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Effect of Summer Vacation on Learning Loss in Mathematics: A Meta-Analysis of the Findings

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Abstract: The purpose of the present study was to perform a meta-analysis to draw conclusions about the effect of summer vacation on learning loss of students in mathematics, and also to identify potential moderators of its effects based on the examination of research literature over the past twenty-five years. The research performed meta-analysis model to examine the effect of summer vacation on learning loss in mathematics. Based on the inclusion criteria, eight independent studies were taken into consideration in the research. To explore possible differential effects on the outcome measure, six moderators were extracted from the included studies. The research indicated that summer vacation influences students negatively, resulting in learning loss in mathematics. Also, the research found no significant effect within sub-group variation in terms of year of publication, publication type, setting, and sample size, but not the instructional level and country.

Keywords: Summer Vacation, Summer Learning Loss, Learning Loss in Mathematics, Meta-Analytic Research

Yaz Tatilinin Matematikte Öğrenme Kaybına Etkisi: Bulguların Meta-Analizi

Öz: Bu çalışmanın amacı, yaz tatilinin öğrencilerin matematikteki öğrenme kayıpları üzerindeki etkisi hakkında sonuçlar çıkarmak için bir meta-analiz yapmak ve ayrıca son yirmi beş yıldaki araştırma literatürünün incelenmesine dayanarak etkilerinin potansiyel moderatörlerini belirlemektir. Araştırmada yaz tatilinin matematikte öğrenme kaybına etkisini incelemek için meta-analiz modeli kullanılmıştır. Dahil edilme kriterlerine göre, araştırmada sekiz bağımsız çalışma dikkate alınmıştır. Sonuç ölçüsü üzerindeki olası farklı etkileri araştırmak için dâhil edilen çalışmalardan altı moderatör belirlenmiştir. Araştırma, yaz tatilinin öğrencileri olumsuz etkileyerek matematikte öğrenme kaybına yol açtığını göstermiştir. Ayrıca araştırmada yayın yılı, yayın türü, ortam ve örneklem büyüklüğü açısından alt grup varyasyonu içinde anlamlı bir etki bulunamamıştır, ancak öğretim düzeyi ve ülke değişkenleri açısından için anlamlı bir etki bulunmuştur.

Anahtar Sözcükler: Yaz Tatili, Yaz Öğrenme Kaybı, Matematikte Öğrenme Kaybı, Meta-Analitik Araştırma

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In recent years, the interest in learning loss of students in summer vacation has taken considerable attention across the world (Broekman et al., 2021), especially due to the outbreak of the Covid-19 pandemic (Daniel, 2020; Kaffenberger, 2021). Since the 1970s, many studies have explored the effects of summer vacation on learning loss (Borman et al., 2005), and they have showed that summer vacation may disrupt the daily learning rhythm (Cooper et al., 1996), which may eventually lead to a possible loss in knowledge and skills in schooling (Alexander et al., 2012). Students acquire academic knowledge and skills more slowly in summer vacation than during the typical school year, and summer learning loss hurts most of the students (Cooper et al., 1996). Learning loss during summer vacation, which is one of the main factors in success differences amongst students (Kerry & Davies, 1998) lowers academic achievement (Gershenson, 2013) and makes it difficult to achieve instructional goals (Patton & Reschly, 2013), which become one of the top issues in education policy worldwide (Gershenson & Hayes, 2013).

Learning, more than actually being involved in a mandatory course, is a continuous process for students to gain knowledge and skills (Heyns, 1978). As sognitive psychology suggests, knowledge and skills in education are most likely to be forgotten if they are not practised (Cooper & Sweller, 1987), which indicates that a break, particularly in summer vacation, negatively affects students' learning (Paechter et al., 2015). In a meta-analysis, summer learning loss was shown to be equal to at least one month of teaching, as evaluated by grade level equivalents on standardised test scores—on average, students' test scores were at least one month lower when they returned to school in the autumn than when they left in the spring (Cooper et al., 1996). On average, students' test scores when they return to school in autumun are at least one month lower than when they leave for summer vacation in spring (Cooper et al., 2000). During the summer vacation period, students experience learning loss particularly in mathematics skills (Cooper, 2003; Wintre, 1986). Research has revealed that students experience significant learning loss in mathematics skills during summer vacation (Gershenson & Hayes, 2013). Other research has demonstrated that students not only have learning loss in mathematics, but they also have learning loss in reading and writing (Allinder et al., 1992) and spelling (Gastright, 1979). Accordingly, students' academic achievement decreases during summer vacation; most learning loss occurs in mathematics skills, followed by reading and writing skills (Cooper et al., 1996). In addition to the academic effects of the long summer vacation, students who are not supervised during non-school time are more inclined to use substances such as cigarettes, alcohol, drugs and commit crimes, and exhibit more behavioural problems (Fairchild & Boulay, 2002).

Loss of learning in mathematics due to summer vacation can continue to pile up after students return to school, causing permanent learning loss as many students left behind during school closures will never be able to catch up (Kaffenberger, 2021). However, the extent of learning loss in summer vacation does not only depend on subject area (Sharp, 2000, as cited in Ari, 2006), but its effects are instead moderated by other variables (Paechter et al., 2015), mainly by family-related characteristics including socioeconomic status (SES) (Alexander et al., 2001) and educational level (Gershenson & Hayes, 2013). Also, disadvantaged students can experience severe learning loss (Cooper & Sweller, 1987), which means that they need more support in learning particularly in summer vacation (Sargent & Fidler, 1987).

Although earlier research has reported that summer vacation leads to a decline of two to three months of learning loss (Cooper et al., 1996), the obtained findings are criticised by other researchers because of using of vote-counting method in data synthesis (Hedges & Olkins, 1980) and lack of adequate research methodology and/or analytical procedures (Shields & Laocque, 1996). The review carried out by Cooper et al. (1996) is—perhaps—the earliest research documenting the effect of summer vacation on learning loss between 1975 and 1995, using a more sophisticated meta-analytic method. Since then, to the best of our knowledge, no meta-analytic research has been conducted to investigate the effect of summer vacation on learning loss of students in mathematics particularly. Moreover, summer learning loss has almost been examined in the US, despite its overall importance (Paechter et al., 2015), excluding the cross-cultural context worldwide. Cross-cultural context is very important in meta-analytic research, because it can make it possible to demonstrate cultural differences in a broader sense, and it can go beyond displaying overall results, by simply melting the findings in a pot. Therefore, due to a growing interest in learning loss in educational studies in recent years, as a result of the Covid-19 pandemic in particular where many countries have imposed severe lockdown for months, a meta-analytic study seems timely, not only to demonstrate the effect of summer vacation on learning loss, but also to identify possible research features and variables that moderate the effect of summer vacation on learning loss of students in mathematics. So, the purpose of this study is to do a meta-analysis in order to make conclusions about the effect of summer vacation on student learning loss in mathematics, as well as to find potential moderators of these effects, based on a review of research literature from the past twenty-five years.

Theoretical Framework

Summer Learning Loss

Summer learning loss, which dates to the early 1900s (Fairchild & Boulay, 2002), is the situation where some of the information that students learnt until the end of a school year cannot be remembered at the end of the summer vacation (Moore, 2010). It is a decline in academic performance between spring and autumun seems to widen the gap between students (Kuhfeld, 2019). Although summer vacation has historically been a time to spend with family and friends while enjoying the pleasant summer days (Hagen, 2002), it can lead to possible learning loss when excessive time is not spent on review of subject matter (Moore, 2010).

After the summer break, teachers may return to school with a desire to reconnect with students and their learning (Paechter et al., 2015), but they mostly find students who did not spend their vacation reviewing subject matter and forgot most of their previous knowledge (Gershenson, 2013). In summer vacation, it often became obvious that many students had already lost much of the information they had learnt during the previous year (Moore, 2010). Therefore, many teachers spend their first week on the rehearsal of the subject matter of the previous year after they return to school in autumn (Cooper, 2003), which confirms that teachers are aware of summer learning loss in students (Davies & Kerry, 1999).

When students return to school after the summer vacation, the test scores they get are at least one month lower on average than the test scores they get when they leave for the summer vacation at the end of spring (Cooper et al., 2000). Summer learning loss is equal to one-tenth of a standard deviation of a test score, or around one month of schooling (Cooper et al., 1996). This means that students have experienced learning loss that can correspond to their one-month gains during the academic year. Over the summer, a typical student loses around a month's worth of mathematics abilities or knowledge (Cooper et al., 1996).

Research indicates that students experience learning loss, especially in mathematics skills, during the summer vacation period. For instance, while there is a significant loss in writing skills in primary school second and third grade students, there is a significant loss in mathematics skills in fourth and fifth grade students (Allinder et al., 1992). Similarly, in another research it was revealed that primary school students experience significant learning loss in mathematics during the summer vacation (Gershenson & Hayes, 2013). Research has overwhelmingly found that summer learning loss in mathematics is higher than reading and writing (Alexander et al., 2001). The fact that students have more opportunities to practise reading in their daily lives is effective in the fact that the regression in mathematics is higher than reading and writing (Cooper, 2003). In addition, parents may be more aware of the importance of reading and take extra precautions to ensure that their children read books during the summer vacation (Cooper, 2003). In sum, summer vacation negatively affects students' learning; most learning loss occurs in mathematics skills, followed by reading and writing skills (Cooper et al., 1996).

Factors Influencing Summer Learning Loss in Mathematics

The extent of learning loss in summer vacation does not only depend on subject area (Sharp, 2000), yet its effects are instead moderated by other variables (Paechter et al., 2015), mainly by family-related characteristics including SES (Alexander et al., 2001) and educational level (Gershenson & Hayes, 2013). Studies have revealed that summer vacation has a particularly detrimental effect on students coming from low-SES backgrounds (Entwisle et al., 1997). Students with low-SES background experience severe learning loss especially in summer vacation (Entwistle & Alexander, 1992). Students with high-SES background start the autumun semester more advantageously than their peers with a lower-SES, thanks to the support learning opportunities for school lessons (Slates et al., 2012).

SES is the most important predictor of learning loss experienced by students, especially in mathematics skills, during summer vacation (Entwistle & Alexander, 1992). The strength of cognitive changes in mathematics skills over the summer months seems to be heavily influenced by the SES of students (Paechter et al., 2015). Research has indicated that there is a significant difference by SES in summer learning gains on mathematics (Burkam et al., 2004), which shows strong loss in mathematics for students with low-SES, whereas gains for students with high-SES (Alexander et al., 2007). Students have little opportunity to practise their mathematics skills outside of the classroom during summer vacation (Fairchild & Boulay, 2002); therefore, students need more extracurricular activities to support their learning, especially during summer break (Covay & Carbonaro, 2010). However, students with low-SES are less likely to reach these activities, and this makes them have severe loss in learning in summertime. On the contrary, students with high-SES have an advantage in reaching these activities, which make them enhance their learning and develop their knowledge and skills. Also, students from high-SES families are more likely to get parental assistance, which can lead to better rates of cognitive development in mathematics during the summer vacation. (Entwisle et al., 1997).

On the other hand, education level of parents makes a difference in summer learning loss of students (Gershenson & Hayes, 2013), which indicates that children of families with higher education earn more during summer vacations than the average. Families with a low level of education spend more time in the care and physical safety of their children during summer vacation, and relatively less time in activities and interaction with children (Gershenson, 2013). Families with higher education offer their children more organised extracurricular activities to improve themselves during summer vacation (Borman, 2001), which are positively related to academic performance (Covay & Carbonaro, 2010). Moreover, research has shown that children from families with higher education watch an average of one and a half hours less television per day than children from families with secondary education (Gershenson & Hayes, 2013). Children with high educated parents are inclined to spend less time watching television than less educated parents (Bianchi & Robinson, 1997). Indeed, children of those parents make more visits to such places as libraries and bookstores during the summer vacation (Burkam et al., 2004), which makes them focus their concentration more on mathematics and less on watching television.

Although the research literature has focused primarirly on the effect of SES and education level of parents in summer learning loss in mathematics, it has mostly neglected the role of other variables such as setting, instructional level, and cross-cultural context. Such variables may have a significant influence on the summer learning loss in mathematics, which the present research focused on.

Methodology

Model

In the present study, to obtain a single result with increased statistical power, a meta-analysis model was used, which is a statistical approach for systematically merging data from independent investigations (Lipsey & Wilson, 2001). Meta-analysis is a quantitative process for statistically combining the findings of individual studies (Cooper, 2017). In order to carry out all meta-analytical tests, Comprehensive Meta-Analysis (CMA) software package was used in the study (Borenstein et al., 2009).

Data Sources

The research examining the effect of summer vacation on learning loss in mathematics was determined by searching reference databases. To locate relevant empirical research on the impact of summer vacation on mathematics learning loss, a systematic literature review was conducted over a one-month period for the period 1996 to 2021, using such databases as PsycINFO, Web of Science, JSTOR, EBSCOhost, Science Direct, Education Resources Information Centre, Scopus, ProQuest®, and Google Scholar, Dissertations Abstracts International, with the following queries: [("summer vacation learning loss" OR "summer slide learning loss")

AND ("summer vacation and learning loss" OR "summer slide learning loss"], ["learning loss" AND "loss in learning"], AND ("students summer vacation learning loss" OR "students summer slide learning loss")]. As a result of this examination, a total of 34 studies, including 26 journal articles and 8 theses, were reached. Thus, over 30 independent studies were created for preliminary review.

Inclusion Criteria

A study has to evaluate the influence of summer vacation on student learning loss in mathematics in order to be included in the present meta-analysis; (ii) include peer-reviewed journal articles and dissertations conducted on K-12 education; (iii) have taken place from 1996 to 2021; (iv) be available in English or Turkish; (v) include sample size, arithmetic mean and standard deviation; (vi) include both pretest and posttest data or mean difference data.

The first four criteria were employed in a preliminary screening of the study abstracts. If there was no abstract available for the study, the entire publication was obtained and extensively evaluated. For the last two criteria, the entire publication was reviewed and checked for sample size, arithmetic means, pretest and posttest data, and standard deviations or mean difference data. The corresponding author was contacted for studies with insufficient statistical information, and the essential information for the missing data was obtained. If the author did not respond or could not supply the missing data, the study was deleted from the meta-analysis. After reviewing each study in light of the inclusion criteria, it was determined that eight papers matched all six research requirements (Table 1).

Table 1. Studies Included in The Meta-Analysis

Author(s)	Publication Type	Sample Size	Summer Vacation	Instructional Level	Country
Ari, 2004	Thesis	704	10 wk	Primary	Turkey
Paechter et al., 2015	Journal article	110	9 wk	Secondary	Austria (EU)
Şahin, 2004	Thesis	580	10 wk	Primary	Turkey
Şen, 2009	Thesis	421	10 wk	Primary	Turkey
Sezgin et al., 2020	Journal article	192	10 wk	Secondary	Turkey
Broekman et al., 2021	Journal article	984	6 wk	Primary	Netherlands (EU)
Lindahl, 2001	Journal article	256	7 wk	Primary	Sweden (EU)
Moore, 2010	Journal article	274	10 wk	Primary	US

In the research, 8 studies were taken into consideration in the meta-analysis, based on the inclusion criteria. Of these studies, 37.5% (n = 3) were theses and 62.5% (n = 5) were journal articles. The sample size of the studies ranged between 110 and 984, and the average duration of summer vacation in the studies was 9 weeks. Also, 75.0% (n = 6) of the studies were conducted in primary schools and 25.0% (n = 2) in secondary schools. Lastly, 50% (n = 4) studies were carried out in Turkey, 37.5 (n = 3) of the studies were conducted in member countries to the EU, and 12.5% (n = 1) studies were carried out in the US.

Possible Moderators

In the study, outcome measure included in this meta-analysis was summer learning loss in students. Summer learning loss included the loss in learning in summer vacation in students enrolled in K-12 education. Six modifiers were identified from the included studies to explore possible differential effects on outcome measurement. The first moderator concerned with *year of publication*, in which it was classified as 2000-2010 and 2011-2021, with a range of ten years. The second moderator, *publication type*, determined whether a study was published as a journal article or a thesis. In the study, not only journal articles were included in the meta-analysis, but also dissertations were taken into consideration, to avoid publication bias (Iyenger & Greenhouse, 1988). If the studies from these were made into a journal article again, they were coded as journal articles according to the last publication type. The third moderator considered *setting*, in which the study was carried out in an urban or a rural area. The fourth moderator referred to *instructional level*, whether the study was conducted in a primary or a secondary school. The fifth moderator referred to *sample size*, the number of student participants in a study. The last moderator concerned with *country*, where the study was carried out.

Computation of Effect Sizes

Because Hedges' *g*-value may overestimate the population effect size when samples are small (Johnson, 1993), standardised effect size of Cohen's *d* was used in the present meta-analysis (Cohen, 1988), which indicates the difference between the mean scores of participants divided by the pooled standard deviation (Lipsey & Wilson, 2001). For studies reporting means and standard deviations for both pretest and posttest, effect sizes were calculated directly from the provided measurements (Glass et al., 1981). For any comparison, Cohen's *d*-value is calculated by multiplying the difference between the two group means by their mean standard deviation or control group standard deviation (Hunter & Schmidt, 1990). When means or standard deviations were not supplied in a potential study, inferential statistics were used to compute effect size of Cohen's *d* (Rosenthal, 1994), retrieved from *t* and *F* (Hedges & Olkin, 1985).

Fixed and random effects models were employed to analyse the research findings in the meta-analysis (Cooper, 2017). The fixed-effects model is based on the assumption that all of the studies in the collection predict the same outcome (Lipsey & Wilson, 2001). Under the accuracy of this assumption, the inverse of the variance of the results of the independent studies and the weighted average with the smallest variance should be found. The fixed-effects model considers the variance between study results to be due to interrelated data (Borenstein et al., 2009). Conversely, the random-effects model makes an evaluation by taking into account the variance within the studies and the variance between the studies (Hedges & Olkin, 1985). The random-effects model assumes that there are several true effects and that the true correlations estimated in each study differ (Lipsey & Wilson, 2001). The random-effects model is preferred to the fixed-effects approach (Borenstein et al., 2009), because meta-analyses generated with this model take into account both changes across studies and variations within studies (Shelby & Vaske, 2008).

In the research, procedures suggested for meta-analysis were followed (Cooper et al., 2009), and the effect of summer vacation on learning loss in students were investigated. Summer vacation was considered as an independent variable and learning loss was taken as a dependent variable. To analyse the data collected from independent studies, CMA software package was used to calculate all statistics, including, for example, effect sizes, publication bias, funnel and forest plots, *z*-values, heterogeneity statistics, lower and upper confidence intervals, and standard errors.

Publication Bias

The risk that not all research conducted on a given issue are representative of reported studies is known as publication bias (Rothstein et al., 2005). The funnel plot, classical fail-safe *N*, Orwin's fail-safe *N*, and Duval and Tweedie's trim and fill are all methodologies used in meta-analysis research to discover publication bias. The funnel plot is the first method for determining whether studies have publication bias (Borenstein et al., 2009). The funnel plot, which depicts the potential for publication bias in meta-analysis research (Sterne et al., 2005), created for the relationships between summer vacation and learning loss in mathematics was shown in Figure 1.

In terms of publishing bias, the funnel plot is likely to be highly lopsided. The effect sizes were spread symmetrically around the vertical line in cases where no publication bias was identified in the funnel plot. Individual studies are expected to cluster around the funnel plot's central line, which indicates the overall influence (Borenstein et al., 2009). Studies distributed asymmetrically around the funnel plot indicate a possible publication bias in the meta-analysis (Sterne et al., 2005).

Also, to minimize the average effect size to insignificant levels, the standard fail-safe *N* was applied, which was required to raise *p*-value to above .05 for the meta-analysis (Rosenthal, 1979). Classical fail-safe *N* revealed that 1786 independent studies with null findings would be required to reduce the overall effect size to a trivial level at. 01. Furthermore, in missing studies, Orwin's fail-safe *N* was used to determine the threshold values for a trivial log odds ratio and mean log odds ratio (Orwin, 1983). As a result, the number of missing null studies needed to lower existing overall average effect sizes to the trivial level of .01 was discovered to be .272.

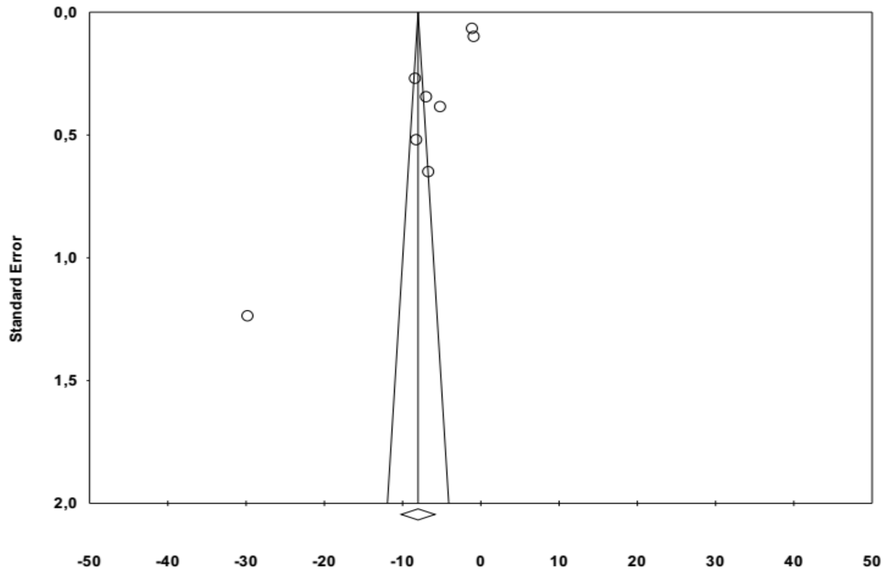

Figure 1. Funnel plot for the effect size of the effect of summer vacation on learning loss

Finally, the trim and fill method, a nonparametric data augmentation method for estimating the number of studies missing from a meta-analysis due to the removal of the most extreme findings on one side of the funnel plot, was used to investigate the possibility of publication bias in the studies (Duval & Tweedie, 2000). Small studies near the far end of the positive side of the funnel plot are deleted with the help of this statistic. Until the funnel plot is symmetrical, the effect size is recalculated (Borenstein et al., 2009). On the funnel plot, effect sizes are distributed asymmetrically when studies suffer publication bias. In the research, the funnel plot showed that there was no publication bias in the present meta-analysis.

Coding Reliability

A coding protocol was created based on the research's goal to identify variables and compute impact sizes for each independent study (Lipsey & Wilson, 2001). Two independent coders extracted the data from all studies selected for inclusion (Miles et al., 2013). All the data of the included studies were coded independently; if an agreement was not reached between the coders, a third independent coder was asked to resolve the disagreement occurred. Because all the studies were independently double-coded and all disagreements resolved by a third independent coder, a reliability coefficient was not calculated.

Results

Effect Size Analysis

A total of 8 studies were included in the meta-analysis with a sample size of 3.521 students. To establish the meta-analysis model to calculate the effect sizes of each independent study, the homogeneity of the fixed-effects and random-effects models was assessed (Table 2).

Table 2. *Results Related to Effect Sizes of The Studies*

Model	ES	SE	Variance	Q	df (Q)	I^2	95% CI	
							Lower	Upper
Fixed Effects	–1.688	0.053	0.003	1798.79	7	99.611	–1.789	–1.581
Random Effects	–8.022	1.102	1.215				–10.182	–5.861

As a result of the analysis, Q value indicated that the distribution of effect sizes was heterogeneous, $Q(7) = 1798.79$, $p < .001$, so that a random effects model was adopted, which shows that the variance of effect sizes is greater than can be explained by simple sampling error (Borenstein et al., 2009). Using the random-effects model, it was indicated that the average effect size value was –8.022, with a standard error of 1.102 (95% CI = –10.182 / –5.861).

Overall Effect Sizes

The negative value for the average effect size obtained in the research was large (Cohen et al., 2007), indicating that summer vacation has a significant effect on learning loss in mathematics. The forest plot of the effect of summer vacation on learning loss in mathematics was displayed in Figure 2.

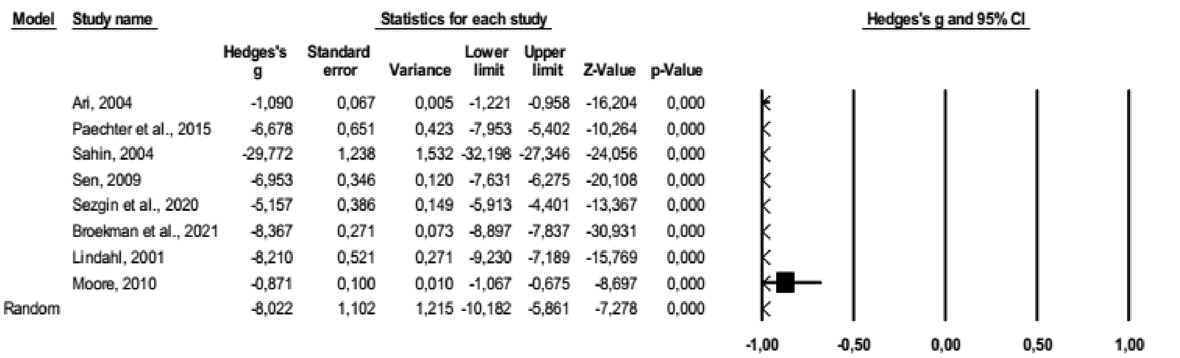

Figure 2. Forest plot showing the distribution of effect size values

In Figure 2, the squares in the graph show the effect sizes of the related studies, and the lines in the squares show the lower and upper limits of the effect sizes at the 95% confidence interval (Ried, 2006). The square represents the weights of the absolute effect sizes for the respective studies. According to the analysis, the minimum value was –29.772 and the maximum was –0.871. All the studies had negative effect sizes, which confirmed that summer vacation has a significant effect on learning loss in mathematics.

Moderator Analysis

In moderator analysis, the effects of two or more groups are compared with one another to display the source of the difference. Moderator analyses were conducted to examine whether effect sizes were attributable to basic research subgroups (Lipsey & Wilson, 2001). In meta-analytic research, *Q* test is used to identify the source of the difference; this indicates that the variation between independent studies is larger than would be expected if the difference could be explained entirely by random error (Borenstein et al., 2009). Table 3 displayed the characteristics of all the independent studies in moderator analyses.

Table 3. Effect Size Differences Related to Moderators

Model	k	ES	SE	95% CI Lower	95% CI Upper	Q_b	df (Q)	p_q	I^2
Overall	8	–8.022	1.102	–10.182	–5.861		7		99.611
Year of publication									
2000-2010	5	–8.568	1.157	–10.836	–6.300	1.259	1	0.262	0.00
2011-2021	3	–6.746	1.138	–8.977	–4.515				
Publication type									
Journal article	5	–5.847	2.036	–9.837	–1.857	2.193	1	0.139	0.00
Thesis	3	–12.424	3.947	–20.161	–4.688				
Setting									
Rural	2	–3.739	2.903	–9.429	1.951	2.781	1	0.095	0.00
Urban	6	–9.757	2.143	–13.957	–5.556				
Instructional level									
Primary	6	–8.724	1.267	–11.207	–6.241	3.858	1	0.049	0.00
Secondary	2	–5.827	0.755	–7.307	–4.347				
Sample size									
100-500	5	–5.558	1.781	–9.049	–2.067	2.959	1	0.085	0.00
501 and above	3	–12.892	3.873	–20.483	–5.301				

Country									
EU	3	–7.891	0.458	–8.789	–6.993				
Turkey	4	–10.515	2.753	–15.915	–5.122	235.40	2	0.000	0.00
US	1	–0.871	0.100	–1.067	–0.975				

Note. *k* = number of studies; *ES* = Effect size; *SE* = Standard error; *CI* = Confidence interval.

Results indicated that neither sub-group, excluding the instructional level and country, moderated the research findings. There was no significant effect within sub-group variation in terms of year of publication $Q_b(1) = 0.262$, *ns*, publication type $Q_b(1) = 0.139$, *ns*, setting $Q_b(1) = 2.781$, *ns*, and sample size $Q_b(1) = 2.959$, *ns*, but not the instructional level $Q_b(1) = 3.858$, $p < 0.05$ and country $Q_b(2) = 235.40$, $p < 0.05$. In other words, no significant moderation effects were found, meaning that summer vacation learning loss was not related to key subgroups, excluding instructional level and country.

Discussion

Although independent studies have examined the influence of summer vacation on learning loss in mathematics, there has been no meta-analytic review to determine its overall effect and to identify the role of possible moderators since 1996 (Cooper et al., 1996). The present meta-analysis aimed to determine the overall effect of summer vacation on learning loss in mathematics by collecting the data from independent studies based on the inclusion criteria, and to identify possible moderators influencing learning loss in students over the last 25 years. Despite the interest in learning loss in summer vacation over a century (White, 1906), the number of studies after the review conducted by Cooper et al. (1996) is considerably very limited. In the present meta-analysis, over 30 independent studies dealing with the link between summer vacation and learning loss were collected from the literature, and only 8 of them met the inclusion criteria, especially focusing on the loss in mathematics.

The findings of the meta-analysis indicated that summer vacation has a significant negative influence on learning loss of students in mathematics in K-12 education. All the studies included in the research showed negative effect sizes, which are not in favour of summer vacation. The findings showed that students experience a considerable learning loss in summer vacation; the average effect size value was calculated to be –8.022 (*SE* = 1.102), which indicates a large effect size (Cohen et al., 2007). The findings of this research are consistent with the previous review (Cooper et al., 1996), which found that students experience severe declines in learning especially in mathematics over summer vacation. Other research has also confirmed the learning loss during summer vacation (Alexander et al., 2001; Entwistle & Alexander, 1992; Lynch & Kim, 2017), which can disturb the daily rhythm of learning of students, and lead to a possible loss in knowledge and skills, particularly in mathematics (Allinder et al., 1992; Cooper et al., 1996). Research has overwhelmingly found that summer learning loss in mathematics is always higher than reading and writing (Alexander et al., 2001; Broekman et al., 2021; Gershenson & Hayes, 2013). During the summer vacation, students suffer from learning loss especially in mathematics skills (Cooper, 2003; Wintre, 1986). In the summer following third grade students lose 27% of their school-year gains and by the summer after seventh grade students lose on average 50% of their school-year gains in mathematics (Kuhfeld, 2019). Indeed, a typical student loses a little more than one month’s worth of skill or knowledge in mathematics combined over the summer vacation (Cooper et al., 1996). Mathematics involves the ongoing acquisition of factual and procedural knowledge and skills (Paechter et al., 2015), and without practice knowledge and skills are more prone to be forgotten if they are not adequately trained (Cooper & Sweller, 1987). Students have little opportunity to apply their mathematical knowledge and skills outside of school (Fairchild & Boulay, 2002); thus, students experience more learning loss in mathematics during summer vacation than in other fields. However, summer schooling loss may be mediated by continued summer schooling opportunities (Cooper et al., 1996). In a meta-analysis, Cooper et al. (2000) found that summer schools focusing on remedial instruction have a positive influence on knowledge and skills of students in mathematics. Also, mandatory summer schools are reported to be effective in mathematics than in other subjects (Matsudaira, 2008). Summer schools can help students reduce learning loss, yet the participation of every student in such programmes can widen the achievement gap (Borman & Dowling, 2006) and cannot help students who are behind to catch up in mathematics (Heyns, 1987). Summer schools can be more effective when disadvantaged students attend consistently and spend more time on tasks academically (Augustine et al., 2016), but to specifically address the achievement gap, these schools will need to specifically target disadvantaged students (Alexander et al., 2001). Summer schools are often remedial for disadvantaged students, and they help these students develop in achievement (Borman & Dowling, 2006).

In the moderator analyses, no significant effect within sub-group variation was found in terms of year of publication, publication type, setting, and sample size, while significant effects within sub-group variation were found regarding the instructional level and country. First, regarding the year of publication, there was no significant difference between the studies included in the meta-analysis. The research indicated that summer learning loss in mathematics did not change considerably over the past two decades. Summer learning loss in mathematics was a serious problem before 2000 (Cooper et al., 1996), yet it is still a serious problem, despite the vast amount of learning opportunities now. Although there have been ongoing debates on how to cope with summer learning loss in mathematics over the years (McCombs et al., 2011), it seems that it will continue to be a serious problem in the near future, especially due to the Covid-19 pandemic. The closure of schools due to the Covid-19 pandemic indicates that students in the US will have lost about 50% of the mathematical knowledge and skills they acquired when they return to school in autumn (Kuhfeld & Tarasawa, 2020).

Regarding the publication type, all the studies were found to have negative effect sizes, meaning that there is no significant difference in terms of the effect of summer vacation on learning loss in mathematics between journal articles and theses. Contrary to the argument of Rust (1990), the effect sizes gathered from all the studies, either journal articles or theses, indicated that publication type is not a significant moderator in the explanation of the effect of summer vacation on learning loss in mathematics. Rust (1990) claims that studies having powerful statistics are generally worth publishing in peer-reviewed journals; on the contrary, they are not. The present meta-analysis combined the data of all the studies, and it concluded that there is not a significant difference between published studies like journal articles, or unpublished work such as theses.

In terms of the setting, interestingly, it was not found a significant difference between studies conducted in urban and rural contexts. To put it in other words, students both in urban and rural settings experience similar summer learning loss in mathematics. Although studies have shown that there is a significant difference between urban and rural students regarding summer learning loss in reading, this is not the case in mathematics. Learning loss of urban and rural students is similar over the summer vacation, because very few students have enough opportunity to practise mathematics in out-of-school facilities (Fairchild & Boulay, 2002). If students living in urban and rural settings have no facilities to practise mathematical knowledge and skills, they are likely to experience learning loss in summer vacation. Summer learning loss is not a phenomenon peculiar to rural students; all students are like to experience learning loss in mathematics, if knowledge and skills are not trained enough (Cooper & Sweller, 1987). Summer learning loss, as the present research demonstrated, may not stem from the setting, but it may well result from SES of students. SES is the most important predictor of learning loss experienced by students, especially in mathematics skills, during summer vacation (Entwistle & Alexander, 1992). Students living in high-SES households are more likely to participate in diverse organised extracurricular activities during summer vacation (Chin & Phillips, 2004); thus, involvement in such activities results in high academic performance (Covay & Carbonaro, 2010). Research has established that summer vacation has a particularly harmful influence on students coming from low-SES backgrounds (Cooper et al., 1996; Entwisle et al., 1997). Students with low-SES experience severe learning loss especially in summer vacation (Entwistle & Alexander, 1992). In contrast, students with high-SES start the autumn semester more advantageously thanks to the support learning opportunities (Slates et al., 2012). High-SES students begin school with gains and general knowledge in mathematics after summer vacation; on the contrary, low-SES students start school with considerable losses (Burkam et al., 2004).

Regarding the instructional level, a significant difference was found between the studies conducted in primary and secondary schools. According to the finding, primary school students experience more losse in mathematics than secondary school students. Research literature has primarily focus on the summer learning loss of primary school students in mathematics (Allinder et al., 1992; Gershenson & Hayes, 2013; Wintre, 1986), rather than secondary school students. Therefore, the finding is an important one to consider. Although earlier research has demonstrated that summer learning loss increases with grade level (Alexander et al., 2007; Cooper et al., 1996), the present research produced a contrasting finding. The research showed that summer vacation affects secondary school students less negatively compared to primary school students, indicating that learning loss in mathematics is a much more serious problem in primary level. The difference between primary and secondary school students' learning loss may be related to variation in cognitive skills required for mathematics (Allinder et al., 1992). The fact that students in upper instructional levels such as secondary school or university use their learning strategies much better than primary school students (Weinstein & Mayer, 1986) may have influenced summer learning loss in mathematics significantly. Students in secondary schools, compared to students in primary schools, can organise strategies according to learning objectives and use the appropriate strategy on their own (Dignath & Büttner, 2008). Students in secondary schools experience less loss in mathematics, compared to students in primary schools, which claims that cognitive growth rate of students is important to decrease the negative effect of summer vacation on learning. Also, students in secondary schools may benefit more from organised extracurricular activities such as private tutoring, academic clubs, etc. (Borman, 2001), which influence their academic performance (Covay & Carbonaro, 2010; Lee & Bowen, 2006) and decrease the level of their learning loss in mathematics.

On the other hand, it was not found a significant difference between studies in terms of sample size, which was another potential source of variation. According to the finding, sample size of studies, whether between 100-500 and 501 and above, did not create any significant difference for learning loss in mathematics. Unlike the previous studies which have suggested that studies with small sample sizes are likely to produce much larger effect sizes (Slavin & Smith, 2009), the present research produced no significant result. So, the research indicated that sample size of independent studies is not an important potential source of variation to determine the influence of summer vacation on learning loss in mathematics. However, the effect size of the studies with a sample size of 500 and above showed that students experience more loss in mathematics, compared to the studies less than 500 sample size. Therefore, more studies with larger sample sizes up to 500 students may bring a clear understanding to the role of sample size in the determination of learning loss in mathematics.

Lastly, learning loss of students in mathematics was examined regarding country variable, which indicated that country is a significant determinant. According to the finding, there was a significant difference between studies in terms of the EU (Austria, Sweden, and the Netherlands), Turkey, and the US. The finding showed that students in the US have less learning loss in mathematics, while the research demonstrated that the students in Turkey have the highest level of learning loss in mathematics. Although the US and Turkey are one of the leading countries implementing a three-months of summer vacation, the present finding demonstrated that the length of summer vacation by itself is not the only factor which results in learning loss in mathematics. Also, given the fact that the EU member countries implement relatively short periods of summer vacation in their education systems, they experience with learning loss in mathematics, as the present research displayed. According to Cooper et al. (1996), summer learning loss may be mediated by continuing schooling opportunities over the summer vacation. Academically oriented summer programmes, which may be considered schooling opportunities over the summer months, may minimise the learning loss (Borman et al., 2005). Summer programmes are growing substantially in the US (Borman & Dowling, 2006), which may be reflected on the result obtained in the research.

Conclusions

The present research aimed to investigate the effect of summer vacation on learning loss of students in mathematics and to identify potential moderators of its effects based on the examination of research literature over the past twenty-five years. The research demonstrated several important findings in terms of learning loss in mathematics. The research showed that summer vacation influences students negatively, resulting in learning loss in mathematics. Also, no significant effect within sub-group variation was found in terms of year of publication, publication type, setting, and sample size. However, significant effects within sub-group variation were found in the research regarding the instructional level and country. Students were found to experience much learning loss in mathematics in primary schools, rather than secondary schools. Besides, it was a significant difference between students in the EU, Turkey, and the US. According to this finding, Turkish students were found to experience much learning loss in mathematics than their peers in the EU and the US, respectively.

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