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Mathematics achievement emotions: Global trend, emotional treatment, and directions for future research

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Abstract

Background: The development of studies related to achievement emotions in mathematics learning has been increasingly grown in two last decades. Achievement emotions is one of significant predictors for students' mathematics achievement. Nevertheless, to date no publications have been found that particularly review studies regarding mathematics achievement emotions.

Aim: Present study highlights global trend of studies in mathematics achievement emotion for future research and examines the effect of emotional treatment on mathematics achievement emotions.

Method: A systematic review using bibliometric analysis and meta-analysis was applied to do this study in which 223 documents from Scopus database published in the period of 2004 – 2023 were used as the data. To analyze the data, this study was promoted by some software, such as PoP, VOS viewer, and CMA.

Results: Results revealed that global trends of studies regarding mathematics achievement emotions describe that number of publications slightly increased while number of citations relatively fluctuated from 2004 to 2023. There were several main themes which emerged in two last decades related to mathematics achievement emotions, such as emotional type, emotional treatment, activities-and outcomes-related emotion, mathematics content, and factors-related emotion. Moreover, emotional treatments slightly increased students' positive emotions and decreased students' negative emotions.

Conclusion: This implies that the stability of mathematics achievement emotions of students in doing mathematics activities has to be generated to promote students' mathematics achievement in which a few of emotional treatments, such as psychological therapies and web-based learning can be applied to stabilize students' mathematics achievement emotions.

INTRODUCTION

Everyday students' academic life is signed by a variety of emotions. Emotions have a crucial role in academic setting, mainly in establishing students' behaviours, perceptions, and experiences on the learning environments followed by them (Bieleke et al., 2023; Gur et al., 2023). Academic emotions are directly related to academic activities (e.g., studying or doing homework and examination) or academic outcomes (e.g., success or failure) in which particularly those are defined as achievement emotions (Pekrun & Linnenbrink-Garcia, 2012; Pekrun & Stephens, 2012). Moreover, Pekrun (2016)

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explained that achievement emotions are categorized by regarding object focus (activity vs. outcome), activation level (activating vs. deactivating), and valance (positive vs. negative). Specifically, of valance view by considering both activation level and object focus, positive emotions (e.g., enjoyment, pride, relaxation, and relief) are positively associated to some academic factors, such as motivation, performance, achievement, and learning interest (Bekker et al., 2023; Moustakas & Gonida, 2023). Meanwhile, negative emotions (e.g., boredom, anger, anxiety, frustration, and hopelessness) are negatively associated to several academic factors, such as achievement, motivation, attention, interest, and performance (Broda et al., 2023; Raccanello et al., 2020). This indicates that the existence of achievement emotions in learning environments (e.g., mathematics learning) must be controlled by increasing positive emotions and decreasing negative emotions.

Achievement emotions generated from mathematics learning activities or outcomes must be stable to support the optimalization of students' mathematics motivation, performance, achievement, and interest. In a literature, Suparman, Juandi, and Herman (2021) stated that the stable achievement emotions of students in following activities of mathematics learning are characterized by the increase of positive emotions and the decrease of negative emotions. Moreover, few empirical studies showed that positive emotions (e.g., enjoyment and pride) are positively associated to mathematics achievement (e.g., Lichtenfeld et al., 2023; Mata et al., 2022). Additionally, some empirical studies also revealed that negative emotions (e.g., boredom, shame, and anxiety) are negatively associated to mathematics achievement (e.g., Bekker et al., 2023; Jenßen, 2023; Putwain & Wood, 2023). Consequently, emotional treatments which effectively stabilize students' achievement emotions are extremely required in mathematics learning environments. To date, many studies regarding mathematics achievement emotions have increasingly been grown in two last decades. Nevertheless, the development of these studies in the period of 2004 - 2023 has not been investigates and presented in some forms of publication, such as review, conference paper or book chapter. Thus, there is a crucial need to review the documents regarding mathematics achievement emotions in providing the information related to global trends, emotional treatments, and directions for the future research.

Furthermore, some empirical studies regarding emotional treatments and achievement emotions have been broadly carried out in mathematics field. Particularly, emotional treatments significantly increased positive emotions, such as enjoyment and pride (Basarkod et al., 2023; Kim & Hodges, 2012; Liverani et al., 2023). Significantly, however, emotional treatments also did not increase positive emotions, and moreover, these treatments decreased positive emotions (Bieleke et al., 2021; Liverani et al., 2023). Additionally, emotional treatments significantly decreased negative emotions, such as boredom, anxiety, shame, anger, and hopelessness (Bieleke et al., 2021). Meanwhile, emotional treatments also did not significantly decrease negative emotions, and moreover, these treatments increased negative emotions (Adigun et al., 2024; Chu et al., 2020; Gildehaus & Jenßen, 2023; Jenßen, 2023; Kim & Hodges, 2012; Liverani et al., 2023; Passolunghi et al., 2020). These empirical reports indicate that the role of

emotional treatments in generating the stability of students' mathematics achievement emotions has not been consistent. The phenomenon of heterogeneous reports related to the effect of emotional treatments in stabilizing students' mathematics achievement emotions requires overall comprehensive analysis of substantial factors. In a literature, Suparman and Juandi (2022b) explained that substantial factors have rigorous relationship to independent and dependent variable. It means that in this context, it is related to emotional treatments and mathematics achievement emotions. Therefore, there are some substantial factors that can be investigated in this study, such as treatment type, emotional type, and treatment duration.

Due to the increase in studies regarding achievement emotions in two last decades, actually there are some relevant studies which review the documents of achievement emotions in many educational fields (e.g., Camacho-Morles et al., 2021; Huang, 2011; Lei et al., 2022; Loderer et al., 2020; Tan et al., 2021; Wu & Yu, 2022). Particularly, few review studies delve the relationships between achievement emotions and academic performance (e.g., Camacho-Morles et al., 2021; Huang, 2011). Additionally, few review studies focus in investigating the effect of achievement emotions on learning outcomes (e.g., Tan et al., 2021; Wu & Yu, 2022). Moreover, Loderer et al. (2020) reviewed achievement emotions in technology-based learning environments. Lei et al. (2022) also reviewed the effect of educational games in stabilizing achievement emotions. Present study, however, reviews the studies regarding achievement emotions generated from activities and outcomes of mathematics learning. Therefore, this study aims to present the global trend of studies regarding mathematics achievement emotions in two last decades for future researches and examine the effect of emotional treatments on students' achievement emotions in mathematics. This study is expected to construct the novel studies in mathematics achievement emotions for future researches and find effective emotional treatment in increasing positive emotions and decreasing negative emotions.

METHODS

Design:

A systematic review was applied to do this study which involved bibliometric analysis and meta-analysis as analysis techniques. Specifically, bibliometric analysis ─ a well-known and rigorous method to highlight and analyse large volumes of scientific data (Fuad et al., 2022; Putra et al., 2024; Sulistiawati et al., 2023; Suyanto et al., 2023), was performed to present the global trend of studies in mathematics achievement emotions and construct the novel ideas for the future studies. Meanwhile, meta-analysis ─ a series of quantitative procedures using the effect size as an analysis unit (Fuad et al., 2023; Helsa et al., 2023; Suparman et al., 2024; Suparman & Juandi, 2022a, 2022b), was used to summarize and examine the effect of emotional treatments in stabilizing students' mathematics achievement emotions.

Inclusion Criteria:

To limit breadth of stated problems, some inclusion criteria were required. Firstly, every document title had to contain keywords: "achievement emotions" AND "Mathematics".

Secondly, the document was such as article, review, or conference paper from journal or conference proceeding written in English. Thirdly, the document was published in the period of 2004 – 2023 and covered several subject areas, such as social sciences, psychology, mathematics, arts & humanities, and multidisciplinary. Fourthly, the participant in document was Asian, American, European, or African students in the level of primary and secondary school and college/university. Fifthly, the intervention in document was emotional treatments, such as positive psychology, happy-fish-little-pond, numerical problems, web-based video, easy & difficult task, e-learning model, math strategy, or therapy. Sixthly, the outcome in document was positive emotions (e.g., enjoyment and pride) and negative emotions (e.g., shame, anxiety, boredom, anger, and hopelessness). Lastly, the study design in document was experimental research which reported adequate statistical data to compute the effect size.

Literature Search and Document Selection:

Scopus database was utilized to find documents regarding mathematics achievement emotions in that Scopus is one of scientific databases which has large volumes of credible and well-qualified documents (Zhu & Liu, 2020). The combinational keywords, such as "achievement emotions AND mathematics" was applied to make easy document search. The initial search of document performed on January 1st, 2024, specifically at 11.59 PM in Indonesian Western Time found 289 documents published in the period of 1976 – 2024. The documents were such as article, conference paper, book chapter, review, book, and note written in some languages. Additionally, to systematically select documents, four steps had to be passed away (e.g., identification, screening, eligibility, and inclusion) (Juandi et al., 2023; Juandi, Suparman, et al., 2022; Juandi, Tamur, et al., 2022; Suparman et al., 2022; Susiyanti et al., 2022; Tawaldi et al., 2023; Yunita et al., 2022). The selection process of those documents is briefly and systematically explained in Figure 1.

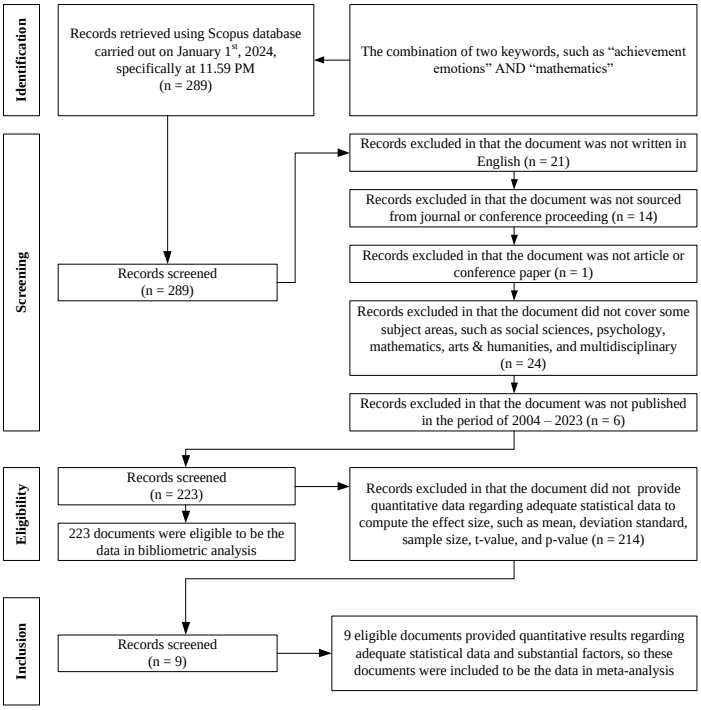


Figure 1. Systematic Process of Document Selection

Data Extraction:

Generally, 223 documents which had passed away the screening step were eligible to be the data in bibliometric analysis. The documents were downloaded from Scopus database in two formats, such as CSV (Comma Separated Values) and RIS (Research Information System). RIS provided some descriptively statistical information, such as publication & citation year, number of papers, number of citations, cites per year, cites per paper, authors per paper, h-index, and g-index (Fuad et al., 2022, 2023). Meanwhile, CSV provided some information, such as document title, author, country, source, institution, publisher, document type, keywords, number of citations, number of publications, and publication year (Putra et al., 2024; Suyanto et al., 2023). Furthermore, 8 eligible documents included to be the data in meta-analysis were extracted to the coding sheet. Those documents provided adequate statistical data (e.g., mean, deviation standard, sample size, t-value, and p-value) and four substantial factors, such as treatment type, emotional type, treatment duration, and mathematics content. Moreover, 8 included documents generated 28 units of effect size and 1,145 students. Additionally, two experts in meta-analysis were involved to verify and justify the data in which Cohen et al. (2018) stated that the credibility and validity of the data must be required to provide the qualified reports.

***Data Analysis*:**

The Performance and co-occurrence analysis were used to carry out bibliometric analysis supported by a few software, such as PoP and VOSviewer (Donthu et al., 2021). These, software were chose to analyse the data because of freely and easily to be accessed. Specifically, performance and citation analysis were applied to highlight the global trend of studies regarding mathematics achievement emotions in the period of 2004 – 2023 while co-occurrence analysis was applied to construct novel ideas related to mathematics achievement emotions for conducting the future studies. Additionally, to do meta-analysis, random effect model was applied as a preference to make decisions in that this model was able to cover the collection of empirical studies which had heterogeneous characteristics, such as participant, instrument, emotional treatment, educational level, and others (Fuadi et al., 2021; Jaya & Suparman, 2021). Hedges' equation was applied to calculate the effect size whereby this formula accommodated quantitative empirical research which had relatively small sample size. The effect size in g unit was categorized as 0.00–0.20 (weak), 0.21–0.50 (modest), 0.51–1.00 (moderate), and >1.00 (strong) (Cohen et al., 2018). Moreover, the Z test was applied to examine the effect of emotional treatments in stabilizing students' mathematics achievement emotions across treatment type, emotional type, and treatment duration. Moreover, a few of publication bias verifications, such as funnel plot analysis and fill & trim test were applied to check indications of publication bias in effect size data (Suparman, Juandi, & Tamur, 2021b, 2021a; Zainil et al., 2024). All of calculations in doing meta-analysis utilised CMA software version 4.0.

RESULTS AND DISCUSSION

RQ1: How are the global trends of studies regarding mathematics achievement emotions in two last decades?

Performance analysis was applied to show the development of publication and citation of studies in mathematics achievement emotions in the period of 2004 – 2023 (See Figure 2).

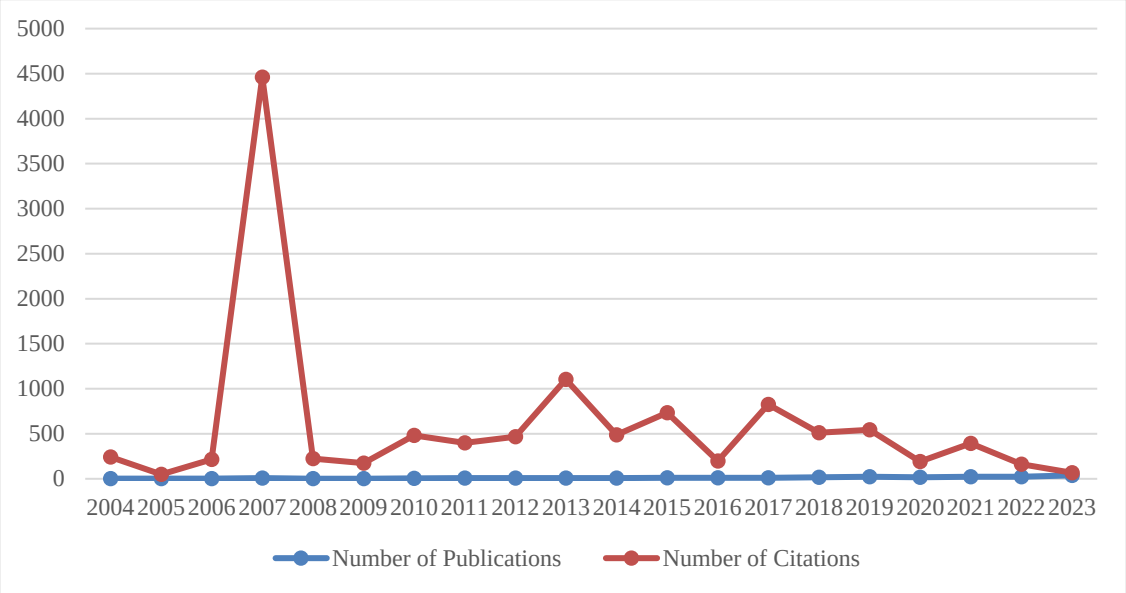


Figure 2. The development of publication and citation of studies in mathematics achievement emotions

223 documents related to mathematics achievement emotions published in two last decades consisted of four reviews, five conference papers, and 114 articles. Figure 2 shows that of the documents, there were two documents published in 2004, 2005, and 2006, followed by seven documents in 2007, one document in 2008 and 2009, four documents in 2010, eight documents in 2012 and 2013, nine documents in 2011 and 2014, ten documents in 2015 and 2016, twelve documents in 2017, sixteen documents in 2018 and 2020, 22 documents in 2019, 23 documents in 2021 and 2022, and 38 documents in 2023. This presents that number of publications regarding mathematics achievement emotions have gradually been increasing in the two last decades. Meanwhile, number of citations towards documents related to mathematics achievement emotions have relatively been fluctuating between 2004 and 2023. In a bibliometric study, Camacho-Morles et al. (2021) also reported that the development of publications regarding achievement emotion studies slightly soars in the last decade while the development of citations on documents related to achievement emotions relatively fluctuates in the period of 2014 – 2023. From the explanations, it can be stated that the development of publications regarding studies of achievement emotions in mathematics is not linier to the development of citations on the studies of achievement emotions in mathematics. Additionally, the gradual increase of publication development indicates

that the topic of achievement emotions in mathematics has been interested by many researchers.

RQ2: What the themes have emerged from studies of mathematics achievement emotions in two last decades? What novel ideas are offered for conducting future studies?

Co-occurrence analysis was applied to construct the novel ideas regarding studies of mathematics achievement emotions for future studies by frequently emerging the themes. Particularly, the network visualization analysis was used to present the frequently emerging keywords related to mathematics achievement emotions (See Figure 3). The minimum number of occurrences of a keyword as many as one occurrence were selected whereby 38 interconnected keywords emerged.

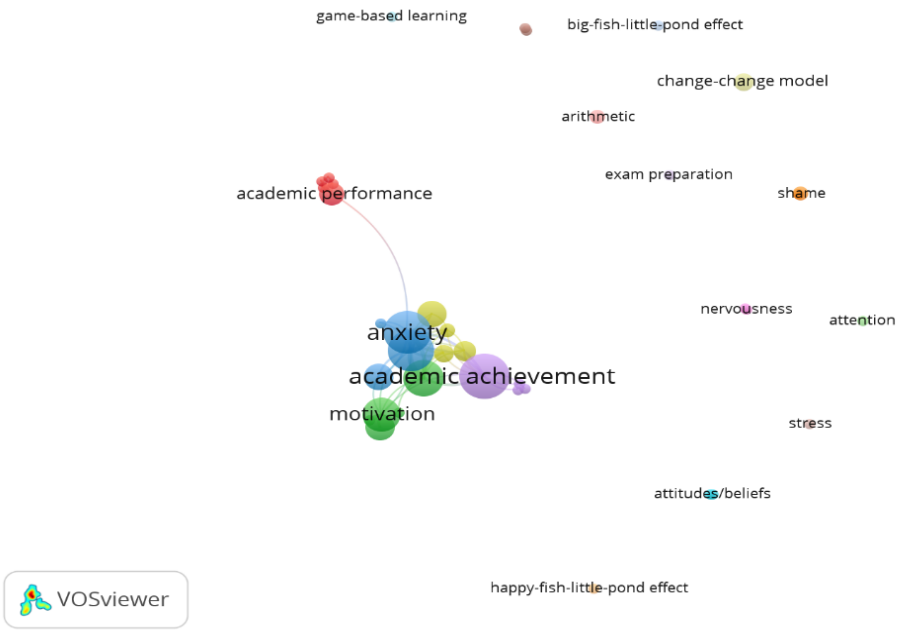


Figure 3. Network visualization of emerging keywords in studies of mathematics achievement emotions

Furthermore, thematic analysis was applied to group some similar emerging keywords related to studies of mathematics achievement emotions into a theme (See Table 1).

Table 1. Themes of emerging keywords regarding studies of mathematics achievement emotions

Theme	Keywords	Frequency
Emotional Type	Anxiety	18
	Enjoyment	17
	Boredom	13
	Anger	3
	Pride	2
	Shame	2
	Hope	1
	Hopelessness	1
	Frustration	1
	Depression	1
	Nervousness	1

	Worry	1
	Stress	1
Emotional Treatment	Change-Change Model	3
	Volitional Strategies	1
	Drawing Strategy	1
	Positive Psychology	1
	Long-term Stimulant Treatment	1
	Psychosocial Treatment	1
	Happy-Fish-Little-Pond	1
	Big-Fish-Little-Pond	1
	Rational Emotive Behavioural Therapy	1
	Relaxation Therapy	1
	Games-based Learning	1
Activity-and Outcome-related Emotion	Homework	4
	Exam preparation	1
Mathematics Content	Arithmetic	2
	Geometry	1
	Number/Fractions	1
Factor-related Emotion	Academic Achievement	20
	Motivation	11
	Self-Regulated Learning	7
	Self-Concept	7
	Self-Efficacy	7
	Academic Performance	5
	Self-Esteem	1
	Attitudes/Beliefs	1
	Attention	1

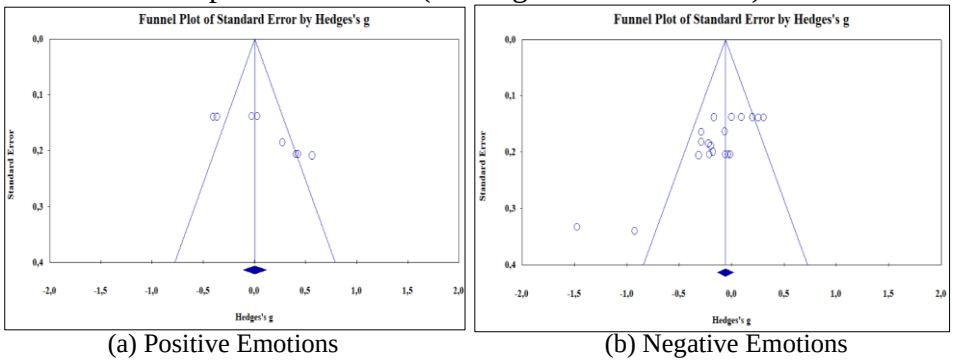
From Table 1, it can be seen that there were some themes which emerged from keywords regarding mathematics achievement emotions, such as emotional type, emotional treatment, activity-and outcome-related emotion, mathematics content, and factor-related emotion. Firstly, emotional type consisted of positive emotions (e.g., enjoyment, pride, and hope) and negative emotions (e.g., anxiety, boredom, anger, shame, hopelessness, frustration, nervousness, depression, worry, and stress). In a literature, Pekrun and Linnenbrink-Garcia (2012) explained that positive emotions consist of enjoyment, hope, pride, gratitude, relaxation, relief, and contentment while negative emotions consist of anger, frustration, anxiety, shame, boredom, hopelessness, sadness, and disappointment. From this explanation, it can be known that there are some achievement emotions which have not been investigated in mathematics activities and outcomes, such as gratitude, relaxation, relief, contentment, sadness, and disappointment. Consequently, these emotions can be investigated in future studies in mathematics education when following mathematics learning process, doing math homework, and doing math exam. Secondly, emotional treatments which had been implemented for stabilizing mathematics achievement emotions were such as change-change model, volitional strategy, drawing strategy, positive psychology, long-term stimulant treatment, psychosocial treatment, happy and big-fish-little-pond, rational emotive behavioural therapy, relaxation therapy, and games-based learning. However, the frequency of studies regarding games-based learning for mathematics achievement emotions had still been minimum. From a meta-analytic review, Lei et al. (2022) revealed that games-based

learning significantly increases positive emotions and decrease negative emotions. This initiates that mobile educational games can be a new stimulant in stabilizing students' mathematics achievement emotions in future studies.

Thirdly, there were few activities-and outcomes-related emotions, such as homework and exam preparation. This shows that activities generate mathematics achievement emotions are homework and exam preparation. In a literature, Pekrun and Stephens (2012) revealed that following mathematics learning process, doing math homework, doing math exam, and preparing math exam are mathematics activities generating achievement emotions. This shows that there are few mathematics activities, such as following mathematics learning process and doing math exam which have not been investigate previously and these can be explored more in the future studies. Fourthly, some mathematics contents, such as geometry, arithmetic, and number/fraction are involved in following mathematics learning, doing math homework, or doing math exam related to achievement emotions. In a literature, Helsa et al. (2023) stated that mathematics contents consist of algebra, geometry, number and operation, measurement, and statistics and probability. This shows that a few of mathematics contents, such as algebra, measurement, and statistics and probability can be involved in following mathematics learning process and doing math exam related to achievement emotions in the future studies. Fifthly, there were some factors-related to mathematics achievement emotions, such as academic achievement, motivation, self-regulated learning, self-concept, self-efficacy, academic performance, self-esteem, attitudes/beliefs, and attention. Some empirical studies revealed that achievement emotions are associated to academic achievement, academic performance, and motivation (e.g., Bekker et al., 2023; Broda et al., 2023; Moustakas & Gonida, 2023; Raccanello et al., 2020). As a consequence, achievement emotions generated from mathematics activities and outcomes has to be made stable that factors-related to those can be controlled.

RQ3: How much the effect size does emotional treatments have on students' mathematics achievement emotions? Do emotional treatments have a significant positive effect in increasing students' positive emotions and decreasing students' negative emotions?

A few of verifications, such as fill and trim test and funnel plot analysis were applied to check the indication of publication bias (See Figure 4 and Table 2).



(a) Positive Emotions (b) Negative Emotions

Figure 4. Analysis of funnel plot on the data of effect size

From Figure 4, it can be seen that the distribution of effect size data regarding both positive emotions and negative emotions was symmetrical. To make sure it, the results of fill and trim test in Table 4 show that there was no effect size data that had to be excluded from the distribution. This justifies that the distribution of effect size data in the funnel plot is really symmetrical. In a literature, Suparman et al. (2024) explained that when the distribution of effect size data in the funnel plot is symmetrical, it shows that there are no indications of publication bias. Thus, it can be stated that the data of effect size related to emotional treatments on positive and negative emotions does not have the indication of publication bias.

Table 2. The results of fill and trim test

Emotional Type		Excluded Data	Effect Size in Hedges' g	Q-value
Positive Emotions	Observed Values		0.088 [-0.159; 0.335]	32.945
	Adjusted Values	0	0.088 [-0.159; 0.335]	32.945
Negative Emotions	Observed Values		-0.112 [-0.239; 0.014]	49.468
	Adjusted Values	0	-0.112 [-0.239; 0.014]	49.468

Furthermore, 8 included documents generated 28 units of effect size and 1,145 students. The measurement of effect size related to emotional treatments on positive and negative emotions using the Hedges' formula is shown in Table 3.

Table 3. Summary and estimated effect size

Emotional Type	Authors	Effect Size in g Unit	Z-value	P-value
Enjoyment	Liverani et al., 2023a	0.566 [0.157; 0.975]	2.712	0.007
Pride	Liverani et al., 2023b	0.275 [-0.088; 0.639]	1.486	0.137
Enjoyment	Kim & Hodges, 2012c	0.407 [0.003; 0.811]	1.975	0.048
Pride	Kim & Hodges, 2012f	0.426 [0.021; 0.831]	2.064	0.039
Enjoyment	Bieleke et al., 2021a	0.030 [-0.241; 0.301]	0.216	0.829
Pride	Bieleke et al., 2021b	-0.024 [-0.294; 0.247]	-0.171	0.865
Enjoyment	Bieleke et al., 2021f	-0.403 [-0.677; -0.130]	-2.888	0.004
Pride	Bieleke et al., 2021g	-0.364 [-0.637; -0.091]	-2.611	0.009
Positive Emotions	Combined Effect	0.088 [-0.160; 0.335]	0.696	0.486
Shame	JenBen, 2023a	-0.288 [-0.645; 0.069]	-1.581	0.114
Shame	JenBen, 2023b	-0.198 [-0.568; 0.173]	-1.046	0.295
Shame	Liverani et al., 2023c	-0.313 [-0.717; 0.090]	-1.522	0.128
Anger	Liverani et al., 2023d	-0.220 [-0.538; 0.142]	-1.191	0.234
Shame	Gildehaus & JenBen, 2023	-0.176 [-0.568; 0.216]	-0.882	0.378
Anxiety	Passolunghi et al., 2020a	-0.289 [-0.611; 0.034]	-1.755	0.079
Anxiety	Passolunghi et al., 2020b	-0.064 [-0.385; 0.257]	-0.392	0.695
Boredom	Kim & Hodges, 2012a	-0.011 [-0.411; 0.389]	-0.052	0.959
Anxiety	Kim & Hodges, 2012b	-0.010 [-0.410; 0.390]	-0.048	0.961
Anger	Kim & Hodges, 2012d	-0.212 [-0.614; 0.189]	-1.038	0.299
Shame	Kim & Hodges, 2012e	-0.033 [-0.433; 0.367]	-0.160	0.873
Hopelessness	Kim & Hodges, 2012g	-0.062 [-0.462; 0.338]	-0.305	0.760
Anxiety	Bieleke et al., 2021c	0.000 [-0.271; 0.271]	0.000	1.000
Anger	Bieleke et al., 2021d	-0.168 [-0.439; 0.103]	-1.215	0.224
Boredom	Bieleke et al., 2021e	0.094 [-0.177; 0.365]	0.683	0.495
Anxiety	Bieleke et al., 2021h	0.200 [-0.071; 0.472]	1.444	0.149
Anger	Bieleke et al., 2021i	0.305 [0.033; 0.578]	2.196	0.028
Boredom	Bieleke et al., 2021j	0.256 [-0.016; 0.528]	1.844	0.065
Anxiety	Adigun et al., 2023a	-1.475 [-2.128; -0.822]	-4.426	0.000

Anxiety	Adigun et al., 2023b	-0.925 [-1.592; -0.258]	-2.719	0.007
Negative Emotions	Combined Effect	-0.112 [-0.239; 0.014]	-1.737	0.082

From Table 3, it can be seen that the effect of emotional treatments on positive emotions (e.g., enjoyment and pride) was 0.088 in which this interprets that emotional treatments have positive weak effect on positive emotions. Moreover, the significance value of Z test for emotional treatments on positive emotions was more than 0.05 whereby this interprets that emotional treatments do not have significant effect on positive emotions. Additionally, Table 3 shows that the effect of emotional treatments on negative emotions (e.g., shame, boredom, anxiety, hopelessness, and anger) was -0.112 whereby this interprets that emotional treatments have negative weak effect on negative emotions. Moreover, the significance value of Z test for emotional treatments on negative emotions was more than 0.05 in which this interprets that emotional treatments do not have significant effect on negative emotions. This indicates that emotional treatments can slightly increase positive emotions although those have not provided the significant effect in increasing positive emotions while emotional treatments can slightly decrease negative emotions although those have not provided the significant effect in decreasing negative emotions. In a literature, Lei et al. (2022) also revealed that games-based learning increases students' positive emotions while it decreases students' negative emotions. This provides strong evidences that emotional treatments can stabilize mathematics achievement emotions. Students who have stable achievement emotions in following mathematics learning process, doing math homework, and doing math exam can promote the enhancement of students' mathematics achievement. This is line to Camacho-Morles et al. (2021) who stated that positive emotions (e.g., enjoyment) positively associate to academic achievement but negative emotions (e.g., boredom, anger, and frustration) negatively associate to academic achievement. This implies that the stability of mathematics achievement emotions of students in following mathematics activities has to be generated to promote students' mathematics achievement.

RQ4: Do emotional treatments significantly increase students' positive emotions and decrease students' negative emotions across treatment type, emotional type, treatment duration, and mathematics content?

The Z test was applied to the significance of emotional treatments in increasing students' positive emotions and decreasing students' negative emotions across treatment type, emotional type, and treatment duration (See Table 4).

Table 4. The results of Z test for substantial factors

Substantial Factor	Group	N	Effect Size in g Unit	Z-value	P-value
Negative Emotions					
Emotional Type	Anxiety	7	-0.270 [-0.581; 0.040]	-1.707	0.088
	Boredom	3	0.140 [-0.033; 0.313]	1.587	0.113
	Shame	5	-0.205 [-0.376; -0.034]	-2.344	0.019

	Anger	4	-0.057 [-0.330; 0.215]	-0.412	0.681
	Hopelessness	1	-0.062 [-0.462; 0.338]	-0.305	0.760
Treatment Type	Easy and Difficult Task	6	0.114 [-0.027; 0.256]	1.580	0.114
	Math Strategy	2	-0.176 [-0.403; 0.052]	-1.516	0.130
	Numerical Problems	2	-0.262 [-0.532; 0.008]	-1.904	0.057
	Positive Psychology	3	-0.224 [-0.439; -0.009]	-2.043	0.041
	Rational Emotive Behavioral Therapies	1	-1.475 [-2.128; -0.822]	-4.426	0.000
	Relaxation Therapies	1	-0.925 [-1.592; -0.258]	-2.719	0.007
	Web-based Video	5	-0.065 [-0.244; 0.114]	-0.716	0.474
Treatment Duration	1 Week	2	-0.262 [-0.532; 0.008]	-1.904	0.057
	2 Weeks	5	-0.065 [-0.244; 0.114]	-0.716	0.474
	4 Weeks	6	0.114 [-0.027; 0.256]	1.580	0.114
	5 Weeks	2	-0.245 [-0.502; 0.012]	-1.865	0.062
	7 Weeks	2	-1.204 [-1.743; -0.665]	-4.380	0.000
	8 Weeks	2	-0.176 [-0.403; 0.052]	-1.516	0.130
	11 Weeks	1	-0.176 [-0.568; 0.216]	-0.882	0.378
Positive Emotions					
Emotional Type	Enjoyment	4	0.128 [-0.293; 0.550]	0.598	0.550
	Pride	4	0.056 [-0.282; 0.394]	0.324	0.746
Treatment Type	Easy and Difficult Task	4	-0.189 [-0.410; 0.031]	-1.686	0.092
	Numerical Problems	2	0.405 [0.122; 0.688]	2.803	0.005
	Web-based Video	2	0.417 [0.131; 0.703]	2.855	0.004
Treatment Duration	1 Week	2	0.405 [0.122; 0.688]	2.803	0.005
	2 Weeks	2	0.417 [0.131; 0.703]	2.855	0.004
	4 Weeks	4	-0.189 [-0.410; 0.031]	-1.686	0.092

From Table 4, it can be seen that emotional treatments had negative weak effect on students' anger and hopelessness, positive weak effect on students' boredom, and negative modest effect on students' anxiety and shame. Nevertheless, those did not provide significant effect on students' anxiety, boredom, anger, and hopelessness but emotional treatments provided significant effect on students' shame. This interprets that emotional treatments can slightly decrease students' anxiety, boredom, anger, and hopelessness while emotional treatments can slightly increase students' shame. Relatively, emotional treatments can decrease students' negative emotions, such as anxiety, boredom, anger, and hopelessness. In a literature, Lei et al. (2022) revealed that games-based learning as an intervention can decrease students' negative emotions. Additionally, emotional treatments had positive weak effect on students' enjoyment and pride. Those, however, did not provide significant effect on students' enjoyment and pride. This interprets that emotional treatments can slightly increase students' enjoyment and pride. All of these, emotional treatments relatively generate the stability of students' achievement emotions in following mathematics learning, doing math homework, and doing math exam.

Several emotional treatments, such as math strategy, numerical problems, positive psychology, rational emotive behavioral therapies, relaxation therapies, and web-based video had negative effect on students' negative emotions. This interprets that those treatments can decrease students' negative emotions. However, easy and difficult task had positive effect on students' negative emotions in which this shows that this treatment

increases students' negative emotions. Of these treatments, the effect size of rational emotive behavioral therapies was higher than other treatments in decreasing students' negative emotions. This interprets that rational emotive behavioral therapy is more effective in decreasing students' negative emotions than other treatments. In addition, a few of emotional treatments, such numerical problems and web-based video had positive effect on students' positive emotions in which this shows that these treatments can increase students' positive emotions. Meanwhile, easy and difficult task had negative effect on students' positive emotions whereby this reveals that this treatment decreases students' positive emotions. Of these treatments, the effect size of web-based video was higher than other treatments in increasing students' positive emotions. This interprets that web-based video is more effective in increasing students' positive emotions than other treatments. A few of empirical studies revealed that psychological therapy can decrease students' negative emotions, such as anxiety, boredom, and shame (e.g., Chen & Lu, 2022; Zhao et al., 2022). Moreover, a few of empirical studies showed that web-based learning can increase students' positive emotions, such as enjoyment and pride (e.g., Putwain et al., 2021; Schukajlow et al., 2021). These strengthen that rational emotive behavioral therapy can decrease students' negative emotions and web-based video can increase students' positive emotions.

Furthermore, the effect size of emotional treatments conducted during seven weeks in decreasing students' negative emotions (e.g., anxiety, shame, anger, boredom, and hopelessness) was higher than the effect size of emotional treatments carried out during 1 week, 2 weeks, 4 weeks, 5 weeks, 8 weeks, and 11 weeks in decreasing students' negative emotions. Particularly, emotional treatments conducted during seven weeks provided the significant negative effect in decreasing students' negative emotions. This interprets that emotional treatments implemented during seven weeks are more effective in decreasing students' negative emotions than other treatment durations. Additionally, the effect size of emotional treatments conducted two weeks in increasing students' positive emotions (e.g., enjoyment and pride) was higher than the effect size of emotional treatments carried out during 1 week and 4 weeks in increasing students' positive emotions. Specifically, emotional treatments carried out during 1 week and 2 weeks provided the significant positive effect in increasing students' positive emotions. This interprets that emotional treatments implemented during two weeks are more effective in increasing students' positive emotions than other treatment durations. Some empirical studies also stated that treatment duration must be an essential consideration in implementing emotional treatments on students' achievement emotions in following mathematics learning process, doing math homework, and doing math exam (e.g., Cerniglia et al., 2021; Kahl et al., 2021; Sachisthal et al., 2021).

CONCLUSIONS

Global trends of studies regarding mathematics achievement emotions describe that number of publications have slightly been increasing while number of citations have relatively been fluctuating in the period of 2004 – 2023. There are several main themes which emerge in two last decades related to mathematics achievement emotions, such as

emotional type, emotional treatment, activities-and outcomes-related emotion, mathematics content, and factors-related emotion. Several positive emotions (e.g., gratitude, relaxation, relief, and contentment) and negative emotions (e.g., sadness and disappointment) can be investigated more in future studies when students follow mathematics learning process, do math homework, and do math exam. Additionally, mobile educational games can be a new stimulant in increasing students' positive emotions (e.g., enjoyment and pride) and decreasing students' negative emotions (e.g., shame, anger, anxiety, boredom, and hopelessness) in future studies. Statistics and probability can be mathematics contents for students in following mathematics learning process and doing math exam related to achievement emotions in the future studies. Furthermore, emotional treatments can slightly increase students' positive emotions and decrease students' negative emotions. This implies that the stability of mathematics achievement emotions of students in doing mathematics activities has to be generated to promote students' mathematics achievement in which a few of emotional treatments, such as psychological therapies and web-based learning can be applied to stabilize students' mathematics achievement emotions.

There are some limitations in this meta-analytic review. Many prospective documents identified in some databases can't be accessed in that those are restricted by publishers, so we have to pay it to get the access of the documents. In addition, a lot of documents do not report adequate information regarding statistical data to compute units of effect size. Consequently, for the future achievement emotion studies in mathematics education, researchers should straightly communicate the restricted documents to authors whereby asking to be provided the access to get the documents freely.

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AUTHOR CONTRIBUTION STATEMENTS

S : Conceptualization, Collecting the Data, Document Selection, Data Extraction, and Writing - Original Draft

DJ : Data Analysis, Interpretation, Review and Editing.

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