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Research article

A meta-analysis of Geogebra software decade of assisted mathematics learning: what to learn and where to go?

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ABSTRACT

Today, hundreds of studies on mathematics learning have been found in various literature, supported by the use of GeoGebra software. This meta-analysis aims to determine the overall effect of using GeoGebra software and the extent to which study characteristics moderate the study effect sizes to consider the implications later. This study analyzed 36 effect sizes from 29 primary studies identified from ERIC documents, Sage Publishing, Google Scholar, and repositories from 2010 to 2020, and a total of 2111 students. In order to support calculation accuracy, a Comprehensive Meta-analysis (CMA) software was used. The effect size is determined using the Hedges equation, with an acceptable confidence level of 95%. It is known that the overall effect size of using GeoGebra software on the mathematical abilities of students is 0.96 based on the estimation of the random-effect model, and the standard error is 0.08. These findings indicate that, on average, students exposed to GeoGebra-based learning outperformed math abilities, which was initially equivalent to 82% of students in traditional classrooms. This study considers the five characteristics of the study. It showed that the GeoGebra software used was more effective in sample conditions less than or equal to 30. Providing classrooms with sufficient numbers of computers allowed students to use them individually, which was necessary to achieve a higher level of effectiveness. GeoGebra software is more effective when the treatment duration is set to less than or equal to four weeks. These findings help educators consider the characteristics of studies that moderate effect sizes using the GeoGebra software in the future.

1. Introduction

Mathematical ability is an essential prerequisite for school performance and career success (Bochniak, 2014). Students completing math classes double their chances of achieving a bachelor's degree (Adelman, 2006). Most of the fastest-growing jobs require a bachelor's degree at the same time (Dohm and Shniper, 2006). These results clearly show that the mastery of mathematical skills has far-reaching consequences for students.

A learning environment equipped with the use of technology can improve the understanding and quality of the education system (NCTM, 2000; Savec et al., 2018; Attard and Holmes, 2020). The use of technology in mathematics learning assertively and creatively helps individuals develop the skills and knowledge needed to meet the expectations of 21st-century education and society (Adelabu et al., 2019; Tamur et al., 2018; Chen et al., 2020). Technology integration provides students with additional practice and the opportunity to examine their problems and to express their findings with different alternative answers (Gonzalez and Birch, 2018; Juandi and Priatna, 2018; Sung et al., 2016; Nurjanah et al., 2020).

The use of GeoGebra software is a form of technological integration for learning mathematics. GeoGebra is a math software package that offers a combination of 2D and 3D dynamic geometry software, CAS, and spreadsheet features (Weinhandl et al., 2020). The use of GeoGebra allows students with more opportunities to visualize geometric concepts, which often accommodates below-average learners (Mthethwa et al., 2020). This understanding supports the urgency of integrating GeoGebra in geometry classrooms. The advantage of GeoGebra is that it operates on

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all standard system software and can be operated via a web browser as well (Iriarte et al., 2014).

The learning of mathematics supported by the use of GeoGebra software is considered to affect the mathematical abilities of students. However (Juandi and Priatna, 2018; Supriadi et al., 2014; Kusumah et al., 2020), previous research examining this theoretical assumption has shown inconsistent results. Research that has been conducted has found that the use of Geogebra software is effective in improving student ability. In the meantime, other research findings found that students' mathematical ability taught using GeoGebra software was no better than those taught using conventional approaches (Setyani, 2016; Ramadhani, 2017; Priyono and Hermanto, 2015). Findings from various studies that give different results can cause errors in building conclusions (Demirel and Dağyar, 2016; Franzen, 2020).

Cover this gap, and efforts must be made to integrate primary findings to provide useful information for policymaking (Higgins and Katsipataki, 2015; Siddaway et al., 2019). For this reason, a meta-analysis study is needed, which includes all the primary studies on the subjects mentioned above, to provide more generalizable findings compared to the primary study (Demirel and Dağyar, 2016; Calzetta et al., 2020). However, in the literature, there has not been a meta-analysis study that assesses the effectiveness of mathematics learning supported by GeoGebra software's use on students' mathematical abilities.

In the literature, several meta-analysis studies have been conducted to assess the effectiveness of mathematics learning supported by the use of computers in general, namely (Bayraktar, 2001; Chan and Leung, 2014; Turgut and Temur, 2017; Turgut and Turgut, 2018; Kaya and Öçal, 2018; Yesilyurt et al., 2019; Tamur et al., 2020c). The study examined the effectiveness of math games, visualization, and dynamic geometry software (DGS). There are no specific meta-analysis studies that have questioned the overall effectiveness of GeoGebra. On the other hand, GeoGebra's use has become a trend for most teachers today (Kusumah et al., 2020). Consequently, there is a need that educators need convincing information to decide under what conditions the mathematics learning supported by the use of GeoGebra software will reach a more effective level of student mathematical ability.

For this reason, this meta-analysis study is needed to assess the effectiveness of using GeoGebra software on students' mathematical abilities as compared to traditional teaching in mathematics. Besides, this study also determines to what extent the influence of using GeoGebra software on mathematical ability is moderated by the year of research, level of education, sample size, student to computer ratio used, and treatment length. These findings will contribute to the literature providing essential information for further use of GeoGebra. In order to achieve the research objectives, these two questions were examined: first, whether the overall effect size of using GeoGebra software had a significant impact on students' mathematical abilities. Second, to what extent do study characteristics (study year, level of education, sample size, student to computer ratio used, and length of treatment) moderate the study's effect size?

2. Research method

2.1. Research design

This meta-analysis study analyzed 29 primary studies that questioned the effect of GeoGebra software on math ability. Meta-analysis estimates general population effect sizes that are not known by analyzing a summary of the quantitative findings obtained in the primary study (Cleophas and Zwinderman, 2017; Liu et al., 2019). This research was conducted using steps; first, inclusion criteria will be provided for studies included in the analysis. Second, it describes the process of finding empirical data and encoding variables. Third, statistical techniques are described (Borenstein et al., 2009b; Pigott, 2012). This job also follows these steps.

2.2. Inclusion criteria

The studies analyzed were selected from experimental and quasi-experimental research that compared students' mathematical abilities who received GeoGebra-based mathematics learning and traditional teaching. The population in this study is a study conducted in Indonesia between 2010 and 2020. The descriptive statistics needed to adjust for the magnitude of the two groups' effects are the mean score of mathematical abilities, the standard deviation, and the number of students involved in the study. Moreover, other information identified to achieve the research objectives were the year of study, class of education, sample size, students' ratio to computers used, and length of treatment.

2.3. Data collection

The empirical data in this study is a template about using software on students' mathematical abilities. The data is identified from an online database that includes ERIC (https://eric.ed.gov/), SAGE Publishing (https://journals.sagepub.com/), the Scopus database, document repositories, and Google Scholar (https://scholar.google.com/). During electronic scanning, expressions such as "mathematical abilities of students", "GeoGebra Software", "GeoGebra software effects on students", "application of GeoGebra software mathematics learning", and their equivalents are in Indonesian. Empirical data for the thesis and preparation carried out for one year were obtained by scanning manually from library sources. Information verification was carried out with the principal investigator via email correspondence. Quality meta-analysis must ensure transparent and complete reporting. In line with that, the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes) use can improve the quality of reporting (Pigott and Polanin, 2020; Nawijn et al., 2019). This study has used the PRISMA protocol (see Figure 1).

The identification results resulted in 134 successful studies collected on the effect of using Geogebra software. The screening stage resulted in primary studies, but 93 studies were excluded because of duplication and did not meet the criteria. Then, 12 studies were excluded from the analysis because their statistical data were insufficient. So, 29 primary studies were eligible for analysis. A flow chart detailing the implementation of the PRISMA protocol in this study is presented in Figure 1.

Figure 1 shows the selection and reporting process for primary studies. The process resulted in 29 primary studies that met the eligibility criteria. However, some studies involved more than one control group, so 36 effect sizes were analyzed. The individual studies included in the analysis process are presented in Appendix 1.

2.4. Coding process and reliability test

Primary studies that meet eligibility are coded according to the focus of the study. A research instrument is a coding form developed to extract information from individual studies into numerical data covering the study year, differences in education levels, sample size, student to computer ratio used, and treatment duration. For this purpose, two coders outside the research team were involved. Both are doctoral students who have previously taken data analysis and meta-analysis courses. The reliability test uses Cohen's Cappa coefficient (κ (7)), which is a vital statistic to test the level of agreement between coders (McHugh, 2012). Cohen's kappa formula is as follows:

$$\kappa(7) = \frac{\Pr(a) - \Pr(e)}{1 - \Pr(e)} \tag{1}$$

where Pr (a) represents an actually observable agreement, and Pr (e) represents a coincidence agreement. A value of 0.85 or greater is predetermined to be considered high. In this study, the level of agreement was obtained as 0.98. That is, there is a substantial to the nearly perfect

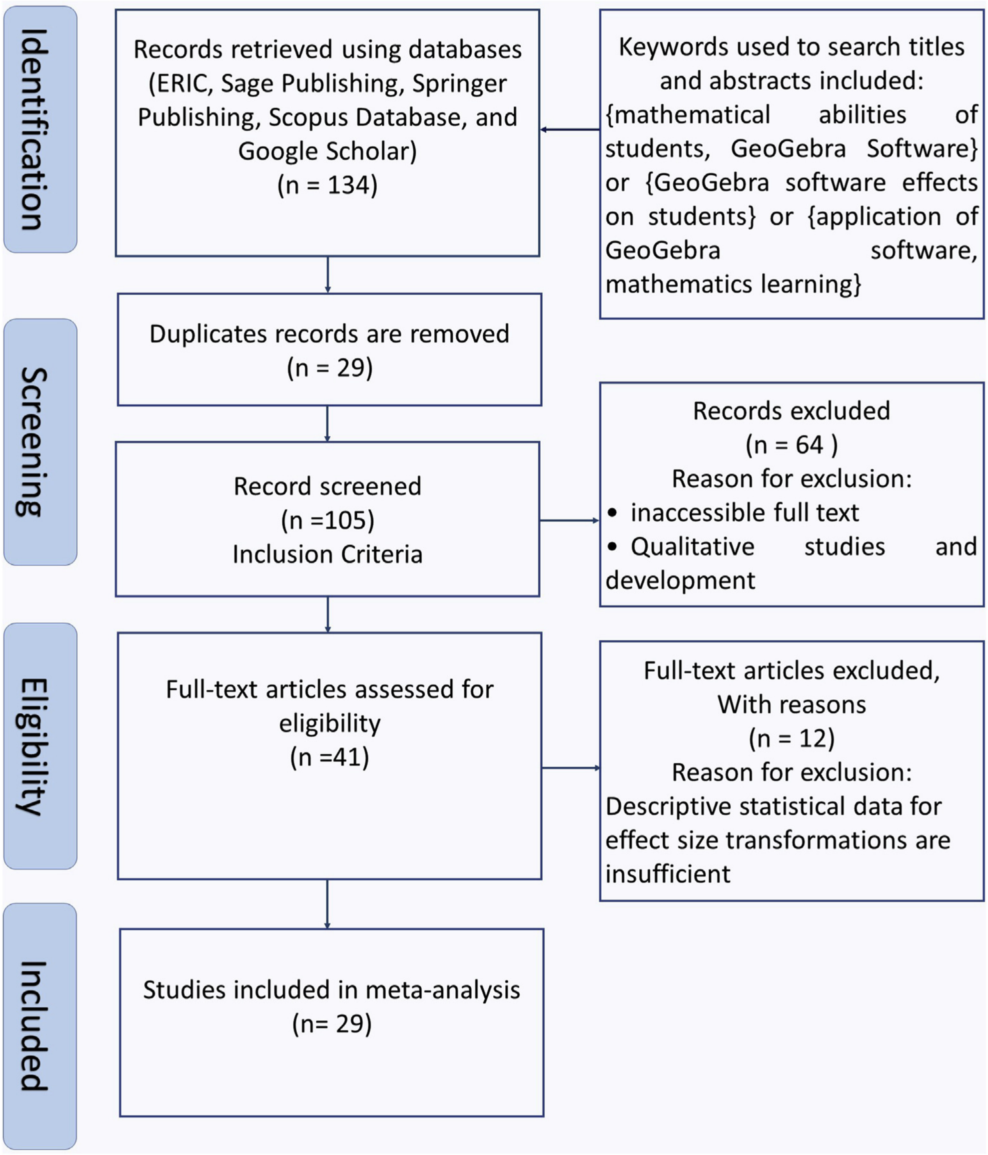

Figure 1. In this research, a flow chart detailing the application of PRISMA.

match between coders. Therefore, the details in this meta-analysis are reliable.

2.5. Statistic analysis

CMA software, which is based on the Hedges'g equation, is used in calculating the effect size. Classification of the sizes of effect using criteria Thalheimer and Cook (2002), namely:

- effect sizes between -0.15 and 0.15: no effect,
- effect size between 0.15 and 0.40: low effect,
- effect size between 0.40 and 0.75: moderate effect,
- effect size between 0.75 and 1.10: high effect,
- effect sizes between 1.10 and 1.45: very high effect,
- effect size 1.45 or higher: excellent effect.

The CMA program transformed each primary study's effect size, determined statistical significance, homogeneity between groups (Q-between), and p-value. The calculation would reject the null hypothesis if $p < 0.05$ (Borenstein et al., 2009b). This means that using GeoGebra software in Indonesia's mathematics learning produces a larger effect size than conventional teaching. The effect size between studies was statistically heterogeneous ($Qb > \chi 2.95$; $p < 0.05$), meaning that the effect size homogeneity hypothesis was rejected, and the effect size estimation was using the random-effect model (Demir and Başol, 2014). Rejecting Qb means that each research characteristic category has a statistically significant difference in mean effect sizes.

The most common criticism of meta-analysis methods is that they may contain biased studies. In order to prevent misstatement of findings, it is necessary to examine publication bias (Juandi et al., 2021; Suparman et al., 2021a; Susanti et al., 2020; Tamur et al., 2021c) If some of the 29 studies included in the analysis were sample biased, the summary of reported effect sizes would reflect this bias (Borenstein et al., 2009a). Publication bias reflects the fact that statistically significant articles have a higher chance of being published and that researchers also rarely (6%) try to publish insignificant research (Cooper, 2017). Consequently, there is concern that this study's findings may overestimate the true effect size (Arik and Yilmaz, 2020; Ferguson and Heene, 2012; Park and Hong, 2016; Tamur et al., 2020b; Tamur et al., 2020a). In order to assess the possible amount of bias, funnel plots were examined, and Rosenthal's

FSN statistics were used to assess the impact of bias (Borenstein et al., 2009a, b; Tamur and Juandi, 2020; Yunita et al., 2020; Suparman et al., 2021a, b). It is said to be bias resistant if the effect size of each study shows a symmetrical distribution along the vertical line (Borenstein et al., 2009a; Tamur et al., 2021a). If the effect sizes are not completely symmetrical distributed, Rosenthal's fail-safe N (FSN) statistic is used. The FSN value/$(5k + 10) > 1$ (K is the number of studies evaluated.) indicates that it is resistant to publication bias (Mullen et al., 2001).

3. Results

3.1. Findings of the effect of using GeoGebra on students' mathematical ability

First, this study aims to examine the effect of using GeoGebra software on students' mathematical abilities. Based on the results of the transformation, the effect size and standard error of each effect size are obtained as presented in Table 1 below:

Based on Table 1, the overall effect size range is from 0.10 to 3.06. According to the category Thalheimer and Cook (2002), it can be checked that five effect sizes are classified as the excellent effect; the four effect sizes were classified as very high; fifteen effect sizes were classified as a high effect; six effect sizes were classified as moderate; the other three were classified as low effects. Only three studies had no effect. Table 2 shows the comparison of the results of the research according to the effects model.

As presented in Table 2, it is seen that according to the fixed effects model estimation, the overall effect size is 0.93, which is classified as high effect according to (Thalheimer and Cook, 2002). The homogeneity test results show that the Q value is 263.76, which is greater than the value of 49,801 in the $\chi 2$ table ($df = 35$; $p = 0.05$). Mean, the distribution of effect sizes is heterogeneous, and therefore the overall effect size was measured using a random effect model. Furthermore, based on the random-effects model, the overall effect size was 0.96, classified as a high effect. The Z-value was found to be 11.22 and, it is said to be statistically significant at the $p < 0.05$ level. The I-square value as 72% reveals the observed variance between studies due to a real difference in effect sizes, and about 28% of the observed variance is expected based on random error.

The study funnel plot included in this study is given in Figure 2 to determine possible publication bias.

Figure 2 shows an asymmetric distribution of effect sizes. Consequently, statistics from Rosenthal's fail-safe N (FSN) were used to assess the likelihood of publication. From the data analysis with the help of CMA software, the Rosenthal safe N value is 5065. Based on the formula (Mullen et al., 2001), $5065/(5 * 29 + 10)$ $5065/(5 * 29 + 10)$, the result of the calculation is 25.97. This estimate suggests that the studies analyzed were immune to publishing bias.

Table 1. Effect size and standard error of each study.

Order	Writer	Date	Effect Size	Standard error
Study 1	Aisyah	2015	1.26	0.29
Study 2	Anggroratri a	2014	0.32	0.31
Study 3	Anggroratri b	2014	0.15	0.31
Study 4	Annajmi a	2016	1.08	0.28
Study 5	Annajmi b	2016	1.01	0.24
Study 6	Atikasari & Kurniasih	2013	0.96	0.25
Study 7	Juandi & Priatna	2018	0.18	0.25
Study 8	Desniarti Siti	2018	0.91	0.33
Study 9	Erana et al.	2018	1.06	0.37
Study 10	Farihah	2015	1.31	0.28
Study 11	Fitra & Sitorusn	2019	0.66	0.30
Study 12	Fitra & Syahputra	2018	0.78	0.27
Study 13	Habinuddin	2018	0.63	0.20
Study 14	Hamidah et al.	2020	0.35	0.27
Study 15	Haris & Rahman	2018	1.03	0.25
Study 16	Jelatu et al. a	2018	1.11	0.28
Study 17	Jelatu et al. b	2018	0.73	0.38
Study 18	Jelatu et al. c	2018	1.08	0.45
Study 19	Khotimah	2018	0.68	0.23
Study 20	Kusumah et al.	2020	0.78	0.23
Study 21	Nurhayat et al.	2020	0.76	0.30
Study 22	Priyono & Hermanto	2015	0.1	0.24
Study 23	Purwasih et al.	2020	0.44	0.24
Study 24	Ramdani	2017	0.48	0.23
Study 25	Rosyid	2018	2.26	0.36
Study 26	Senjayawati & Bernard	2018	1.07	0.27
Study 27	Septian	2016	1.94	0.31
Study 28	Setyani & Lestari	2015	0.1	0.28
Study 29	Siswanto & Kusumah	2017	1.09	0.30
Study 30	Sumarni et al.	2017	3.06	0.54
Study 31	Supriadi et al. a	2014	1.66	0.34
Study 32	Supriadi et al. b	2014	2.04	0.37
Study 33	Supriadi et al. c	2014	1.05	0.36
Study 34	Sutrisno et al. a	2020	1.02	0.30
Study 35	Sutrisno et al. b	2020	1.04	0.30
Study 36	Usman & Halim	2017	1.11	0.25

Table 2. The research results are based on an estimation model.

Estimation Model	n	Z	p	Q_b	I-squared (p = 0.05)	Effect Size	Standard error	95% Confidence Interval	
								Lower limit	Upper Limit
Fixed effects	36	20.79	0.000	127.12	72.46	0.93	0.04	0.84	1.01
Random-effects	36	11.22	0.000	127.12	72.46	0.96	0.08	0.79	1.13

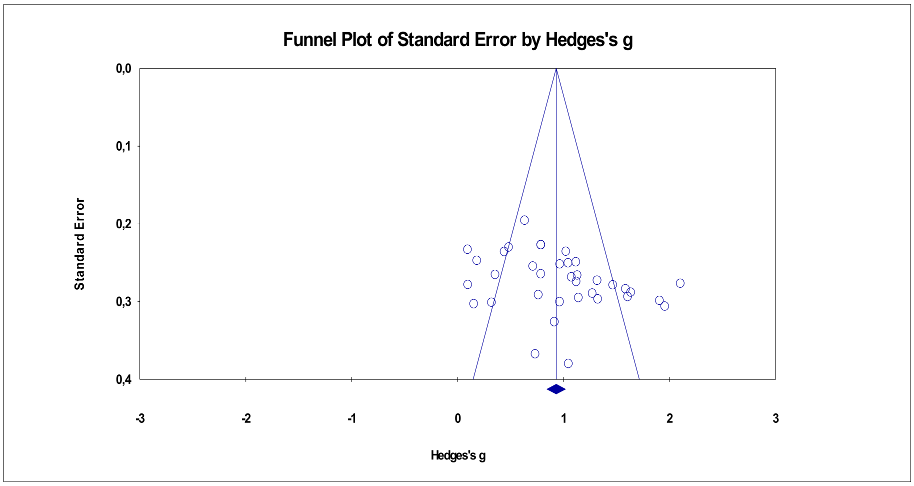

Figure 2. Funnel chart.

3.2. *Findings of effect size in terms of study characteristics*

Second, this study aims to examine the extent to which study characteristics moderate the study's effect size. For this purpose, 36 effect sizes were examined in terms of study characteristics, namely study year, the grade of education, sample size, comparison of students to the computer used, and treatment duration. Table 3 provides a summary of the results of the analysis.

Table 3 shows for all study characteristics, the p-value was found to be less than 0.05. This means that mathematics learning supported by the use of GeoGebra software is more effective than conventional teaching.

4. Discussion

The study's overall effect size was estimated at 0.96, according to the random-effects model, which indicates that the GeoGebra software has a high impact on students' math abilities. An effect size of 0.96 shows that the average student who is exposed to GeoGebra software is over 82 percent in traditional students who initially were comparable. The interpretation of these findings is that the average student ranked fifteen in the experimental group is comparable to students ranked sixth in the control group (Coe, 2002). This finding is supported by research Chan and Leung (2014) which found an overall effect size of 1.02 when they analyzed 587 studies that impact dynamic geometry software (DGS). Similar results have been reported in previous studies. For example (Turgut and Turgut 2018), conducted a meta-analysis of the effect of visualization on mathematics achievement using computer software. The mean effect size value calculated according to the random-effects model was 0.81, with a standard error of 0.07.

Furthermore (Turgut and Temur, 2017), reported an effect size of 0.79 when they analyzed 26 studies comparing computer software use to students' mathematical abilities. Finally (Kaya and Öçal, 2018), reported an effect size of 0.88 when they analyzed 36 studies comparing the use of DGS software on students' mathematical academic achievement in

Table 3. Analysis results based on primary study characteristics.

Study Characteristics	Group	n	Hedge's g	Heterogeneity		
				(Q_b)	df(Q)	p
Year of Study	2013–2014	7	1.04	4.32	3	0.03
	2015–2016	7	1.02			
	2017–2018	14	0.98			
	2019–2020	8	0.79			
Grade of education	College	5	0.98	3.64	2	0.31
	JHS	20	1.01			
	SHS	11	0.89			
Sample Size	30 or less	16	0.92	6.46	1	0.01
	31 or over	20	0.69			
The ratio of students to computers used	One computer for one student	16	1.12	6.12	1	0.01
	One computer for two or more students	20	0.81			
Duration of treatment	≤ Four weeks	12	1.11	7.62	2	0.03
	≥ Four weeks	18	0.85			
	Unspecified	6	0.92			

Turkey. Although the number of studies included in this analysis differed from the previous investigators' sample size, this study showed fairly similar software's use points to an overall trend.

Based on the year of research, it was found that research conducted in 2013–2014 had a larger effect size than the year after. Qb's statistical value was 4.32, which was smaller than the value of 3.841 (CI = 95%, p = 0.05). This indicates that the different years of research change the effect size of using Geogebra on students' mathematical abilities. This finding is very surprising and contradicts previous predictions that the size of using GeoGebra on the mathematical ability of students in recent years will be larger due to updated software and improved teacher quality. However, about previous findings, the results of this study are consistent with studies conducted by Kaya and Öçal (2018), Cheung and Slavin (2013), and Tamur et al. (2020c). The investigators found that the older study group's study effect size was greater than the effect size in the newer study group.

Based on the analysis results presented in Table 3, the effect sizes in the studies were conducted in junior high school (JHS) was 1.01 (high level), greater than the effect size in studies conducted in high school (JHS), namely 0.89 (high level). Descriptively, the combined effect size of studies conducted in junior and senior high schools was not different from the effect size of research conducted in tertiary institutions, namely 1.06 (high level). The value of Qb as 3.64 less than the value of 5.99 (CI = 95%, p = 0.05). This indicates that differences in education grades do not change the size of the effect of using GeoGebra software on students' mathematical abilities. These results are consistent with the findings of studies conducted by (Bayraktar, 2001) and (Cheung and Slavin, 2013), who found that the study effect sizes by the grade of education were not significantly different. However, these results differ from the findings of (Chan and Leung, 2014), who reported that the study group effect sizes in primary schools were larger than secondary schools and colleges. The difference in the results is another issue that can be investigated further.

The summary findings in Table 3 show, based on the sample size, that in studies conducted with 1–30 students, the effect sizes are 1.12 (very high), larger than in studies conducted with a total of 31 or more students, which is 0.79 (high) students. The value of Qb as 8.23 was found to be greater than the value of 6.46 (CI = 95%, p = 0.05). That is, differences in sample sizes change the effect size of using GeoGebra software on students' mathematical abilities. These results are consistent with a study conducted by (İ. G. Turgut and Turgut, 2018), who found that the study group effect size on the small sample was larger than the study group effect size in the large sample. However, these results differ from the findings of studies reported by Chan and Leung (2014), Turgut and Temur (2017), & Cheung and Slavin (2013), Who found smaller samples to have smaller sizes of effect than large samples. This difference in outcomes is another problem that can be further investigated.

Judging from the comparison of students and computers used, the summary of the results in Table 3 shows that the effect size in a one-to-one study, namely one computer unit for one student, is 1.12 (very high level) is greater than the effect size in the study. This is done with a comparison of one computer unit for two or more students equal to 0.81 (high level). The value of Qb as 6.12 greater than the value 3,841 (CI = 95%, p = 0.05), the 0.05 significance level. This indicates that the difference in the ratio of computers used in learning changes the effect of using GeoGebra software on students' mathematical abilities. These results are consistent with findings (Bayraktar, 2001), who found that the study group using computers individually achieved a better level of effectiveness than using computers. However, the current research did not discuss the impact of cooperation when one student learns with others. Nowadays, students can easily use his/her mobile or tablet to use the GeoGebra software.

The summary of results given in Table 3 shows that the effect size in the study group with a treatment duration of fewer than four weeks was 1.11 (very high level), greater than the effect size in the study with a treatment duration of more than four weeks, namely 0.85 (high level). Meanwhile, the study group whose treatment duration was not determined had an effect size of 0.92 (high level). The value of Qb as 7.62 greater than the value of 5.99 (CI = 95%, p = 0.05), the 0.05 significance level. That is, the difference in treatment duration in learning changes the effect size of using GeoGebra software on students' mathematical abilities. This finding is in line with the results of studies conducted by Bayraktar (2001), Chan and Leung (2014), and Tamur et al., (2021b), who reported that the effect size of studies with a treatment duration of fewer than four weeks, which is higher than the effect size of studies with a treatment duration of more than four weeks. However (Cheung and Slavin, 2013), in their study reported that the study group whose treatment duration was less than 30 min/week had a smaller effect size than the study group whose treatment duration was 30–75 min/week. Furthermore, the study group whose treatment duration was more than 75 min/week had a smaller effect size than the study group whose treatment duration was 30–75 min/week. These findings suggest that the use of computer devices in mathematics learning, such as GeoGebra software, should consider treatment duration. These findings provide accurate information that the use of Geogebra software in mathematics learning will achieve a high level of effectiveness if it is given in conditions of treatment duration of less than or equal to four weeks. This can be explained by the Hawthorne effect, namely the fact that students are encouraged to put in more effort simply because of the new treatment, and the effect becomes less pronounced if the treatment lasts for a long time. This fact is in line with the analysis results based on the research year that studies conducted in the longest year have a larger effect size than the year after.

5. Conclusions

Studies have been undertaken to integrate the results of the use of GeoGebra software on students' mathematical abilities and the different characteristics of the study. Some of the conclusions of the investigation are given below. First, the combined effect size is 0.96, based on the random-effects model estimation, and the standard error is 0.08. So GeoGebra software has a significant impact on the mathematical skills of students compared to traditional learning. Second, investigating the effectiveness of using GeoGebra based on the identified research characteristics revealed that it was more effective under certain conditions. For example, this analysis reveals that differences in sample size change the size of the effect of using GeoGebra software on students' mathematical abilities. The use of GeoGebra software is very effective in sample conditions less than or equal to 30. Third, differences in grade of education do not change the size of the effect of using GeoGebra software on students' mathematical abilities. Thus, GeoGebra software is recommended for use in JHS, SHS, and colleges. Fourth, this meta-analysis reveals differences in the ratio of computers used in learning to change the effect size of using GeoGebra software on students' mathematical abilities. The study group's effect size using the computer individually had more significant than the study group using the computer group. Thus, providing classrooms with a sufficient number of computers, allowing students to work individually rather than in groups, would be beneficial and recommended to achieve a higher effectiveness level. Fifth, this analysis also reveals that differences in treatment duration in learning change the effect size of using GeoGebra software on students' mathematical abilities. The use of Geogebra software in mathematics learning will achieve a high level of effectiveness if given in conditions that the duration of the treatment is less than or equal to four weeks.

The results of this analysis indicate that the use of GeoGebra software has a significant effect on mathematical abilities. However, these findings are based only on studies that meet the inclusion criteria. Many comparative studies have not been analyzed due to a lack of necessary statistical information. Variables of cultural differences and research locations based on the division of western, central and eastern Indonesia and the material being taught have not been identified in this study. It is suggested that further researchers conduct research by analyzing more related primary research and combining the results of research other than in Indonesia. It will give a more comprehensive result.

Declarations

Author contribution statement

Dadang Juandi, Yaya S. Kusumah, Maximus Tamur, Krisna S. Perbowo, Tommy Tanu Wijaya: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

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