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The effect of student-centred methods and techniques on primary school students' mathematics achievement: A meta-analysis study

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A B S T R A C T

The purpose of this study was to synthesize experimental studies that explain the effect of student-centered methods and techniques used in primary school mathematics courses on academic achievement. Some certain criteria were selected and applied regarding the inclusion of primary study in the synthesis. As a result of qualitative systematic review, data of the study were obtained from 63 studies that meet the inclusion criteria. The reliability of the coding protocol in the study was procured in two stages by assessing the "inter-coder reliability". The reliability (AR) was assessed as 0.88 and was considered sufficient (AR > .80). The validation of the study was provided by publication bias and quality assessment in primary studies, language bias, time delay bias, and database bias. There was no evidence of bias. Meta-analysis results showed that student-centered strategy, methods or techniques were more effective than traditional teaching methods. The effect size was evaluated using 66 effect sizes from 63 studies and was found to be 0.787 under the random-effect model. The overall impact value attained indicates a wide and medium level of impact according to various classifications. In the moderator variables analysis, except for the moderator of the application approach, there was no significant difference found for the moderators of application time, type of publication, database, and grade level, the scale used, and school starting age, country, and sample size.

INTRODUCTION

Mathematics has a substantial role in human life. People with poor math skills have difficulty solving problems in their everyday life. Students with poor math skills are incapable of coping rationally with the problems they encounter in the future. It is also noteworthy in the literature that adults with poor mathematics skills are more likely to be unemployed (Bottge, Rueda, La Roque, Serlin, & Kwon, 2007; Hekimoglu & Kittrell, 2010; Vukovic & Siegel, 2010; A. H. Wang, 2010). It is obvious from this perspective how important it is to learn mathematics.

The global movements that began and continued at the end of the 20th century, in which societies became mutually dependent on each other in economic, political, and cultural terms, as well as rapidly developing information and communication technologies and postmodernism movements, have resulted in the development of various educational approaches The essence of these approaches, which contributed to the development of different perspectives in education, has been shaped based on multi-channel flexible education and lifelong learning. In these approaches that emphasize learning rather than teaching, the focus is on the learner (Neo & Neo, 2000; Oktay, 2003; Özden, 2002). It has been observed in the studies conducted in this process that approaches towards permanent knowledge rather than direct education (traditional education) are at the forefront for all ages in providing students with the necessary knowledge and skills (Armstrong, 2009; McCombs & Whisler, 1997; McTighe & Wiggins, 1999). The concept of Student-Centred Education has come into prominence as a result of these advancements.

Student-centred education is based on teachers getting to know their students better and then using that knowledge to fulfil their needs, knowing that learning is a constructive process, making what is taught meaningful for students, allowing students to actively participate in learning, and establishing a positive learning environment (McCombs & Whisler, 1997). Teachers who adopt student-centred education practice the applications in the classroom by placing the student at the centre. Mathematics is one of the courses in which Student-Centred Education is applied. In mathematics courses, teachers can increase mathematics achievement by using student-centred methods and techniques following the conception of student-centred education.

The methods and techniques selected in the processing of mathematics course are important elements in the application of the achievements included in the curriculum. In primary school mathematics courses, the use of student-centred methods and techniques instead of teacher-centred teaching methods due to the developments in the field of education motivates students more to the course. In classroom environments where these methods and techniques are used, students' level of motivation is higher, and students directly participate in the learning process. However, despite the effort to keep up with all these developments, when evaluations were made based on countries, it was seen that the expected success in mathematics has not been achieved in both national and international exams. The results have prompted researchers to investigate the reasons for this failure and ways to increase mathematics achievement. Several experimental studies on mathematics education have been conducted to determine the effectiveness of the methods applied. When these studies were examined one by one, it was seen that each of them had a positive effect on academic achievement in mathematics courses. It would be beneficial to determine the effect level of the methods and techniques used in experimental studies on this subject and to see the effect of the applications. However, through synthesizing these and reaching more generalizable information, it could be possible to obtain more precise information about mathematics achievement, evaluation, creation and quality of the curriculum. The effect of student-centred methods and techniques used in primary school mathematics courses was tried to be revealed by combining the research results in this study. Student-centred methods and techniques were handled in a holistic framework within specific limitations, and the effect of these methods and techniques on primary school students' mathematics achievement was extensively and comparatively investigated.

In addition to being a holistic evaluation of alternative methods, the study will enable the emergence of effective methods in increasing primary school mathematics achievement. The accumulation and growth of scientific knowledge also create some problems such as keeping, organizing and synthesizing findings and putting the knowledge into practice. In most research areas, research is carried out at an increasing pace, making it difficult for stakeholders (teachers, researchers, programmers, etc.) to be aware of all research in their field. This study is considered significant in providing a holistic perspective, its scope (database, time interval), focusing on contemporary learning approaches (student-centred approaches) and contributing significantly to shareholders in increasing primary school mathematics achievement. This study will enable a commentary over a certain period in terms of the results of studies conducted between 2008 and 2018 and provide a possibility to compare similar studies that will be conducted for subsequent periods. In addition, the fact that there are theses and articles in Turkey and abroad within the scope of this study is important in terms of both the breadth of the scope and the opportunity to compare according to the countries. The databases included in the study are the databases shown as the most prestigious nationally and internationally. This inclusion criterion privileges the study.

It is believed that the findings of the study are expected to be instructive in three areas.

1. The place, importance and effective use principles of student-centred methods and techniques in mathematics programs are thought to contribute to the field in improving the work of developing these programs.
2. It is thought that it will help to teachers in the process of effectively conducting student-centred methods and techniques (with the help of effect dimensions and moderator analysis results).
3. The results of the study are thought to be important in terms of the fact that the researchers look at the experimental studies that examine the effect of student-centred methods and techniques used in primary school mathematics courses on academic achievement in mathematics courses from a holistic perspective and can guide the studies to be carried out afterwards.

The general purpose of the study is to obtain more generalizable information by synthesizing experimental studies that focus on the effect of student-centred methods and techniques used in primary school mathematics courses on academic achievement in mathematics courses. In line with this general purpose, the sub-objectives of the research are as follows;

1. What is the general effect of student-centred strategy, methods and techniques on primary school students' mathematics achievement according to teacher-centred approaches?
2. Does the effect of student-centred strategy, methods and techniques on primary school students' mathematics achievement differentiate according to years, grade level, published database, country, type of publication, period of experimental application,

measurement tool, method and technique used, age of starting school and sample size?

METHODS AND MATERIALS

The research method of this study is composed of meta-analysis. Meta-analyses appear as a statistical method entailing the scope of inclusion criteria and focusing on the quantitative results of the study conducted relevant to a particular subject, using to integrate the information obtained from the findings of these studies and creating a general summary, synthesizing in the form of effect dimensions (Card, 2012; Cooper, 2017; Karaçam, 2013; Lewis, 2000; Littell et al., 2008).

Selecting and Coding the Data (Studies)

Articles and theses on the effect of student-centred methods and techniques used in primary school mathematics courses in the world and Turkey on academic achievement in the mathematics course were the main data source of this study. The included studies were searched in different time periods in TR Index, ERIC, Social Sciences Citation Index, ProQuest, and National Thesis Centre databases and proceeded in a controlled manner. The addition and subtraction criteria of the studies included in the study are as follows:

1. The studies should be conducted between the years of 2008-2018,
2. The studies should be conducted in the field of education and the sample group was composed of primary school students,
3. The studies should be included in the research, conducted at home and abroad such as master's theses, PhD theses and articles,
4. Having been published in scientific, refereed journals (for articles), approved by the jury (for theses),
5. Studies should be experimental studies with statistical findings, but should not be longitudinal.

A qualitative systematic review method was adopted within the framework of the above criteria. The titles and abstracts were searched using the keywords "primary school", "success", "experimental", and "mathematics" of the studies, and also filtered through the criteria mentioned above. It was observed that there were studies that passed through the filter after the search, but no full text of which could be found. The authors or consultants responsible for these studies have been contacted by email, and the studies have been reached.

The proper studies to be included in the research have taken their ultimate form at the end of all of these steps. As a result of the search, 63 of 117 studies whose full text could be accessed were included in systematic review and meta-analysis. How these studies were reduced to 63 studies is shown in a broader range of PRISMA (Liberati et al., 2009) flow graph. PRISMA was the compilation protocol adopted for this study. PRISMA Flow Graph is given in Figure 1.

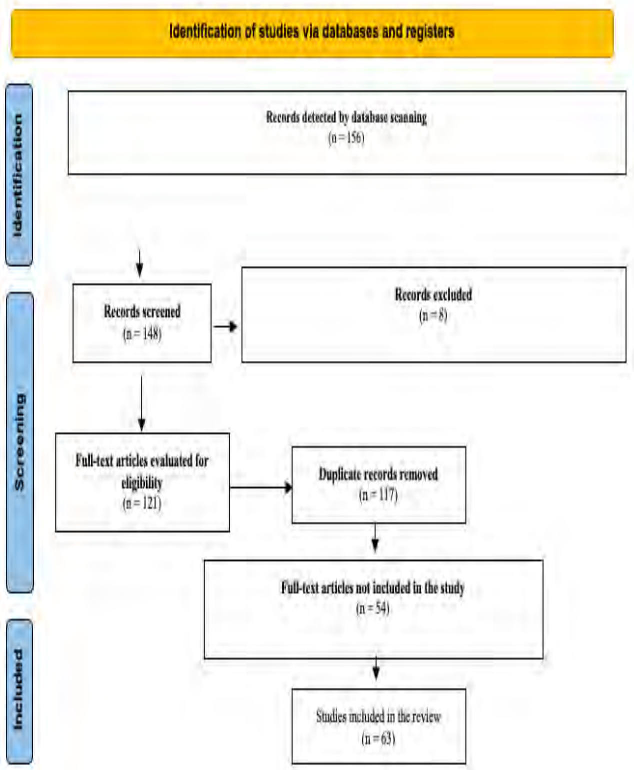


Figure 1. PRISMA flow chart according to the total of studies

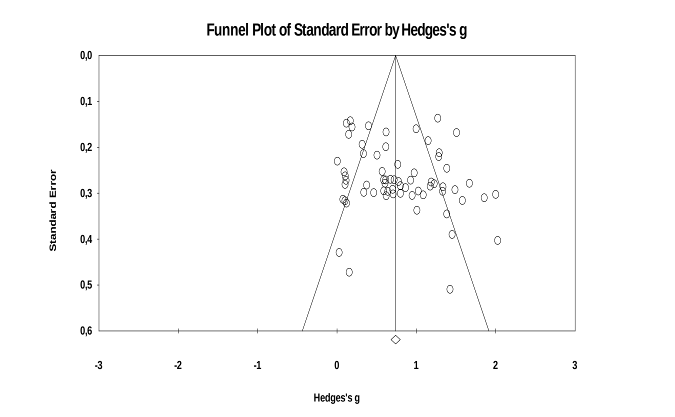
For individual studies, the title, author, year of publication, type of publication, sample size, publication language of the study, and used measuring tool etc. was coded. In order to ensure the reliability of the encoded data, experts presented their opinion, and a comparison of the encodings was carried out.

The reliability of the coding protocol was given in two stages in this study by calculating the "inter-coder reliability." these qualifications stated they could do was implemented following the planning.

The "agreement rate" (AR) was used as the reliability measure in the study. AR is widely used in research synthesis. Metrics for AR range from 0 to 1. A ratio of 0.80 and above is considered sufficient by many psychometricians. The formula AR= number of opinions agreed on / the total number of opinions was used for the agreement rate (Orwin & Vevea, 2009).

Validity

Validity in systematic synthesis methods is generally provided by publication bias and quality in primary studies (Borenstein et al., 2009; Kettry & Lipsey, 2018; Rothstein, Sutton, & Borenstein, 2005). However, other biases in the literature include language bias, time delay bias, and database bias (Carol et al., 2017). This study was conducted by considering all these validity factors. In addition, the researcher received meta-analysis training before the study. At the stage of ensuring the validity of the study, the first focus was on the validity of the data collection tools used in the primary studies. The validity of all studies was examined based on the view that each validity in the primary studies would be an indicator of the validity of the meta-analysis (Petitti, 2000). In all 63 primary studies included in this meta-analysis, it was observed that data collection tools were valid. Second, the JBI-Qualitative Assessment and Review Instrument (JBI-QARI) (Institute, 2003) (see Annex 4) data measurement tools were applied to make a critical evaluation of the quality of research. The researcher translated this 11-item tool, which was a Critical Evaluation Checklist for Systematic Assessment and Research Synthesis (see Annex 5), and a language expert reviewed it. This tool was a comprehensive checklist that could extract information from each research report on methodologies, interests, environment, geographic and cultural context, participants, and data analysis, and systematically and critically examine qualitative research reports by two observers. It was effective in deciding whether the primary study would be included in the synthesis or not (Johnstone & Turale, 2014). During this process, two observers (one of whom was the researcher, the other was a faculty member from the department of English Language Teaching) met to discuss the findings after completing the process of including the primary studies in the research and conducted the control. Another validity factor is publication bias. In this study, publication bias was tested using two methods such as Funnel Plot and



Orwin's Fail-Safe N formula. Graph 1 shows the publication bias data according to the tests of the studies included in the study with the Funnel Plot method.

Graph 1. Funnel Plot of Studies Containing the Effect Size Data of Student-Centred Strategies, Methods and Techniques on Primary School Students' Mathematics Achievement

Among the primary studies included in this meta-analysis, it was observed that there were those that extend beyond the pyramid. These studies, on the other hand, were concentrated in the funnel's middle and upper parts. If there were publication bias in the 63 primary studies included, then most of the studies would be expected to be concentrated in the lower part of the funnel shape and/or only part of the vertical line of overall effect size (Borenstein et al., 2009). The funnel plot obtained in this meta-analysis was one of the indicators that there was no publication bias. Another publication bias calculation tested in the study was Orwin's Fail-Safe N formula. Table 1 shows the publication bias data based on testing the studies included in the study with Orwin's Fail-Safe N formula.

Table 1. Orwin's Fail-Safe N for Publication Bias

Output	Value
Hedge's g for the observed studies	0.73800
Criterion for "Nonsignificant" Hedge's g	0.01500
Avarage Hedge's g for lost studies	0.00000
FSN	3182

The logic of Orwin's Fail-Safe N calculation is based on the calculation of the number of studies that are likely to be missing in the meta-analysis (Rothstein et al., 2005). Orwin's Fail-Safe N value calculated in this study was 3182. In other words, the number of studies required for the average effect size of 0.738 reached as a result of the analysis to reach 0.015 level (trivial), that is, almost zero effect level, was 3182.Apart from these, it is not possible to reach 3182 more studies. This indicator is another proof that there is no publication bias in this meta-analysis.

Moderator Analysis

The coding in this study made it possible to analyse the influence of potential moderators. In order to explain the heterogeneity of the combined effect size of student-centred methods and techniques used in primary school mathematics courses, 8 categorical and 1 continuous data moderators were analysed. Analog ANOVA was applied for the first 8 of the moderators (categorical moderators) below, and meta-regression tests were applied for the 9th moderator (continuous data moderator).

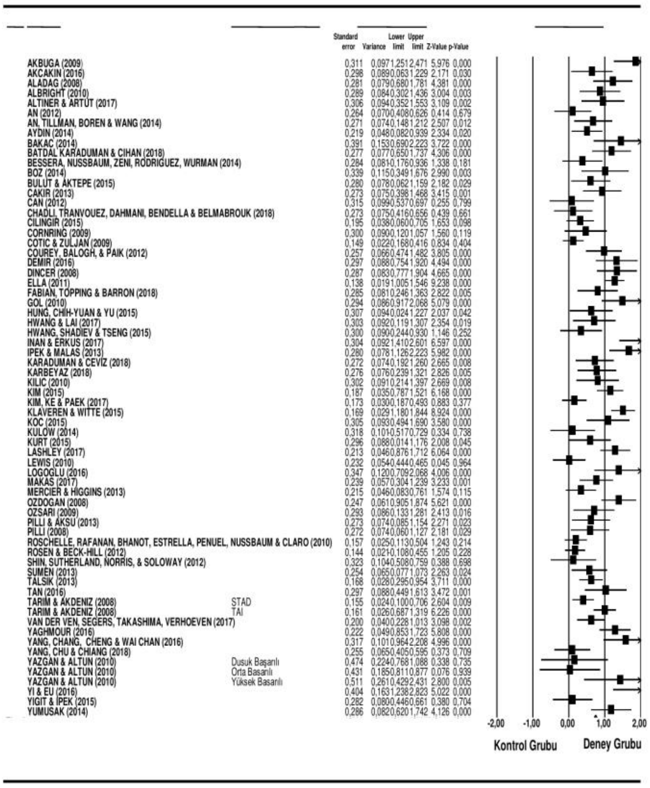
1. Application period (in weeks)
2. Publication type (PhD thesis, master's thesis, article)
3. Database (ERIC, ProQuest, SSCI, TR Index, National Thesis Centre)
4. Grade level (1st Grade, 2nd Grade, 3rd Grade, 4th Grade)
5. Scale (developed by the researcher, ready-made scale, international exam questions)
6. School starting age (in months)
7. Country
8. Application approach (Method, technique)
9. Sample size

RESULTS AND DISCUSSIONS

Results

Effect sizes related to student-centred methods and techniques used in primary school mathematics courses were ranked from a small effect size value to a large effect size value. The standardized effect sizes of 66 studies vary between 0.010 and 2.031 values, while the confidence interval varies between -0.444 and 1.238 (See appendix 1).

After analysed, it is seen that there is a greater than zero difference in favour of the experimental group. The effect size that can be found visually will be less than 2.00 but above zero, except for two studies (İnan & Erkuş, 2017; Yi & Eu, 2016). The effect size of these two studies is greater than 2.00.



Graph 2. The forest plot of the studies shows the 66 studies included in the study collectively.

When Graph 2 is analysed, it is seen that there is a greater than zero difference in favour of the experimental group. The effect size that can be found visually will be less than 2.00 but above zero, except for two studies (İnan & Erkuş, 2017; Yi & Eu, 2016). It is understood that the effect size of these two studies is greater than 2.00.

The average effect size of perceptions of student-centred strategies, methods and techniques used in primary school mathematics courses combined according to the fixed-effects model, the lower and upper limits according to the standard error and 95% confidence interval are given in Table 2.

Table 2. Effect Size Meta-Analysis According to Fixed-Effects Model

Model	Effect Si	Standard Er	Variance	Lower Li	Upper Li	Z Value	p
Fixed E	0.738	0.030	0.001	0.679	0.797	24.641	0.00

The average effect size value of the effect size values of the studies included in the study according to the fixed-effect model was ES = 0.738, the standard error of the average effect size was SE = 0.030, the upper limit of the confidence interval of the mean effect size was 0.797, and the lower limit was calculated as 0.679.

Data from 66 studies included in the meta-analysis according to calculations found that academic achievement was more positive in favour of the experimental group than the achievement of the control group according to the fixed-effects model. Since the effect size value remains between 0.50 and 0.80, it has been determined that it has a moderate effect according to Cohen's classification, Cohen (1988). In the classification of Lipsey (2001), there is a moderate effect size since it remains in the range of 0.45-0.90. According to the classification of Thalheimer and Cook (2002), it has a moderate effect (0.40 - 0.75).

Homogeneity Test, Q and I2 Statistics

Statistical significance was calculated utilizing the Z test, and it was determined as Z = 24,641. It was determined that the result obtained did not indicate a statistically significant difference with p = 0.000. Six of 66 studies included in the study (An, Tillman, Boren, & Wang, 2014; Ozsari, 2009; Hwang & Lai, 2017; Karaduman & Ceviz, 2018; Makas, 2017; Karbeyaz, 2018) were within the lower and upper limits of the average effect size value. These studies were close to the average effect size. The remaining 60 studies received values below or above these limits. The homogeneity test results of the effect size distribution are given in Table 3.

Table 3. Homogeneity Test Results of Effect Size Distribution

Q value	df (Q)	p	I^2 value
283.659	65	0.000	77.085

The "Q" value for the homogeneity test (Q-statistics) conducted within the scope of the study was calculated as 283.659. For the obtained 65 degrees of freedom, the value determined for the 95% significance level from the Chi-square (Chi-Square-$\chi 2$) values table was 84.821. Since the Q-statistic value (Q = 283.659) was higher than the critical value ($\chi 2$ 0, 95 = 84.821) of the chi-square distribution with 65 degrees of freedom, there was no homogeneity of the effect size distribution according to the fixed-effects model. In other words, the effect size distribution has a heterogeneous feature according to the fixed-effects model.

In the homogeneity test, the calculation of the I^2 value besides the Q statistics provides more precise information in the evaluation in terms of heterogeneity (Petticrew & Roberts, 2006). The total variance ratio for the effect size emerges with the calculation of the I^2 value. One of the advantages of the I^2 statistic from the Q statistic is that the number of studies included has no effect on the calculation. In the interpretation of I^2, the rate of 25% and below indicates a low level of heterogeneity, up to 50% (including 50%) moderate heterogeneity, and 75% (including 75%) high heterogeneity (Cooper et al., 2009). Since the I^2 value showed a high level of heterogeneity with 77%, the model was converted to a random-effects model according to the average effect size of 0.738 obtained in the study.

The combined average effect size of the effect sizes of perceptions regarding student-centred methods and techniques used in primary school mathematics courses conforming to the random-effects model (without removing outliers), the lower and upper limits according to the standard error and 95% confidence interval are given in Table 4.

Table 4. Effect Size Findings According to Random-Effects Model

Model	Effect S	Standa	Varian	Lower	Upper	Z Valu	p
Rando	0.787	0.065	0.004	0.660	0.913	12.19	0.000

Referring to Table 4, the data of 66 studies included in the meta-analysis were 0.065 for the standard error, 0.913 for the upper limit of the 95% confidence interval, 0.660 for the lower limit, and ES = 0.787 for the effect size value according to the random-effects model. It was determined that student-centred strategies, methods and techniques used in primary school mathematics courses were more positive than the control group in favour of the experimental group regarding the effect on academic achievement. Since the effect size value was greater than 0.50 and less than 0.80, it was determined that it had a moderate effect according to Cohen's classification (Cohen, 1988). There was a medium effect size in Lipsey's classification, as it remained in the range of 0.45-0.90. It has a high level (0.75 - 1.10) effect, according to Thalheimer and Cook (2002) classification.

Table 5. Moderator Analysis Results of the Application Period

Moderator	k	Effect Size (d)	Standard Error	Variance	Lower Limit (%95 CI)	Upper Limit (%95 CI)	Z Value	Q (Heterogenity)	f	p
1-3 week	12	0,64	0,13	0,39	0,90	4,980	0,00	34,942	11	0,00
4-6 week	27	0,92	0,08	0,74	1,09	10,31	0,00	83,677	26	0,00
7 w or mo	20	0,69	0,12	0,45	0,92	5,682	0,00	88,383	19	0,00
Uncen	7	0,75	0,24	0,28	1,22	3,141	0,00	43,425	16	0,00
							Tota with	283,65	65	0,00
							Tota betw	4,058	3	0,25

According to the results obtained from the moderator analysis for the experimental application period, the variance between studies was not statistically significant (QB = 4.058, p> 0.05). Accordingly, in studies on the effect of student-centred strategies, methods and techniques used in primary school mathematics courses on academic achievement, it was determined that the period of the experimental application being "1-3 weeks", "4-6 weeks", or "7 weeks and above" did not change the effect size. Studies in which there were no findings regarding the experimental application period did not change the variance between studies.

Table 6. Moderator Analysis Results of the Publication Type

Moderator	k	Effect Size (d)	Standard Error	Variance	Lower Limit (%95 CI)	Upper Limit (%95 CI)	Z Value	Q (Heterogenity)	f	p
Articl	37	0,71	0,03	0,63	0,78	18,80	0,00	201,80	36	0,00
Thesi	29	0,78	0,04	0,68	0,87	15,96	0,00	80,660	28	0,00
							Tota with	283,65	65	0,00
							Tota betw	0,084	1	0,77

According to the results obtained from the moderator analysis for the type of publication, the variance between studies was not statistically significant (QB = 0.084, p> 0.05). Accordingly, in studies on the effect of student-centred strategies, methods and techniques used in primary school mathematics courses on academic achievement, it was determined that the publication type being "article" or "thesis" did not change the effect size.

Table 7. Moderator Analysis Results of the Database

Moderator	k	Effect Size (d)	Standard Error	Variance	Lower Limit (%95 CI)	Upper Limit (%95 CI)	Z Value	Q (Heterogenity)	f	p
Natio	33	0,85	0,04	0,75	0,94	17,44	0,00	79,847	32	0,00
Inter onal	33	0,66	0,03	0,59	0,74	17,65	0,00	195,08	32	0,00
							Tota with	283,65	65	0,00
							Tota	2,248	1	0,13

							betw			

According to the results obtained from the moderator analysis for the database, the variance between studies was not statistically significant (QB = 2.248, p> 0.05). Accordingly, it was observed that there was no difference in effect size in "national" or "international" databases of studies on the effect of student-centred strategies, methods and techniques used in primary school mathematics courses on academic achievement.

Table 8. Moderator Analysis Results of the Grade Level

					%95 CI			Heterogenity		
Moderator	k	Effect Size (d)	Standard Error	Variance	Lower Limit	Upper Limit	Z Value	Q	f	p
1st gr	5	0,74	0,12	0,50	0,99	6,076	0,00	9,044	4	0,06
2nd grade	12	0,96	0,07	0,81	1,10	12,98	0,00	49,802	11	0,00
3rd grade	13	0,72	0,07	0,58	0,86	10,11	0,00	30,816	12	0,00
4th g	36	0,68	0,03	0,60	0,75	17,62	0,00	182,66	35	0,00
							Tota with	272,32	63	0,00
							Tota betw	0,634	3	0,88

According to the results obtained from the grade-level moderator analysis, the variance between studies was not statistically significant (QB = 0.634, p> 0.05). Accordingly, in studies conducted on the effect of student-centred strategies, methods and techniques used in primary school mathematics courses on academic achievement, it was determined that grade levels being "1st grade", "2nd grade", "3rd grade", or "4th grade" did not change the effect size.

Table 9. Moderator Analysis Results of the Scale

					%95 CI			Heterogenity		
Moderator	k	Effect Size (d)	Standard Error	Variance	Lower Limit	Upper Limit	Z Value	Q	f	p
Developed by research er	49	0,78	0,03	0,70	0,85	21,33	0,00	196,15	48	0,00
Pre-develo d	17	0,65	0,05	0,55	0,75	12,49	0,00	83,442	16	0,00
							Tota with	283,65	65	0,00
							Tota betw	2,861	1	0,09

According to the results obtained from the moderator analysis for the measurement tool, the variance between studies was not statistically significant (QB = 2.861, p> 0.05). Accordingly, in studies conducted on the effect of student-centred strategies, methods and techniques used in primary school mathematics courses on academic achievement, it was determined that the measurement tool being "developed by the researcher" or "previously developed" did not change the effect size.

Table 10. Moderator Analysis Results of the School Starting Age

					%95 CI			Heterogenity		
Moderator	k	Effect Size (d)	Standard Error	Variance	Lower Limit	Upper Limit	Z Value	Q	f	p
60 mont	4	0,91	0,10	0,70	1,11	8,820	0,00	21,880	3	0,00
69 mont	37	0,86	0,04	0,77	0,94	19,66	0,00	105,02	36	0,00
72 mont and above	25	0,57	0,04	0,49	0,66	12,88	0,00	133,37	24	0,00
							Tota with	260,27	63	0,00
							Tota betw	5,122	2	0,07

According to the results obtained from the moderator analysis for school starting age, the variance between studies was not statistically significant (QB = 5.122, p> 0.05). Accordingly, in studies conducted on the effect of student-centred strategies, methods and techniques used in primary school mathematics courses on academic achievement, it was determined that the age of starting school for children included in the studies being "60 months", "69 months", or "72 months" did not change the effect size.

Table 11. Moderator Analysis Results of the Country

					%95 CI			Heterogenity		
Moderator	k	Effect Size (d)	Standard Error	Variance	Lower Limit	Upper Limit	Z Value	Q	f	p
USA	11	0,52	0,05	0,40	0,64	8,856	0,00	69,931	10	0,00
Other	13	0,75	0,06	0,63	0,87	11,91	0,00	72,654	12	0,00
Taiwa	5	0,61	0,13	0,35	0,86	4,655	0,00	14,436	4	0,00
Turke	37	0,86	0,04	0,77	0,94	19,66	0,00	105,02	36	0,00

Tota with	262,04	62	0,00
Tota betw	6,562	3	0,08

According to the results obtained from the moderator analysis for the country, the variance between studies was not statistically significant (QB = 4.058, p> 0.05). Accordingly, in the studies conducted on the effect of student-centred strategies, methods and techniques used in primary school mathematics courses on academic achievement, it was determined that the countries where the studies were conducted being "USA", "Others", "Taiwan", or "Turkey" did not change the effect size.

Table 12. Moderator Analysis Results of the Application Approach

					%95 CI			Heterogenity		
Moderator	k	Effect Size (d)	Standard Error	Variance	Lower Limit	Upper Limit	Z Value	Q	f	p
CAI	2(	0,54	0,05	0,44	0,65	10,06	0,00	75,31:	1§	0,0(
CAI/(	3	0,50	0,12	0,27	0,74	4,18:	0,00	16,95!	2	0,0(
ABMI	4	1,33	0,14	1,05	1,61	9,29!	0,00	9,450	3	0,02
Other	7	1,08	0,10	0,88	1,28	10,5:	0,00	12,70:	6	0,04
EG	5	1,28	0,11	1,05	1,50	11,3(	0,00	5,133	4	0,27
RME	9	0,52	0,09	0,33	0,71	5,40!	0,00	12,34	8	0,1:
CL	7	0,88	0,07	0,74	1,03	12,1	0,00	36,86(	6	0,0(
TM	7	0,75	0,09	0,57	0,93	8,05!	0,00	12,60	6	0,0!
PBL	4	0,35	0,11	0,13	0,57	3,187	0,00	13,88	3	0,0(
							Tota with	195,2!	57	0,0(
							Tota betw n	28,19(	8	0,0(

ABMI: Activities Based on Multiple Intelligences, EG: Educational Games, Others: Other approaches, CL: Cooperative Learning, TM: Teaching with Music, CAI: Computer-Assisted Instruction, RME: Realistic Mathematics Education, CAI/CL: Computer-Assisted Instruction and Cooperative Learning, PBL: Problem Based Learning.

According to the results obtained from the moderator analysis for the application approach, the variance between studies was statistically significant (QB = 28.190, p> 0.05). Accordingly, in the studies conducted on the effect of student-centred strategies, methods and techniques used in primary school mathematics courses on academic achievement, it was determined that the application approach being respectively, "Activities Based on Multiple Intelligences", "Educational Games", "Other approaches", "Cooperative Learning", "Teaching with Music", "Computer-Assisted Instruction ", "Realistic Mathematics Education", "Computer-Assisted Instruction and Cooperative Learning", and "Problem Based Learning" increased the effect size.

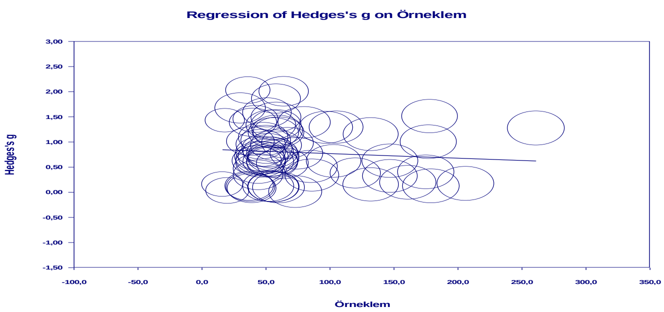
The distribution of the studies included in the research was made between 30 and 261 participants, including the number of samples, the continuous data moderator, and the total of the experimental and control groups.

Table 13. Analysis Results of the Sample Number Moderator

	Random Effect Model						
distribution							
	Effect (d)	Standard Error		Vari:	Lo Lir	Uן Li	Z V
Interc	0,8605	0,1195			0,62	1,0	7,:
Sample		-0,0009	0,0012	-0,00	0,001	-0,7:	0,4635

According to Table 13, the regression coefficient (d = -0.0009) value for the sample will correspond to a decrease (-) of 0.0009 in the effect size of each participant included in the sample. In this case, the effect size does not represent a logarithmic risk ratio. As it is understood from here, each participant increase in the sample number will not change the effect size (p <0.05).

The regression graph for the random-effects model of the sample number moderator in studies on the effect of student-centred strategies, methods and techniques applied in primary school mathematics courses on academic achievement is given in Graph 3.



Graph 3. Regression Graph for Random-Effects Model of the Sample Number Moderator

As can be seen from Graph 3, as a result of the meta-regression made according to the sample number variable; it is understood that each participant increase in the sample size does not change the effect size of student-centred methods and techniques used in primary school mathematics courses in studies aimed at increasing academic achievement.

CONCLUSION AND DISCUSSION

When the overall effect size achieved in this study was examined, it was found that student-centred methods and techniques had moderate and high-level effects on mathematics academic achievement according to different scales compared to teacher-centred methods and techniques, Cohen (1988). The result obtained is considered as a medium level effect according to the classification of Lipsey (Cooper et al., 2009) and a high-level effect according to the classification of Thalheimer and Cook (2002). This result of student-centred applications coincides with the results obtained in the studies conducted by Çelik (2013) and Topan (2013), which showed that it was effective on academic achievement in mathematics courses compared to teacher-centred practices. In the meta-analysis study conducted by Uyar and Doğanay (2018), it was concluded that some teacher-centred approaches were more effective on mathematics achievement than student-centred approaches (creative drama and collaborative learning). Uyar and Doğanay (2018) associated the reasons for this situation with students' not having encountered the method used before, having difficulty in associating mathematics with daily life, and inadequate social skill levels. The results of this study and the different results reached by Uyar and Doğanay (2018) can be explained by the sample level, measurement tool or confounding variables.

In the study, 9 moderator variables were examined whether they changed the effect size after the studies to determine the general effect were completed. As a result of the moderator analysis, the significant difference between the effect sizes was found only for the moderator analysis "Application approach (method, technique)". The results of other moderator analyses are also discussed in this section. It is also good to explain some important points in the moderator analysis process of this study.

The variables included in the moderator analysis explain a considerable amount of inter-study variance. In this study, some variables that were not in sufficient number were categorized. Thus, a certain number of variables within the categories were gathered under the same group. If the variables were not categorized, the results would not be meaningful, but the number of studies would be too few for some levels. However, the logic of the statistical comparison is based on making comparisons over equivalent quantities. So the groups being compared should be close to each other. For example, in this study, a moderator analysis was made for the "country" variable. However, considering the countries where primary studies were conducted; they were done as 37 in Turkey, 11 in the USA, 5 in Taiwan, 2 in Netherlands and Georgia, 1 each in Costa Rica, Malaysia, Jordan, Slovenia, Georgia, Guayana, Scotland, Cyprus, England and in Algeria. In the Analog ANOVA applied in the moderator analysis in the study, as in the ANOVA statistics, the opinion that if the number of elements in the groups is low, it will affect the analysis. Based on this, the countries where 1 and 2 studies were conducted were grouped under the name of "Other Countries". The new groups formed were analysed as Turkey with 37 studies, the USA with 11 studies, Taiwan with 5 studies and Other Countries with 13 studies. Thus, it became more suitable for statistical comparison between categories.

Although there was no statistically significant difference between levels in some variables included in the moderator analysis that were not categorized, the interpretation of the effect sizes was at different levels (such as low, medium, high level) after the effect size of the levels was interpreted. For instance, although there was no significant difference according to the grade level regarding the results of the moderator analysis by taking the grade level variable, the effect size level in the 2nd grade was higher than the effect size level in the other classes according to the classification of Cohen (1988). It is also possible to explain this considering that the" p value" does not mean that although it does not make a difference statistically, it does not have an effect in practice. The difference in effect size between levels can be at a level that can make a difference in increasing success.

It is understood from the literature that published studies reveal larger effect sizes than unpublished studies (Rothstein et al., 2005). The findings obtained in this meta-analysis showed a result contrary to this claim by showing that the theses create a larger effect size compared to the articles. This might be due to the fact that possible confounding variables are better controlled in articles compared to theses. The control, in this case, is related to the strict peer-review controls in the databases of the articles examined in this study. If this possibility is correct, the result is that the actual effect sizes are excessive by the reason of the effects of confounding variables, but it is impossible to come to this conclusion because how much confounding variables are controlled is not a clear indication of the primary studies.

The average effect sizes in studies conducted were (0.860) in Turkey, (0.755) in various other countries (Costa Rica, Malaysia, Netherlands, Jordan, Slovenia, Georgia, Guyana, Scotland, TRNC, England, Algeria), (0.611) Taiwan, and (0.525) in the USA. Although there was no significant difference between the groups in terms of effect size, the average effect size of the studies conducted in Turkey was higher than in other countries. This result may also be influenced by other moderator variables, for instance, the influence of the country variable is greater than the grade level variable, so it is not possible to explain this difference only with confounding variables. The difference might be due to the concentration of the studies conducted in different countries at different grade levels.

For the grade level variable, the findings obtained showed that the effect sizes were (0.749) for the 1st grade, (0.961) for the 2nd grade, (0.722) for the 3rd grade and (0.681) for the 4th grade. These can be listed as distribution of countries' programs by grades, school starting age, appropriateness of the approach used to the level, etc. In addition, depending on the age of the students, the level of prior knowledge, skills and attitude about the subject is shown as an important variable that should be taken into account in the use of student-centred strategies, methods and techniques. It is a common view in the literature that the basic knowledge gained by the students participating in the study should be taken into account in the use of student-centred methods (Uyar & Doğanay, 2018).

Although there was no significant difference between the groups in terms of effect size, the effect size level in the 2nd grades was high according to the classification of Cohen (1988), and it was at the medium level in all other grades. Basic mathematics knowledge, reading, and writing education are predominant in the 1st grade. There is a limitation here in terms of the student-centred strategy, method or technique to be used and the studies conducted. In this respect, it is possible that the effect size is lower than the 2nd class. This result might be affected by other confounding variables. These can be listed as the distribution of the countries' program according to the classes, the age of starting school, the suitability of the approach used, etc. The application period is another variable taken for moderator analysis, but the corresponding results are not statistically significant. The results show that the effect of the application has the greatest value when the application period is between 4 and 6 weeks. The effect size values for less than 4 weeks and longer than 6 weeks are smaller than the effect size values reached for 4 to 6 weeks. A smaller effect size value for a shorter period of time is understandable because it may take some time for students to get used to a student-centred approach that is completely different from a teacher-centred practice. One of the reasons for the decrease over longer periods might be the mitigating effect of innovation, which is different than traditional education. The difficulty of controlling all other confounding variables for a long time can also reduce the effectiveness of the application. In a similar study (Topan, 2013), the effect sizes of student-centred methods in mathematics teaching were compared according to the application period. In his meta-analysis, the researcher found the highest effect size on mathematics achievement in studies with an application period of 5-6 weeks, and the lowest effect size in studies with 9 weeks or more. In the intergroup exchange test, it was concluded that the effectiveness of student-centred methods on academic achievement did not change according to the application period.

Another moderator variable for the effectiveness of practices involving student-centred approaches is the type of assessment tools that do not produce statistically significant results. The different results obtained in individual studies with meta-analysis may have resulted from the non-standard structure of measurement tools used in primary studies. In this context, the structure of data collection tools used to measure academic achievement in meta-analyses is seen to be an important factor to be considered in interpreting effect levels (Dinçer, 2014; Johnson et al., 2000). In primary studies where data collection tools developed by researchers were used as an assessment tool, the effect size indicated larger effect sizes than studies using previously developed data collection tools. Multiple reliability coefficients are obtained for previously developed scales. That is, most of the scales are used by various researchers on different samples, and all researchers obtain a reliability coefficient for their research (Gliner, Morgan, & Leech, 2015). Hence, if it is assumed that the pre-existing tests are more reliable than the tests developed by the researcher, the results for this moderator analysis variable are the opposite of predictions. However, the data collection tool developed by the researchers might be more valid because it was developed specifically for research. While it is difficult to make a definitive judgment in both results, it can be concluded that the type of assessment tool makes a difference in the effect size, but not significantly.

The database in which primary studies are published is another variable taken for moderator analysis, but the corresponding results are not statistically significant. The effect size is larger in national databases (TR Index and Thesis Center) compared to international databases (Web of Science-SSCI, ERIC, ProQuest). While most of the national publications are composed of theses, the majority of international publications are articles. Comment on the publication type moderator analysis can also be made here. The difference between the effect sizes may have resulted from the better control of possible confounding variables in the articles compared to theses. If this probability is correct, it is concluded that the actual effect sizes are higher by the influence of the confounding variables.

The results of the moderator analysis conducted for the school starting age variable showed that as the school starting age decreased, the application effect increased. The effect size of the applications in countries where the school starting age is 60 months is higher than the effect size in countries with a school starting age of 69 months and 72 months. However, in this moderator analysis, it is unknown how the primary studies were at the control point for confounding variables. For instance, students who participated in the research at the 4th grade level in primary studies may not have started school life in the country where they are located. In this respect, it is a variable that should be controlled. Considering that all confounding variables are controlled, the results of the moderator analysis obtained indicate the opposite of the literature. In particular, literature on developmental psychology shows that children who start school at older ages are more successful (Bedard & Dhuey, 2006; Vygotsky, 1978; Whitebread et al., 2011). Black et al. (2011) and

Fredriksson and Öckert (2014) concluded in their research that educational attainment increases with the increase in the age of starting school. In another study (Bedard & Dhuey, 2006), using data obtained from a sample of 20 countries, they found that those who were older than other students at school enrolment age generally achieved higher scores in fourth and eighth-grade achievement tests in mathematics and science. According to the data obtained from the intramural student population, many studies specific to various countries revealed that students who start school later scored significantly higher on intramural tests (Crawford, Dearden, & Meghir, 2007; McEwan & Shapiro, 2008; Puhani & Weber, 2008).

Another moderator analysis was for the strategy, method and technique variable used in the studies. According to the results obtained from the moderator analysis, the variance between studies was statistically significant. It was concluded that the activities based on multiple intelligence theory and the applications made with educational games had more effect on mathematics academic achievement than other approaches. In the meta-analyzes regarding academic achievements in various courses, approaches in similar studies such as project-based learning (Ayaz & Söylemez, 2015), collaborative learning (Biçer, 2017; Capar & Tarim, 2015; Hattie, 2009; Johnson et al., 2000b; Kyndt et al., 2013; Savelsbergh et al., 2016; Schroeder et al., 2007; Şen & Yılmaz, 2013; Springer et al., 1999; Tarım, 2003; Tuncer & Dikmen, 2017; Uyar & Doğanay, 2018) and problem-based learning (Ayaz, 2015; Vernon & Blake, 1993; Zhou et al., 2016), it was found that these approaches had a greater impact on academic achievement than teacher-centred approaches.

Group size (sample size) analysis was another moderator variable that was not statistically significant. As the data showed continuity here, meta-regression was performed. The findings revealed that each participant increase in the sample size did not differ on the effect size. The effect size of the study with the smallest group size was higher than the effect size of the study with the largest group size. The group size of the study with the highest effect size was quite small, while the group size of the study with the lowest effect size was at medium levels. This result cannot be interpreted as the student-centred strategy, method or technique works better in large groups or small groups. This result might be affected by other moderator variables. For instance, if there are large groups in studies with a short application period, the opportunity for students to interact might be reduced with this approach. It will be difficult to make comparisons about the effect sizes that will occur under the effect of this kind of confounding variable.

Limitations and suggestions

This research is limited in line with the inclusion criteria. Inclusion criteria in meta-analyses naturally impose limitations (check "Selecting and Coding the Data").

Teachers can adopt the results of this study as an important source to help them choose a strategy, method, or technique in a course that is appropriate for the outcomes in the process of improving primary school mathematics academic achievement. Those responsible for the preparation of national mathematics curricula might view the results of this study as an important resource in the context of teaching principles and methods. While scientific research on the use of student-centred strategies, methods, or techniques continues, it is inevitable to add new study findings to this study in the following years. In this context, systematic review and meta-analysis studies can be repeated for primary school mathematics courses. Since the year intervals in these studies will be different, it may be possible to compare them with the results of this study. A synthesis can be carried out, keeping the inclusion criteria different. For instance, the studies included in this study were determined as cross-sectional studies. This research can be repeated with longitudinal studies. Moderator analyses are valuable in meta-analysis studies (for example, the role of moderators in Karl Pearson's typhoid vaccine studies). In this context, every analysis study sheds light on future studies. In meta-analyses conducted on this study or similar subjects, the moderators determined in this study may be excluded. Thus, the contribution of similar studies to the field will increase even more. According to the results obtained from this systematic review and meta-analysis study, it may prevent the repetition of testing some variables in primary studies of the same type. In this way, it can guide future studies that will make a different contribution to the literature.

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