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A meta-analysis on the effectiveness of strategies and programs used to address the mathematics learning difficulties

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Abstract

The present study aimed to obtain an empirical evidence about the effectiveness of strategies and programs used to address mathematical learning difficulties through studies published in some Arab periodicals and through adopting the meta-analysis method. Furthermore, the study investigated whether the efficacy of these strategies and programs differ according to the independent variables and educational stage in the selected studies. A systematic search of experimental and quasi-experimental studies published between 2012 and 2022 was conducted. 47 studies from a total of 154 studies met the study selection criterion. The results revealed that the average standard effect size (ES) for all studies included in the meta-analysis was 3.19, with a huge ES. The results also showed no difference in the efficiency of strategies and programs in the selected studies according to the independent variables and the educational stage.

Keywords: learning difficulties, mathematics learning difficulties, meta-analysis, Arab World, Arab learners

INTRODUCTION

The methods teachers use when teaching mathematics affect students' comprehension. Therefore, many learners judge mathematics as a complex subject (Akcay et al., 2021), and consequently, those learners face difficulties when they come to learn mathematics (Kroesbergen et al., 2022). Thus, learning difficulties in mathematics are common among children and adults and these difficulties significantly impact learners' level. These difficulties are common among both males and females, and 10% of the students continuously face challenges while learning mathematics. This percentage may vary depending on the criterion of a discrepancy between achievement in mathematics (Jarrah & Al-Natour, 2021). Hence, diversified and good amount of studies have been conducted and dealt with several strategies and programs to address the difficulties of learning mathematics (Abdullah, 2021; Abu Shabab, 2019; Al-Farhood, 2021; Al-Hutaila & Hamadneh, 2020; Al-Mustafa & Ijbarah, 2020; Al-Qahtani & Al-Zubairi, 2020; Al-Shahrani, 2019; Al-Shahrani & Al-Zoubi, 2019; Al-Shammari, 2022; Ashour & Al-Samiri, 2019; Khalil et al., 2019; Chirinda & Barmby, 2018; De Jager, 2017; Maluleke, 2019; Mohammad, 2020; Rababa'a, 2021; Sayed et al., 2019). The superficial view of the results of these studies did not show sufficient evidence to support the preference of these strategies and programs and which ones are more effective in addressing these difficulties.

Meta-analysis is a statistical analysis method for many experimental studies that aim to integrate the results of these various studies (Mohamed, 2018). It is an organized quantitative statistical method for organizing a huge amount of data through the findings of a group of studies objectively and comprehensively, with the aim of extrapolating generalizations from the findings of such studies (Glass et al., 1981). The meta-analysis also aims to collect data on the results of a group of studies that investigate a common goal by calculating the effect size (ES) for each of these studies and extracting a typical effect size for all of these studies (Means et al., 2013). It also aims to understand the results of any investigation in the context of other similar studies, whether ESs are consistent across all studies. If there is a consistency, then there must be an estimation for ES of these studies as accurately as possible (Al-Ghamdi, 2021).

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Contribution to the literature

- The study identifies specific strategies and programs consistently demonstrating positive effects on addressing mathematics learning difficulties.
- The study explores factors that may influence intervention effectiveness, such as age groups, types of learning difficulties, and program duration.
- The study provides educators with practical insights into designing targeted and tailored instructional approaches for students with mathematics learning difficulties.
- The study contributes to developing evidence-based practices in mathematics education, promoting informed decision-making and continuous improvement.

Literature Review

Mathematics learning difficulties are defined as the educational difficulties that students face during their study of mathematics and make them unable to understand and comprehend mathematics and its related subjects (Ramli et al., 2013). In the last two decades, interest in using meta-analysis has increased in mathematics education research (Young & Young, 2022). Being a new method in research, meta-analysis represents the quantitative parallel line for reviewing research and studies. In this regard, several studies have dealt with meta-analysis in teaching mathematics. A study carried out by Gersten et al. (2009) used meta-analysis for a group of semi-experimental studies in educational curricula and enhancing mathematics competence for students with learning difficulties. It concluded that the methods used in those analyzed studies had a medium and significant impact, with an ES ranging between 0.21 and 1.56. Another survey was conducted by Jacobse and Harskamp (2011) and examined the effect of interventions in teaching mathematics in grades (kindergarten to sixth) through a meta-analysis of 69 ESs drawn from 40 previous studies. The results showed a statistically significant positive effect of educational interventions on learners' achievement. In a similar study, a survey conducted was by Akcay et al. (2021) and aimed to determine the size of the overall impact of the use of technology on academic achievement in mathematics among primary school students by collecting experimental studies conducted during the period 2013-2019. The results of the study concluded that the use of technology in teaching mathematics has a positive impact on students' achievement.

Likewise, a study conducted by Myers et al. (2021) found a relatively significant effect of treatments designed to improve mathematics achievement for high school students with difficulties in mathematics through a meta-analysis of 45 studies published during the period 1978-2020. These treatments fall into four categories: technology-based processors, schema-based processors, the use of visual representations, and knowledge-based education. Another study conducted by Turgut (2021) found a positive effect of using the realistic v approach on students' achievement in which the total ES using (Hedges' *g*) coefficient was 0.76, through a post-analysis of the 43 ESs that were extracted from previous studies published before 2020. At the same time, a recent meta-analysis study by Wijaya et al. (2022) analyzed 26 ESs collected from 17 studies that dealt with electronic books' effect on mathematics achievement. The results showed that the use of electronic books in teaching mathematics has a significant impact on students' achievement. Despite this growing interest, the meta-analysis results conducted by Samritim et al. (2023) showed an ES of 0.725 for the blended learning model on mathematics learning achievement.

However, it is noticeable that studies in Arab periodicals are scarce in this field, especially those related to the difficulties of learning mathematics. Therefore, this study represents an important step towards consolidating the studies in Arab periodicals that dealt with problems in learning mathematics by highlighting the best strategies and programs that address difficulties using a modern and essential statistical method, the meta-analysis. Furthermore, the study results help mathematics teachers apply the best strategies and educational programs to address learning difficulties and achieve learning outcomes.

Present Study

In this study, there was not any Arab study that dealt with the meta-analysis of strategies and programs for addressing the difficulties of learning mathematics within the limits of what was found through a survey of the available databases in Arabic language. To bridge this gap, meta-analysis was adopted to analyze the quantitative data from experimental studies conducted in this field. Thus, this study aimed to report the impact of strategies and programs used to address the difficulties of learning mathematics by using the meta-analysis of the results of studies published in some Arab periodicals during the period 2012-2022. To achieve this goal, this study sought to answer the following two questions:

Q1. What is the efficiency of strategies and programs for addressing the difficulties of learning mathematics according to the meta-analysis of

Table 1. Distribution of study sample in terms of ESs according to educational stage & independent variables

Independent variable	Sum		Educational stage	
	n	Percentage (%)	Primary	Intermediate
E-learning	16	30.77	12	4
Active and collaborative learning	15	28.85	11	4
Mind maps and brain-based learning and thinking	21	40.38	15	6
Total	52	100.00	38	14

studies published in Arab periodicals during the period 2012-2022?

Q2. Does the efficiency of strategies and programs for addressing mathematics difficulties differ according to the meta-analysis of the sample for the selected studies according to independent variables and educational stage?

METHOD

The study adopted the descriptive approach based on the meta-analysis method presented by Glass in 1976, where ES was calculated for each of the previous studies according to the Hedges method. This method is one of the quantitative methods that depend on forms of statistics in organizing and extracting more comprehensive results than the results of previous research and studies. The dimensional analysis was used to reach a more comprehensive result to search for the best interventions to address the difficulties of mathematics by combining the results of some Arab studies that dealt with the treatment of difficulties in learning mathematics, which was published during the period 2012-2022, and are available in the databases of Dar Al-Mandumah. These databases are the most comprehensive database of Arab studies and research published in most of the journals published in the Arabic language. Basic steps of the dimensional analysis were applied, represented by identifying the experimental studies that serve the purpose of the research in this study and then emptying the data of the sample size, the arithmetic mean, and the standard deviation for each of the experimental and control groups for those studies, and then calculating ES using the Hedges method using my program SPSS and comprehensive meta (CMA), and then perform the rest of the statistical analyzes of the calculated ESs and then interpret them.

Sample

The population of this study consisted of all the studies published in some Arab peer-reviewed periodicals available on the databases of Dar Al-Mandumah during the period 2012-2022, which dealt with the treatment of difficulties in learning mathematics. The study sample consisted of 52 ESs extracted from 47 studies that dealt with strategies and programs to address the difficulties of learning mathematics applied in the primary and intermediate stages of school. The studies used as a sample in this research were conducted during the period 2012-2022. **Table 1** shows distribution of study sample according to the educational stage and the independent variables in which the strategies and programs were based.

Procedures

The meta-analysis has a set of steps that can be followed in reviewing the results of experimental research studies. These steps are represented by defining the focus of interest, collecting published studies and research, examining and describing these studies, and then tabulating, and analyzing data and results (Abu Hasel, 2019). First, the researchers identified the study problem and the subjects. Secondly, the studies were limited to the degree of their relevance to the variables of this study and the availability in the databases of Dar Al-Mandumah. Thirdly, the researchers determined the criteria for including or excluding studies. Fourth, the previous studies were determined on which the meta-analysis was conducted according to specified criteria. Fifth, the researchers unloaded the data of the studies that were selected according to the previously specified criteria to the two programs (SPSS and CMA), represented in the name of the study, its number, the academic stage to which it was applied, the independent variables of each study, the number of members of each of the experimental and control groups, in addition to their arithmetic mean, and their standard deviation. **Appendix A** shows the data of the studies that were subjected to the meta-analysis. Sixth, the data was analyzed using the SPSS, 28 statistical program, as well as the comprehensive meta-analysis "CMA" V3.exe program, and the Hedge's *g* formula, which was used as an indicator of ESs, and the value of ES was interpreted using the criterion proposed by Sawilowsky (2009), as follows: 0.01 is very small, 0.20 is small, 0.50 is medium, 0.80 is large, 1.20 is very large, and 2.00 is huge.

Selection Criteria

The researchers relied on several criteria when selecting the studies that were analyzed, as shown in **Table 2**.

This process passed through four stages, as shown in **Figure 1**. The first stage consisted of surveying studies according to the degree of their relevance to the variables of this study and the availability of their data in the databases of Dar Al-Mandumah using the following keywords when searching: (mathematics learning difficulties–learning difficulties in mathematics–

Table 2. Criteria for including or excluding the analyzed studies

Variable	Criteria
Year	Studies conducted through 2012-2022.
Method	Studies that followed the experimental approach in its experimental and semi-experimental style, which was applied to two experimental and control groups.
Dependent variable	Studies that dealt with the treatment of difficulties in learning mathematics in the cognitive field.
Country	Studies conducted in Arab countries.
Educational stage	Studies conducted in the primary and intermediate stages.
Type of research	Limited to analyzing the results of Arab studies and research published in peer-reviewed Arab journals, excluding other research such as master's theses and doctoral dissertations.
Data availability	Studies in which data were available for both the experimental and control groups (group size "*n*", mean "*M*" , standard deviation "*SD*") were selected in the post application of the study tools.
Databases	Limited to the studies available in the educational database (Edu Search) of Dar Al-Mandumah, which contains most of the Arabic peer-reviewed journals.

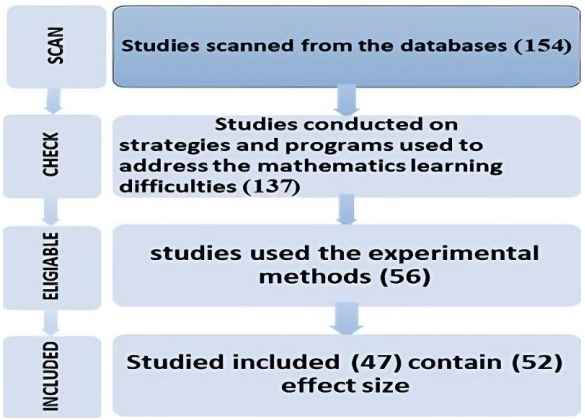

Figure 1. Selection process of studies (Source: Authors' own elaboration)

difficulties in teaching mathematics–slow learners in mathematics–a low achievement in mathematics). The studies scanned in the database were 154 studies. The second stage included examining the surveyed studies and identifying studies that dealt with strategies and programs to address the difficulties of learning mathematics. The number of studies was 137. In the third stage, studies that followed the experimental approach and dealt with two groups, one experimental and the other control, were selected. A clear and specific methodology was provided, which amounted to 56 studies. Finally, the fourth stage in which the studies of meta-analysis was conducted were identified, after excluding the studies in which the mean, standard deviation, or sample size was not available for any of the two groups, and the number reached 47 studies.

RESULTS

Efficiency of Strategies and Programs to Address Difficulties of Learning Mathematics

Publication bias

A publication bias occurs when researchers publish only positive results. A funnel shape diagram was used to detect the absence of publication bias for the analyzed studies. Publication bias can be assessed when the distribution of ESs is not uniform around the overall ES (Rubio-Aparicio et al., 2018) as shown in **Figure 2**.

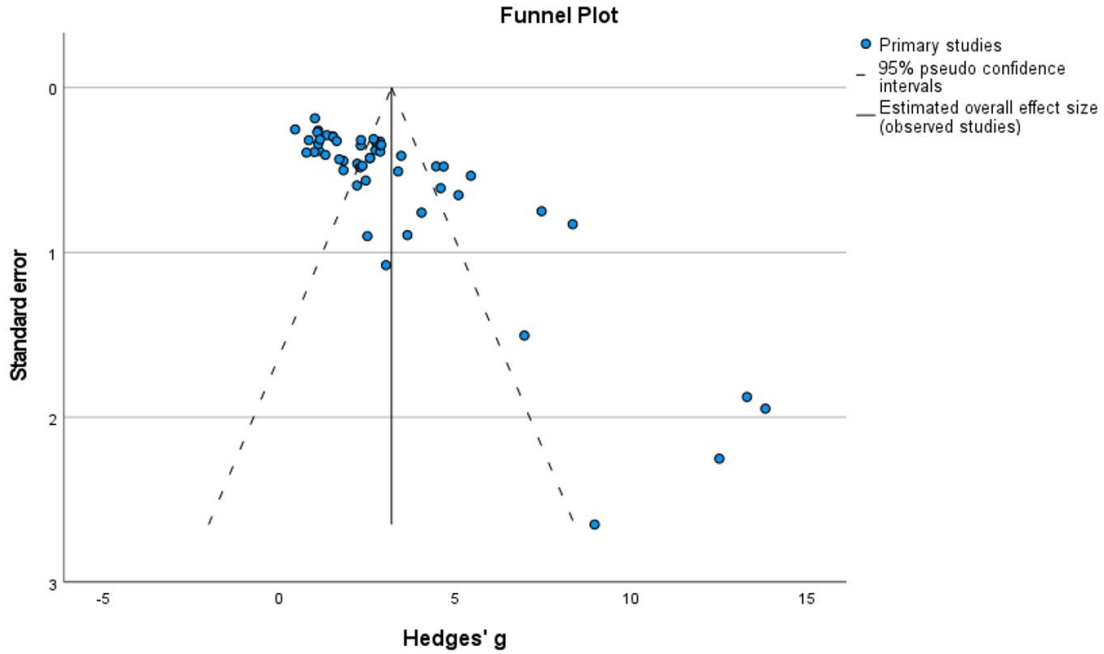

Figure 2. Funnel plot diagram (Source: Authors' own elaboration)

Table 3. Classic fail-safe n for meta-analysis effect

Bias indicator	Value
The z-value for observed studies	42.71
The p-value for observed studies	0.00
Alpha	0.05
Tails	2.00
The z-value for alpha	1.96
Number of observed studies	52
p> number of missing studies for the alpha result	24,638

Table 4. Test of homogeneity

Chi-square			I-squared (%)
(Q statistic)	df	Sig.	
592.531	51	0.00	98.20

The funnel plot shows the relationship between the standard error and ES with a confidence interval 95%. **Figure 2** clearly shows that as ES increases, the standard error decreases. It is also evident that the collection of ESs is distributed almost symmetrically around both sides of the vertical line that represents the expected ES, and this indicates the absence of bias in publication, and ensures the absence of bias as an additional evidence. CMA program used the Rosenthal safe method, and **Table 3** shows the results.

Table 3 shows the results of the meta-analysis are not statistically significant of 24,638 studies with an ES that contradict the analyzed 52 studies must be available. The amount of Mulle) can be calculated by the formula:

$$24{,}638/(5 * 52 + 10) = 91.25] = ([\frac{N}{5K+10}], \quad (1)$$

where it turns out that the output of the formula (91.25) is more significant than one, and this indicates that there is no publication bias, which confirms the reliability of the study (Mullen et al., 2001).

Test of non-homogeneity

The heterogeneity test was used in order to ensure that there are statistically significant differences at the level 0.05 between the observed variation in ESs calculated for the data of the analyzed studies and the expected variation resulting from the sampling error. That was done in order to determine the appropriate model for all ESs for the studies included in the meta-analysis. **Table 4** shows the results of test of homogeneity.

Table 4 shows that the Chi-square value is amounted to 592.53, with a level of significance 0.00, and this level is less than 0.05, which means that there is no homogeneity between ESs in previous studies. The variance ratio, which is amounted to 98.2%, showed that there is a great deal of heterogeneity between those studies, and this indicates that the observed variation in ES of these studies is greater than the expected variation resulting from sampling error. This confirms that these studies do not share a standard ES. For this reason, the random effects model was used, which assumes that the average effects are the combined effects among the results of heterogeneous studies (Borenstein et al., 2009).

Table 5. Mean ES & joint z value for a sample of post-analysis studies using random effects model (ES estimates)

n	ES	SE	z	Sig. (2-tailed)	95% Confidence interval	
					Lower	Upper
52	3.19	0.42	7.53	0.00	2.36	4.03

Mean mutual effect size

The random effects model and the average combined ES were found for the sample of the analyzed studies. The standard error (SE) and the lower and upper limits of the confidence interval 95% were also found. The value of z and its significance were found to ensure the significance of the mean size of the joint effect, as shown **Table 5**.

Table 5 shows that the average joint ES for all studies included in the post-analysis was 3.19, with a standard error 0.42, and a confidence interval ranging between 4.03 and 2.26 at a confidence level 95%, which is considered the size of the effect. There is a huge effect according to the criterion set by Sawilowsky (2009), and the value of z reached 7.53 at the level of significance 0.00, which is less than 0.05.

Appendix A shows that ESs calculated for the selected studies that were subjected to the meta-analysis ranging between 13.81 and -0.47, and through the values of z and their statistical significance, it was noted that there is no statistically significant effect at a level greater than or equal to 0.05 for two of ESs, one of which is related to the use of the method of practice and discovery in the study of Sahrawi and Najat (2018), and the second is the study of Al-Shammari (2022) with regard to the use of the Marzano model for the dimensions of learning. While the results of **Appendix A** shows a statistically significant ES at a level less than 0.05 on the rest of ESs, it ranged between very large and huge. The forest shape diagram shown in **Figure 3** shows the distribution of ESs for meta-analysis sample around the average joint ES.

Figure 3 shows that the size of only one effect touches the zero-vertical axis. In contrast (51), the size of the effect was in the positive direction, which confirms the existence of efficiency for strategies and programs to address the difficulties of learning according to the meta-analysis of the results of studies published in some Arab periodicals during the period 2012-2022 and these results are in line with the results of (Myers et al., 2021).

Differences Between Efficiency of Strategies and Programs According to Independent Variables and Educational Stage

Meta-analysis was used for the subgroups that represent the dependent variables and the educational stage, as shown in **Table 6**.

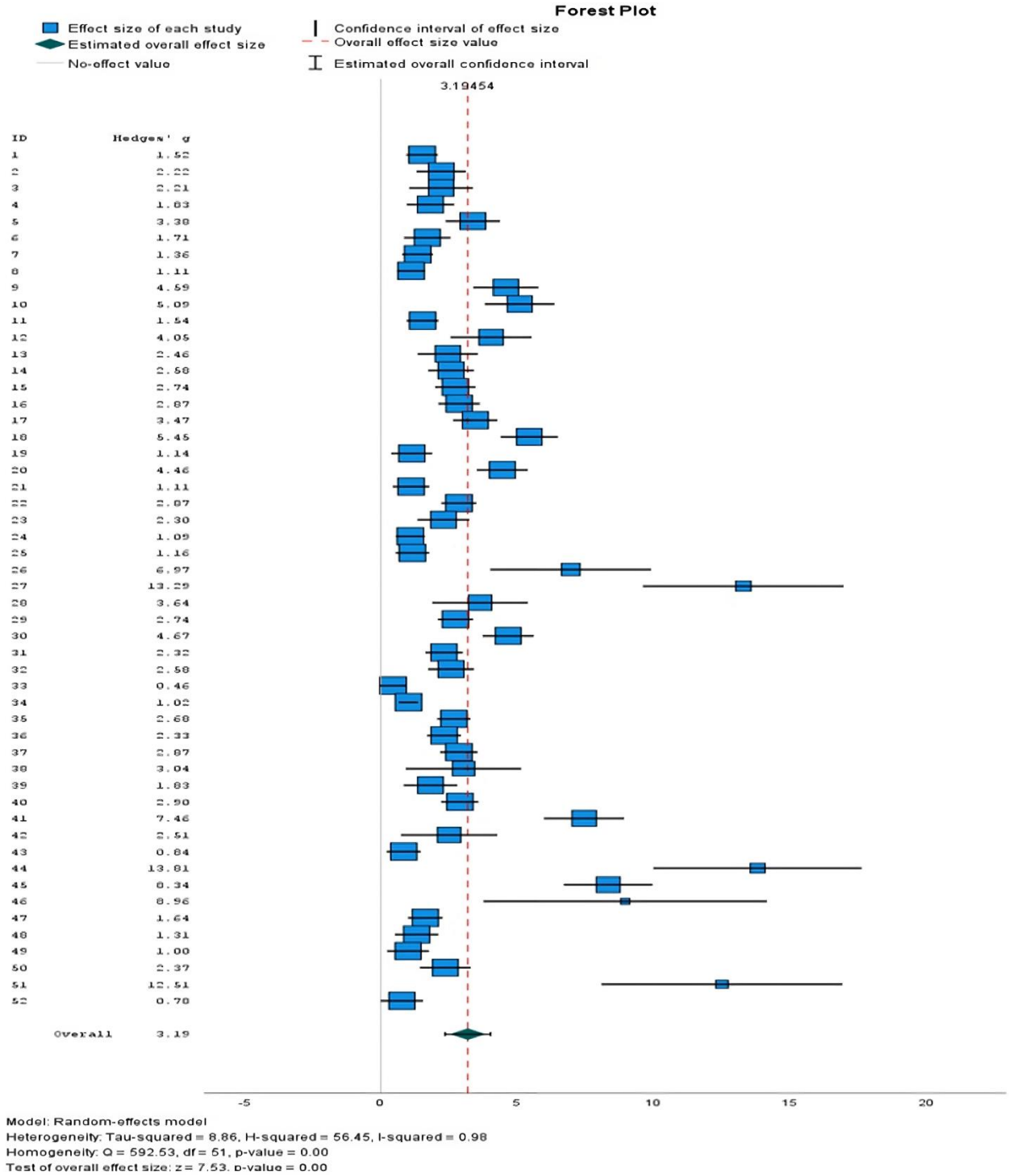

Figure 3. Forest plot diagram (distribution of ESs for meta-analysis sample around mean joint ES) (Source: Authors' own elaboration)

Table 6. Post-analysis of subgroups (independent variables & educational stage of study)

	Category	ES	SE	z	Sig. (2-tailed)	95% CI		Chi-square (Q statistic)	Sig.
						Lower	Upper		
Independent variables	E-learning	2.97	0.53	5.65	0.00	1.94	4.00	0.313	0.86
	Active & collaborative learning	3.17	1.04	3.06	0.00	1.14	5.21		
	Mind maps & brain-based learning & thinking	3.44	0.66	5.22	0.00	2.15	4.73		
	Overall	3.20	0.42	7.53	0.00	2.36	4.03		
Educational stage	Primary	3.33	0.57	5.88	0.00	2.22	4.44	0.343	0.56
	Middle	2.94	0.37	8.04	0.00	2.22	3.65		
	Overall	3.20	0.42	7.53	0.00	2.36	4.03		

Note. SE: Standard error & CI: Confidence interval

Table 6 shows that there is no statistically significant difference at the level of 0.05 in the efficiency of the strategies and programs for addressing the learning difficulties in according to the meta-analysis of the sample of the selected studies based on the different independent variables as the Chi-square value was 0.303 with a significance level of 0.86, which is larger than 0.05. This indicates that the efficiency of all strategies and programs according to the divided categories is similar, and this is evident from the values of ES and its statistical significance for each category, as ES for the four categories ranged between 2.97 and 3.44. It is also clear that there is no statistically significant difference at the level of 0.05 in the efficiency of strategies and programs for addressing the learning difficulties in according to the meta-analysis of a sample of the selected studies at different levels 3of study because the Chi-square value was 0.313 with a significance level 0.56, which is greater than 0.05. This is an indication that the efficiency of all strategies and programs is similar whether applied at the primary stage or intermediate stage.

DISCUSSION

Efficiency of Strategies and Programs to Address Difficulties of Learning

The present study aimed to report on the impact of strategies and programs that addressed the difficulties of learning by using a meta-analysis of the results of studies published in some Arab periodicals during the period 2012-2022. Based on the results that were obtained to answer the first research question, it is shown that the size of the joint effect is amounted to 3.19, and this size is much larger when compared to the size of the impact in some previous studies that dealt with the meta-analysis of some interventions in education, as in the various studies (Akcay et al., 2021; Gersten et al., 2009; Myers et al., 2021; Turgut, 2021; Wijaya et al., 2022). This indicates the efficiency of strategies and programs for addressing learning difficulties according to the meta-analysis of the results of studies published in some Arab periodicals during the period 2012-2022.

These results can be attributed to the fact that the strategies and programs that were dealt with are based on modern trends and philosophies in teaching, which made the learners active in the learning process. This in turn led to the development of learners' knowledge in, even though they were in the primary and intermediate stages in which learners most often face difficulties related to the cognitive aspects. In classes and due to that fact difficulties in learning are related to disturbances in many cognitive processes students who suffer from difficulties in learning, they usually have an apparent decrease in the level of academic achievement (Al-Shami, 2016). For this reason, all the analyzed studies focused on developing different aspects of knowledge, especially in the academic achievement, in a significant way and led to a positive impact of these interventions on addressing the difficulties of learning. Effective teaching methods are based on the effectiveness of experimental group students with difficulties in learning in different educational situations.

The results showed that the educational situations and activities presented to the experimental group students varied. Most of them relied on cooperative learning, and this kept the students away from boredom and worked to raise their attention towards the learning process, as in the studies of (Al-Farhood, 2021; Al-Mustafa & Ijbarah, 2020; Al-Saidi, 2018; Mohammad, 2020; Rababa'a, 2021; Sayed et al., 2019).

Several learning strategies and programs focused on providing learners with immediate feedback, and this would help the students know the difficulties they face in the class and made them do their best to overcome the difficulties, as indicated by the study of (Al-Farhood, 2021; Rababa'a, 2021; Sayed et al., 2019). It was also found that the most significant ES in these studies was related to the use of TRIZ theory strategies in developing achievement among students with learning difficulties in which was mentioned in the studies (Al-Qahtani, 2017; Al-Qahtani & Al-Zubairi, 2020). The strategies of this theory depend on creative solutions to problems through a set of principles that students use when solving problems related to arithmetic operations.

Differences Between Efficiency of Strategies and Programs According to Independent Variables and Educational Stage

The current study focused on verifying the existence of a difference or similarity in the efficiency of strategies and programs for addressing learning difficulties in according to the meta-analysis of a sample of selected studies with regard to the independent variables and the study stage. Studied according to the meta-analysis for the sample of the selected studies based on the different independent variables indicated that all the strategies that have been applied are among the practical strategies that develop students' knowledge in, primarily since they all focus on the cognitive aspect. Through meta-analysis and by looking at ES for each category of the independent variables, it was noted that the largest ES was for mental maps and brain-based learning and thinking, as the joint ES for these strategies was 3.44. That was followed by active and cooperative learning strategies, with a joint ES 3.17, and the least of them were e-learning strategies, with an ES 2.97.

As for the educational stage, the results showed that there was no statistically significant difference at the level 0.05 in the efficiency of the strategies and programs for addressing the learning difficulties in according to the meta-analysis of the sample of studies chosen according to the different educational stages. This result is somewhat logical. The study was limited to only two

stages, which are primary and intermediate, and these two stages are classified in several countries as one stage called the primary stage. They are very similar in the characteristics of learners in their classrooms, and most of the difficulties that students face in the two stages are related to the academic achievement in the cognitive aspect, and this is in contrast to the findings of the studies of (Akcay et al., 2021; Samritim et al., 2023). These two studies showed the difference in the effect of education programs at different educational levels, however, these two studies were applied to ordinary students and not those with learning difficulties.

Limitations, Implications, and Future Research

This study was limited to 52 ESs that were analyzed in 47 studies that only dealt with addressing learning difficulties. Although this sample is relatively large compared to similar studies that dealt with meta-analysis, it may be considered small to obtain more precise overall ES, and this is an inherent limitation in the descriptive analyzes addressed by previous studies (Myers et al., 2021). The present study was limited to the analysis of studies that addressed cognitive difficulties in mathematics. Furthermore, this study did not include the emotional and skillful aspects. This study was limited to analyzing studies published in Arabic language that dealing with the difficulties of learning mathematics, as per the rules of Dar Al-Mandumah. This study dealt only with two stages of study (elementary and intermediate). The results in this study clearly show the importance of using effective teaching strategies: e-learning, active and collaborative learning, mental maps and brain-based learning and thinking–with positive effects on reducing the difficulties of learning mathematics. This study suggests conducting more empirical studies related to strategies and programs that limit the difficulties of learning mathematics, as well as conducting a meta-analysis of both Arab and foreign studies to reveal the size of a joint effect of programs that solve mathematics learning difficulties. The results of the proposed studies should reveal the efficiency of treatment programs and other details such as the period of application, areas of mathematical content, and the place of conducting the study. The study recommends analyzing experimental studies that are relevant to addressing the difficulties of learning mathematics in different educational stages so that they include all aspects of learning (cognitive, emotional, and skill).

CONCLUSIONS

In this study, 47 previous studies published in Arab periodicals on the strategies and programs that deal with the difficulties of learning mathematics were compiled, which contained 52 ESs. These strategies and programs were built on several educational philosophies that fall into four categories: e-learning, active and cooperative, mental maps, and brain-based learning and thinking, and these categories can be applied to primary and intermediate school students in several Arab countries for addressing mathematics learning difficulties.

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Ethical statement: Authors stated that the study did not require approval from an ethics committee since the study did not contain any live subjects. Authors further stated that ethical considerations on strategies and programs targeting mathematics learning difficulties encompass the assurance of participant confidentiality, voluntary participation, informed consent, and adherence to established research ethics guidelines.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX A

Table A1. Value of z to find out the significance of the ES of the post-analysis sample studies

ID	Study	Year	Independent variable	ES	SE	z	Sig. (2-tailed)	95% CI		Value
								Lower	Upper	
1	Al-Dukhi	2012	Blended e-learning	1.52	0.30	5.14	0.00	0.94	2.10	Huge
2	Al-Za'bi	2012	Active learning	2.22	0.46	4.81	0.00	1.32	3.12	Huge
3	Al-Omari	2012	A training program in mathematics skills	2.21	0.59	3.73	0.00	1.05	3.38	Huge
4	Rihaan et al.	2012	Visual representation strategy	1.83	0.44	4.11	0.00	0.96	2.70	Huge
5	Sawalha	2012	(Lattice) method	3.38	0.51	6.65	0.00	2.39	4.38	Huge
6	Al-Za'bi	2013	Cooperative learning	1.71	0.44	3.93	0.00	0.86	2.56	Huge
7	Al-Mashhari & Al-Samadi	2013	Emotional intelligence theory	1.36	0.29	4.70	0.00	0.79	1.92	Huge
8	Abdulrazak	2013	Math lab	1.11	0.26	4.27	0.00	0.60	1.62	Very big
9	Ahmed	2014	Mind maps	4.59	0.61	7.53	0.00	3.40	5.79	Huge
10	Ahmed	2014	Mind maps	5.10	0.65	7.81	0.00	3.82	6.37	Huge
11	Al-Harthi	2014	Self-regulated learning	1.54	0.30	5.14	0.00	0.95	2.12	Huge
12	Al-Saidi	2014	Electronic educational games	4.05	0.76	5.34	0.00	2.56	5.53	Huge
13	Al-Saidi	2014	Electronic educational games	2.46	0.56	4.37	0.00	1.36	3.57	Huge
14	Al-Saidi	2014	Educational scaffolding	2.58	0.43	6.03	0.00	1.74	3.42	Huge
15	Al-Najar	2015	Model (PASS)	2.74	0.38	7.23	0.00	2.00	3.48	Huge
16	Al-Najar	2015	Model (PASS)	2.87	0.39	7.40	0.00	2.11	3.63	Huge
17	Desouki & Desouki	2015	Learning style preferences	3.47	0.41	8.39	0.00	2.66	4.28	Huge
18	Zaghloul	2015	Computer simulation	5.45	0.53	10.19	0.00	4.40	6.50	Huge
19	Ahmed	2016	Cooperative learning	1.14	0.38	2.96	0.00	0.38	1.89	Very big
20	Al-Shami	2016	Information processing	4.46	0.48	9.34	0.00	3.52	5.40	Huge
21	Al-Atoum et al.	2016	Cooperative learning	1.11	0.34	3.25	0.00	0.44	1.78	Very big
22	Abd-Rabbo	2016	Dramatization of curricula	2.87	0.33	8.77	0.00	2.23	3.51	Huge
23	Hefnawi	2017	Electronic activities on principle of gamification	2.30	0.48	4.74	0.00	1.35	3.25	Huge
24	Al-Dukhi	2017	Flipped learning strategy	1.09	0.27	4.01	0.00	0.56	1.62	Very big
25	Al-Rimoni et al.	2017	Mental arithmetic strategies	1.16	0.31	3.70	0.00	0.55	1.78	Very big
26	Al-Ghola	2017	Computerized treatment program	6.97	1.50	4.63	0.00	4.02	9.92	Huge
27	Al-Qahtani	2017	TRIZ theory	13.29	1.88	7.08	0.00	9.61	16.97	Huge
28	Al-Kandari et al.	2017	Formative assessment methods	3.64	0.89	4.07	0.00	1.89	5.40	Huge
29	Abu Al-Hadid	2017	Format system	2.74	0.33	8.35	0.00	2.10	3.38	Huge
30	Jad	2017	Mind maps	4.67	0.48	9.76	0.00	3.74	5.61	Huge
31	Al-Shahat & Al-Balah	2018	Cognitive strategy training	2.32	0.35	6.61	0.00	1.63	3.01	Huge
32	Al-Saidi	2018	Semantic web tools	2.58	0.43	6.03	0.00	1.74	3.42	Huge
33	Sahrawi & Najat	2018	Practice and discovery	0.46	0.25	1.80	0.07	-0.04	0.95	Middle
34	Fars	2018	Mind maps	1.02	0.19	5.46	0.00	0.65	1.38	Very big
35	Farghal	2018	Differentiated learning	2.68	0.31	8.60	0.00	2.07	3.29	Huge
36	Metwally	2018	Brain-based learning	2.33	0.32	7.32	0.00	1.70	2.95	Huge
37	Metwally	2018	Brain-based learning	2.87	0.35	8.17	0.00	2.18	3.55	Huge
38	Al Shahrani	2019	Multimedia	3.04	1.08	2.82	0.01	0.93	5.15	Huge
39	Al-Shahrani & Al-Zoubi	2019	Peer teaching	1.83	0.50	3.65	0.00	0.85	2.81	Huge
40	Abu Shabab	2019	Differentiated education	2.90	0.35	8.35	0.00	2.22	3.58	Huge
41	Khalil et al.	2019	Cognitive load theory	7.46	0.75	9.94	0.00	5.99	8.93	Huge
42	Syed et al.	2019	Software on multiple intelligences	2.51	0.90	2.78	0.01	0.74	4.27	Huge
43	Ashour	2019	Multiple intelligences	0.84	0.32	2.64	0.01	0.22	1.47	Very big
44	Al-Qahtani & Al-Zubairi	2020	TRIZ theory	13.81	1.95	7.09	0.00	10.00	17.63	Huge
45	Al-Mustafa & Ijbarah	2020	Educational technology	8.34	0.83	10.06	0.00	6.72	9.96	Huge
46	Al-Hutaila	2020	Brain sport	8.96	2.65	3.38	0.00	3.77	14.16	Huge
47	Mohammed	2020	Semantic web tools	1.64	0.32	5.06	0.00	1.00	2.27	Huge
48	Al-Farhood	2021	Electronic program	1.31	0.41	3.22	0.00	0.51	2.11	Huge
49	Al-Farhood	2021	Electronic program	1.00	0.39	2.57	0.01	0.24	1.77	Very big
50	Rababa'a	2021	Learning by playing	2.37	0.47	4.99	0.00	1.44	3.30	Huge
51	Abdullah	2021	Self-learning strategies	12.51	2.25	5.56	0.00	8.09	16.92	Huge
52	Al-Shammari	2022	Marzano's dimensions of learning model	0.78	0.39	1.97	0.05	0.01	1.55	Big

Note. SE: Standard error; CI: Confidence interval