-3	Worried	SD	NU	-0,35	354	0,24	0,05	0,14	0,34
Hanin & Nieuwenhoven (2016)-4	Worried	SM	NU	-0,26	115	0,29	0,09	0,11	0,47
Holm et al. (2020)-4	Worried	SM	NU	-0,34	1322	0,25	0,03	0,19	0,31
Kim et al. (2014)-3	Worried	SM	NU	0,33	72	0,99	0,12	0,75	1,23
Luo et al. (2014)-4	Worried	SM	NR	-0,36	273	0,24	0,06	0,12	0,36
Muis et al. (2015)-2	Worried	SD	NU	0,36	79	1,06	0,11	0,84	1,28
Peixoto et al. (2016)-3	Worried	SM	NR	-0,27	1219	0,29	0,03	0,23	0,35
Putwain et al. (2021)-2	Worried	SD	NU	-0,17	1298	0,35	0,03	0,29	0,41
Raccanello et al. (2019)-2	Worried	SD	NR	0,13	767	0,65	0,04	0,57	0,73
Westphal et al. (2018)-2	Worried	SM	NU	-0,24	1803	0,31	0,02	0,27	0,35
Ganotice et al. (2016)-6	Embarrassed	SM	NR	-0,29	341	0,28	0,05	0,18	0,38
Hanin & Catherine (2019)-2	Embarrassed	SD	NU	-0,19	354	0,34	0,05	0,24	0,44
Hanin & Nieuwenhoven (2016)-5	Embarrassed	SM	NU	-0,33	115	0,25	0,09	0,07	0,43
Holm et al. (2020)-5	Embarrassed	SM	NU	-0,32	1322	0,26	0,03	0,20	0,32
Kim et al. (2014)-5	Embarrassed	SM	NU	-0,37	72	0,23	0,12	-0,01	0,47
Ganotice et al. (2016)-5	Angry	SM	NR	-0,27	341	0,29	0,05	0,19	0,39
Hanin & Nieuwenhoven (2016)-3	Angry	SM	NU	-0,31	115	0,26	0,09	0,08	0,44
Holm et al. (2020)-3	Angry	SM	NU	-0,29	1322	0,28	0,03	0,22	0,34
Kim et al. (2014)-4	Angry	SM	NU	-0,51	72	0,16	0,12	-0,08	0,40
Parr et al. (2019)-3	Angry	SD	NU	-0,31	1307	0,26	0,03	0,20	0,32
Peixoto et al. (2016)-2	Angry	SM	NR	-0,31	1219	0,26	0,03	0,20	0,32
Ganotice et al. (2016)-7	Hopeless	SM	NR	-0,34	341	0,25	0,05	0,15	0,35
Hanin & Catherine (2019)-1	Hopeless	SD	NU	-0,15	354	0,37	0,05	0,27	0,47

Authors	Emotion	TP	NHBM	r	N	M	SE	BB	BA
Hanin & Nieuwenhoven (2016)-7	Hopeless	SM	NU	-0,37	115	0,23	0,09	0,05	0,41
Holm et al. (2020)-6	Hopeless	SM	NU	-0,39	1322	0,22	0,03	0,16	0,28
Kim et al. (2014)-7	Hopeless	SM	NU	-0,44	72	0,19	0,12	-0,05	0,43
Peixoto et al. (2016)-1	Hopeless	SM	NR	-0,43	1219	0,20	0,03	0,14	0,26
Bailey et al. (2014)-1	Pleased	SM	NU	0,26	102	0,85	0,10	0,65	1,05
Chen et al. (2020)-1	Pleased	SM	NU	0,24	2225	0,82	0,02	0,78	0,86
Di Leo et al. (2019)-1	Pleased	SD	NU	0,06	138	0,56	0,09	0,38	0,74
Ganotice et al. (2016)-1	Pleased	SM	NR	0,30	341	0,93	0,05	0,83	1,03
Hanin & Catherine (2019)-5	Pleased	SD	NU	0,06	354	0,56	0,05	0,46	0,66
Hanin & Nieuwenhoven (2016)-1	Pleased	SM	NU	0,13	115	0,65	0,09	0,47	0,83
Holm et al. (2020)-1	Pleased	SM	NU	0,41	1322	1,19	0,03	1,13	1,25
Kim et al. (2014)-1	Pleased	SM	NU	0,41	72	1,19	0,12	0,95	1,43
Luo et al. (2014)-1	Pleased	SM	NR	0,31	273	0,95	0,06	0,83	1,70
Muis et al. (2015)-1	Pleased	SD	NU	0,24	79	0,82	0,11	0,60	1,04
Parr et al. (2019)-1	Pleased	SD	NU	0,26	1307	0,85	0,03	0,79	0,91
Peixoto et al. (2016)-5	Pleased	SM	NR	0,43	1219	1,25	0,03	1,19	1,31
Putwain et al. (2018)-1	Pleased	SD	NU	0,42	1057	1,22	0,03	1,16	1,28
Putwain et al. (2021)-1	Pleased	SD	NU	0,16	1298	0,69	0,03	0,63	0,75
Raccanello et al. (2019)-1	Pleased	SD	NR	0,20	767	0,75	0,04	0,67	0,83
Reindl et al. (2018)-1	Pleased	SM	NR	0,38	700	1,11	0,04	1,03	1,19
Schukajlow & Rakoczy (2016)-1	Pleased	SM	NU	0,21	144	0,77	0,08	0,61	0,93
Schukajlow et al. (2021)-1	Pleased	SM	NU	0,04	220	0,54	0,07	0,40	0,68
Westphal et al. (2018)-1	Pleased	SM	NU	0,16	1803	0,69	0,02	0,65	0,73

TA is Education Level; SM is Middle School; SD is Primary School; r is the correlation coefficient; N is the number of samples; M is the effect-size value; SE is standard error; BB is the lower limit; BA is the upper limit, NHBM is the mathematics learning outcome score; NU is the test score; and NR is the report card value.

Based on the extraction results as presented in Table 1, the effect size was between 0.16 to 1.67 and the standard error was between 0.02 to 0.12.

Tabel 1.
Heterogeneity Test

Emotion	Q	df	p	I ² (%)
Angry	1,31	5	0,93	0,00
Worried	173,08	12	< 0,001	98,00
Bored	53,56	17	< 0,001	68,62
Hopeless	9,13	5	0,10	51,89
Embarassed	2,16	4	0,71	0,00

Emotion	Q	df	p	I ² (%)
Pleased	665,67	18	< 0,001	97,23
Proud	910,40	7	< 0,001	98,33

The heterogeneity test, as presented in Table 2, was conducted using the Q parameter approach. The results showed that anger (Q = 1.31; p = 0.93), despair (Q = 9.13; p = 0.10), and Embarassed (Q = 2.16; p = 0.71) exhibited low heterogeneity. Meanwhile, anxiety, boredom, happiness, and pride showed high heterogeneity,

prompting a moderation test based on education level and learning outcomes.

Table 3.
Meta-regression test results

Emotion	K	M	95% CI		p
			BB	BA	
Angry	6	0,27	0,24	0,30	< 0,001
Worried	6	0,25	0,19	0,30	< 0,001
Embarassed	5	0,28	0,23	0,32	< 0,001

The meta-regression test results, as presented in Table 3, indicate that anger has a moderate effect on mathematics learning outcomes (M = 0.27; $\rho < 0.001$; [95% CI, 0.24; 0.30]; K = 6; N = 4376). Similarly, despair also shows a moderate effect on mathematics learning outcomes (M = 0.25; $\rho < 0.001$; [95% CI, 0.19; 0.30]; K = 6; N = 3423), and Embarassed exhibits a moderate effect as well (M = 0.28; $\rho < 0.001$; [95% CI, 0.23; 0.32]; K = 5; N = 2204).

Despair in mathematics learning can lead to a cycle of failure in learning (Au et al., 2010). Students who perceive themselves as more competent in mathematics tend to feel less despair during exams and take greater pride in their scores (Peixoto et al., 2016). When students feel despair about their abilities or the mathematical tasks they face, it can

result in decreased motivation, self-efficacy, and perseverance in mathematical activities (Hanin & Nieuwenhoven, 2019; Peixoto et al., 2016).

If students are not interested in mathematics or do not enjoy learning it, they may experience various negative emotions, such as anger (Schunkajlow, 2015). Anger can lead students to ignore or withdraw from the learning process. This emotion may arise from feelings of frustration, injustice, or perceived obstacles in learning, reflecting a strong emotional response to difficulties or challenges in mathematics (Hanin & Nieuwenhoven, 2016).

Embarassed is a consequence of how students perceive themselves (Oades-Sese & Matthews, 2014). It is a negative emotion experienced after failure in learning (Hanin & Catherine, 2019). Students who feel embarassed often do so due to their low mathematical ability (Holm et al., 2020).

The meta-regression results for the emotions of happiness, bored, worried, and proud, along with their moderation by education level and performance measurement, are presented in Table 4.

Table 4.
Coefficient Estimates and Moderation Tests Using the Random Effects Model

Emotion	Total/ Moderation	Aspect	K	M	95% CI		Z	p	Heterogenity		
					BB	BA			Qw	Qb	p
Happy (AE)	Overall		1	0,8	0,7	0,9	16,0	< 0,00	665,6	-	< 0,00
			9	6	6	7	3	1	7		1
	Education Level	Elementary School	7	0,7	0,6	0,9	8,93	< 0,00	658,0	7,64	0,010
		High School	1	0,9	0,7	1,0	13,5	< 0,00			
			2	1	8	5	4	1			

Emotion Aspect	Total/Moderation	Aspect	K	M	95% CI		Z	p	Heterogeneity		
					BB	BA			Qw	Qb	p
	Performance Measurement	Exam Scores	1 4	0,8 1	0,6 9	0,9 4	12,9 3	< 0,00 1	563,5 6	92,11	< 0,00 1
		Report Card Grades	5 0	1,0 0	0,8 3	1,1 7	11,5 5	< 0,00 1			
Bored (AE)	Overall		1 8	0,3 3	0,2 9	0,3 7	17,1 7	< 0,00 1	53,56	-	< 0,00 1
	Education Level	Elementary School	7 4	0,3 4	0,2 5	0,4 3	7,37	< 0,00 1	47,67	5,89	0,015
		High School	1 1	0,3 3	0,3 0	0,3 7	16,8 9	< 0,00 1			
Performance Measurement	Exam Scores	1 3	0,3 4	0,2 8	0,3 8	13,2 0	< 0,00 1	48,92	4,64	0,031	
	Report Card Grades	5 3	0,3 3	0,2 7	0,4 0	10,2 1	< 0,00 1				
Worried (PE)	Overall		1 3	0,4 2	0,2 7	0,5 6	5,66	< 0,00 1	173,0 8	-	< 0,00 1
	Education Level	Elementary School	5 4	0,5 4	0,2 7	0,8 1	3,86	< 0,00 1	126,0 4	47,04	< 0,00 1
		High School	8 4	0,3 4	0,1 9	0,4 9	4,49	< 0,00 1			
Performance Measurement	Exam Scores	9 5	0,4 5	0,2 5	0,6 5	4,40	< 0,00 1	164,2 8	8,80	0,003	
	Report Card Grades	4 6	0,3 6	0,1 6	0,5 5	3,58	< 0,00 1				
Proud (RE)	Overall		8 9	0,8 1	0,6 1	1,1 7	6,19	< 0,00 1	910,4 0	-	< 0,00 1
	Education Level	Elementary School	2 9	0,6 9	0,3 0	1,0 8	3,46	< 0,00 1	840,7 9	69,01	< 0,00 1
		High School	6 5	0,9 5	0,6 0	1,3 0	5,31	< 0,00 1			
Performance Measurement	Exam Scores	5 1	0,9 1	0,4 9	1,3 3	4,24	< 0,00 1	709,2 7	201,1 5	< 0,00 1	
	Report Card Grades	3 5	0,8 5	0,4 7	1,2 3	4,40	< 0,00 1				

AE refers to Activity Emotions, PE refers to Prospective Emotions, RE refers to Retrospective Emotions, K represents the number of article samples, M represents the effect size, BB is the lower bound, BA is the upper bound, Qw denotes within-group variance, and Qb denotes between-group variance.

Happiness shows a strong effect on mathematics learning outcomes (M = 0.86; $p < 0.001$; [95% CI, 0.76; 0.97]; K = 19; N = 13,536). Furthermore, based on moderation by education level, the combined effect size for studies conducted

in elementary schools was 0.78, while in secondary schools, it was 0.91. The heterogeneity test results showed a Qb value of 7.64 and $p < 0.05$, indicating a significant difference in the combined effect size between education levels. Thus,

happiness has a greater influence on secondary school students than on elementary school students.

Additionally, based on moderation by performance measurement, the combined effect size for studies using exam scores was 0.81, while for report card grades, it was 1.00. The heterogeneity test results showed a Q_b value of 92.11 and $p < 0.05$, indicating a significant difference in the combined effect size between performance measurement groups. Therefore, happiness has a greater influence on students' report card grades compared to their exam scores.

Findings on the strong effect of happiness on mathematics learning outcomes are supported by research from Schubert et al. (2023), which concluded that happiness enhances students' attention and motivation in constructing mathematical proofs. Additionally, Liu et al. (2017) found that happiness increases student engagement in mathematics learning, while Quintanilla & Gallardo (2022) stated that feelings of happiness can serve as a stimulus for academic achievement.

Happiness signifies satisfaction with one's achievements (Ainley & Hidi, 2014). When students experience happiness in mathematics learning, they are more likely to continue seeking positive experiences while completing tasks assigned by their teachers. This, in turn, facilitates academic engagement and helps prevent academic procrastination (Guo et al., 2023).

Based on Table 4, boredom has a moderate effect on mathematics learning outcomes ($M = 0.33$; $p < 0.001$; [95% CI, 0.29; 0.37]; $K = 18$; $N = 11,311$). Furthermore, based on moderation by education level, the combined effect size for studies conducted in elementary schools was 0.34, while in secondary schools, it was 0.33. The heterogeneity test results showed a Q_b value of 7.64 and $p < 0.05$, indicating a significant difference in the combined effect size between education levels. Thus, boredom has a greater influence on elementary school students than on secondary school students.

Additionally, based on moderation by performance measurement, the combined effect size for studies using exam scores was 0.34, while for report card grades, it was 0.33. The heterogeneity test results showed a Q_b value of 4.64 and $p < 0.05$, indicating a significant difference in the combined effect size between performance measurement groups. Therefore, boredom has a greater influence on students' exam scores compared to their report card grades.

Boredom and happiness are related to students' learning motivation (Pekrun et al., 2002). Happiness has a much stronger influence on learning motivation than boredom (Bailey et al., 2014). Additionally, students who experience happiness in mathematics learning are less likely to feel bored, and their happiness in learning mathematics is highly dependent on their

interest and motivation (Schunkajlow, 2015).

Students who experience boredom in learning mathematics perceive it as monotonous, meaningless, unchallenging, and unvaluable (Holm et al., 2017). Those who frequently feel bored tend to show lower behavioral and cognitive engagement in mathematics learning (Şimşek et al., 2020). Boredom hinders students' concentration and motivation to learn mathematics (Schubert et al., 2023) and leads to a lack of active participation in classroom discussions (Schukajlow & Rakoczy, 2016).

Providing students with stimulating opportunities to develop various mathematical problem-solving solutions has a positive impact on their happiness and reduces boredom during mathematics learning (Schukajlow & Rakoczy, 2016). Engaging students in tasks that stimulate mathematical thinking and problem-solving skills can enhance happiness and decrease boredom in mathematics learning (Lazarides & Buchholz, 2019).

Based on Table 4, anxiety has a strong effect on mathematics learning outcomes ($M = 0.42$; $p < 0.001$; [95% CI, 0.56; 0.66]; $K = 13$; $N = 10,006$). Furthermore, based on moderation by education level, the combined effect size for studies conducted in elementary schools was 0.54, while in secondary schools, it was 0.34. The heterogeneity test results showed a Q_b value of 47.04 and $p < 0.05$, indicating a significant difference in the combined

effect size between education levels. Thus, anxiety has a greater influence on elementary school students than on secondary school students.

Additionally, based on moderation by performance measurement, the combined effect size for studies using exam scores was 0.45, while for report card grades, it was 0.36. The heterogeneity test results showed a Q_b value of 8.80 and $p < 0.05$, indicating a significant difference in the combined effect size between performance measurement groups. Therefore, anxiety has a greater influence on students' exam scores compared to their report card grades.

Students with lower mathematics achievement experience less happiness and pride but more anxiety, anger, and shame compared to high-achieving students (Held & Hascher, 2022). Anxiety and happiness influence the cognitive and metacognitive strategies students use during problem-solving (Muis et al., 2015; Schukajlow et al., 2021). Additionally, both anxiety and happiness can motivate students to continue striving for more mathematical problem-solving solutions (Barnes, 2020).

Anxiety can enhance students' motivation to learn and potentially lead to good grades. However, for some students, anxiety can be debilitating, reducing their motivation and resulting in poor academic performance (Pekrun, 2006). When students experience anxiety in learning, they tend to procrastinate on academic

tasks as a way to escape the anxiety triggered by those tasks (Guo et al., 2023).

Based on Table 4, pride has a strong effect on mathematics learning outcomes ($M = 0.89$; $p < 0.001$; [95% CI, 0.61; 1.17]; $K = 8$; $N = 5,003$). Furthermore, based on moderation by education level, the combined effect size for studies conducted in elementary schools was 0.69, while in secondary schools, it was 0.95. The heterogeneity test results showed a Q_b value of 69.01 and $p < 0.05$, indicating a significant difference in the combined effect size between education levels. Thus, pride has a greater influence on secondary school students than on elementary school students.

Additionally, based on moderation by performance measurement, the combined effect size for studies using exam scores was 0.91, while for report card grades, it was 0.85. The heterogeneity test results showed a Q_b value of 201.15 and $p < 0.05$, indicating a significant difference in the combined effect size between performance measurement groups. Therefore, pride has a greater influence on students' exam scores compared to their report card grades.

Pride reflects a sense of self-satisfaction after success (Legendre in Hanin & Nieuwenhoven, 2016), and achieving good mathematics exam scores can evoke feelings of pride in students. The ability to solve challenging mathematical problems can also lead to pride (Pekrun et al., 2018). However, this pride arises from students'

self-evaluation of their own accomplishments (Pekrun, 2006; Hanin & Van Nieuwenhoven, 2016).

Positive emotions (such as happiness and pride) support students in the learning process, whereas negative emotions (such as anger, shame, anxiety, and despair) can hinder or reduce students' participation in class and their engagement with peers in learning (Chen et al., 2020). Positive emotions encourage students to explore, seek solutions, engage deeply with problems, and try different problem-solving approaches (Di Leo et al., 2019). Additionally, positive emotions in mathematics learning are correlated with increased motivation and the enhancement of cognitive strategies (Parr et al., 2019).

Students' self-perception of mathematics learning in class or during exams is closely related to their mathematical self-concept (Zulkarnaen, 2018). From the perspective of the Control-Value Theory (CVT), students' perceptions of control and value are key antecedents of achievement emotions (Pekrun & Stephens, 2010). This is supported by research findings from Beek et al. (2017), Balaž et al. (2021), Clem et al. (2021), Lazarides & Raufelder (2021), Muis et al. (2015), Muwonge et al. (2018), Westphal et al. (2018), and Zhang (2020).

Mathematical self-concept influences students' achievement emotions and fully mediates the relationship between mathematics learning outcomes and

emotions, particularly anxiety and enjoyment (Lazarides & Raufelder, 2021). When students have a higher level of mathematical self-concept, they tend to experience lower levels of anxiety toward mathematics (Zhang, 2020).

Students' emotional experiences in the classroom, such as enjoyment, anxiety, and boredom, are closely related to their mathematical self-concept (Westphal et al., 2018). Students who experience high levels of enjoyment and lower levels of anxiety and boredom in learning mathematics tend to have a positive self-concept. Conversely, students who frequently experience anxiety and boredom while lacking enjoyment in learning often have a lower self-concept (Beek et al., 2017). Students' self-assessment plays a significant role in determining their levels of enjoyment and anxiety in mathematics learning (Muwonge et al., 2018).

Self-control functions as a negative predictor of anxiety, indicating that students who feel more in control experience less anxiety during problem-solving (Muis et al., 2015). Additionally, strong self-control directly and indirectly predicts students' academic success, as those who perceive greater academic control tend to achieve higher grades in school (Balaž et al., 2021).

When students experience enjoyment in learning mathematics, they are more likely to be motivated, focused, and actively engaged in the learning process. Feelings of

enjoyment and pride contribute to satisfaction and intrinsic motivation, thereby enhancing student engagement and improving mathematics learning outcomes (Liu et al., 2017). A positive self-perception of one's mathematical ability can foster enjoyment in learning, creating a cycle of positive reinforcement (Clem et al., 2021).

Students' perceptions of control and value play a crucial role in shaping their emotional experiences in mathematics learning. Their perception of mathematical ability also influences their emotional responses. Therefore, having a positive outlook on one's mathematical abilities can lead to enjoyment in the learning process, creating a positive cycle in mathematics education.

The final step in this study is detecting publication bias. The assessment of publication bias in this research was conducted using the File-Safe N method, as presented in Table 5.

Table 5.
Results of File Drawer Analysis

Aspect	K	5k + 10	FSN
Angry	6	40	492
Worried	13	75	4750
Bored	18	100	6299
Hopeless	6	40	339
Embarassed	5	35	241
Pleased	19	105	58418
Proud	8	50	9819

Based on Table 5, the FSN values for the emotions of anger, anxiety, boredom, despair, shame, happiness, and pride are greater than the K value. This indicates that

the conducted meta-analysis does not have issues with publication bias and can be scientifically justified.

IV. CONCLUSION

This study aims to analyze the relationship between achievement emotions and mathematics learning outcomes through a meta-analysis. The findings indicate that emotions have a significant impact on mathematics learning outcomes, with variations in effect depending on the type of emotion and learning context. Anger, shame, despair, and boredom exhibit a moderate effect, while happiness, anxiety, and pride demonstrate a strong effect on mathematics learning outcomes. Moderator analysis reveals that the influence of emotions varies based on education level and assessment type. Happiness and pride have a greater impact on secondary school students, whereas boredom and anxiety have a stronger effect on primary school students. Regarding performance assessment, happiness has a greater influence on report card grades, while boredom, anxiety, and pride have a stronger impact on exam scores.

Based on these findings, it is crucial for mathematics teachers to monitor and manage students' emotions throughout the learning process. Efforts should be made to transform negative emotions into positive ones while maintaining and enhancing existing positive emotions.

Teachers need to foster students' confidence in mathematics, which can significantly impact their engagement and learning outcomes. Adjusting the difficulty level of tasks is also essential to sustain student engagement and motivation. Mathematics tasks should be designed to be challenging yet not overly difficult, preventing boredom or frustration that could diminish positive emotions and hinder student learning.

Creating a positive learning environment is also key to improving mathematics learning outcomes. Teachers can implement interactive and engaging teaching strategies to reduce boredom and frustration. Given the varying effects of emotions at different educational levels, emotion management strategies should be adapted for elementary and secondary school students. Additionally, teachers need to consider the different impacts of emotions on exam scores and report card grades when designing instructional and assessment strategies.

For future research, it is recommended to expand the range of emotions studied and conduct longitudinal studies to examine changes in the impact of emotions on mathematics learning outcomes over time. Contextual factors, such as teaching methods and parental support, should also be analyzed to provide valuable insights. Developing emotion-based interventions and utilizing mixed-method research approaches can further deepen our understanding of the role of emotions in

mathematics learning. By applying these findings and recommendations, it is hoped that student engagement, learning motivation, and ultimately, mathematics achievement across different educational levels can be enhanced.

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