

## Effects of GeoGebra on Students' Attitudes towards Learning Geometry: A Review of Literature

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### Abstract

The rapid growth of technology for teaching and learning of geometry includes the introduction of educational software commonly known as GeoGebra. However, a few studies were found that provide evidence on the effectiveness of this software on students' attitudes towards geometry. The present study aims to provide a comprehensive view of prior literature related to the effects of GeoGebra in enhancing students' attitudes towards geometry. The present study employed a systematic review. To collect data, the researcher downloaded journal papers, conference proceedings papers, and theses from different databases such as Google Scholar, Research gate, Academia, Research for life, and Education Resources Information Center (ERIC). Thus, 96 documents were initially obtained. After download, duplicating papers were immediately deleted. Thus, a deep analysis followed and 68 documents were filtered out. Twenty-three documents including 22 journal papers and one thesis remained for analysis. The reviewed literature showed that there are positive effects on students' attitudes towards geometry in terms of interest, engagement and active learning, self-efficacy and self-regulation, and enhanced positive attitudes. More than a half of authors (12 out of 23) employed quasi-experimental research design to investigate the effects of GeoGebra on students' attitudes toward geometry. Considering categories of attitudes identified, the majority of authors (8 out of 23) reported that GeoGebra enhanced students' interest to learn geometry.

Keywords: GeoGebra; geometry; students' attitudes towards geometry; teaching and learning geometry

### Introduction

Geometry is an important topic in the mathematics curriculum that deals with properties of lines, angles, curves, and shapes, etc. (Majerek, 2014). Geometry helps students to associate patterns in mathematics and equips students with the ability to apply acquired knowledge while solving real-life problems (Length, 2013). In an age of Science, Technology, Engineering, and Mathematics (STEM), it is critical that we motivate students at early age and turn them onto math through technology (Graziose & Ave, 2013). In addition, the digital challenges

found in education needs to be addressed through a combined effort that involves the distribution of ICT tools and recognition of every student's participation in interacting with these tools to ensure students' active learning (Ludvigsen, 2012; Majerek, 2014; Mehdiyev, 2009; Rwanda Education Board [REB], 2015). Within this regards, the use of digital technologies in teaching and learning can stimulate students' learning and fosters their attitudes towards mathematics in general, and geometry in particular (Hanč, Lukáč, Sekerák, & Šveda, 2011). One the technologies which is expected to potentially shape learners' knowledge acquisition and

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autonomy is GeoGebra (Uworwabayeho, 2009).

Literature studies on the effects of GeoGebra on students' attitudes were documented. For instance, Abu, Fauzi, Ayub, Su, and Ahmad (2010) showed that GeoGebra increased the confidence of the students, whereby students felt satisfied by using GeoGebra while learning mathematical concepts. GeoGebra was reported to be adequate in modelling real-world problems, supporting problem solving, providing visualizations and interactive illustrations, improving student motivation and cognitive development, and enhancing learner-centered pedagogy (LCP) (Calder, 2011). Through GeoGebra, students develop the positive attitudes of constructing their knowledge and understanding (Cox, Webb, Beauchamp, & Rhodes, 2004; Mehdiyev, 2009; Samur & Akyuz, 2016; Thambi & Eu, 2013; Yimer & Feza, 2019). Thus, using a computer algebra system and an interactive geometric dynamic system may likely enhance students' cognitive abilities and enhance their interest in learning mathematics in general, and geometry in particular (Dolonen & Ludvigsen, 2012).

There are some students who experienced negative attitudes towards geometry and started developing geometry-phobia (Bora & Ahmed, 2018). Students declared that they still have problems in learning geometry and are not confident enough to learn this topic (Hussin, Yusoff, Mustafa, & Mokmin, 2018). Likewise, "students often find geometrical concepts abstract and difficult to understand. This results into students' poor performance, which contributes to the declining of students' interest in learning geometry" (Bhagat & Chang, 2015, p. 77). However, it was argued that GeoGebra enhances the teaching and learning of mathematics and thus, can similarly lead to students' positive attitudes towards geometry (Hohenwarter & Lavicza, 2003).

This study is grounded in Vygotsky's social constructivism cognitive development learning theory that plays a vital role in learners' conceptual knowledge development (Yimer & Feza, 2019), whereby learners actively construct their knowledge (Rwanda Education Board [REB], 2015). Thus, GeoGebra is expected to motivate students to enjoy learning mathematical concepts while fighting math anxiety including negative attitudes towards geometry.

This review paper aims at exploring the effects of GeoGebra in enhancing secondary students' positive attitudes towards geometry. Gaining insights into students' attitudes and beliefs is most important most importantly for teachers to understand the learning environment of mathematics affected by the introduction of computers and other technologies (Grandgirard, Poinot, Krespi, Nénon, & Cortesero, 2002). Within the same vein, teachers' awareness about students' attitudes towards geometry is useful for teachers since they can recognize those students who have negative attitudes towards geometry and take timely and adequate precautions in return that may lead to students positive attitudes towards the learning subject (Aktas C. & Aktas Y., 2012). Studies providing evidence about this software effectiveness concerning students' attitudes are still rare (Arbain & Shukor, 2015; Singh, 2018; Ukobizaba, Ndiokubwayo, Mukuka, & Uwamahoro, 2019). In addition, to the best of my knowledge, no systematic review studies have been conducted on the effects of GeoGebra on secondary students' attitudes towards geometry. Hence, attitudes as students' feelings and behavioral tendencies towards geometry need to be investigated (Komar, 2019). To this end, the research questions guiding this study are:

1. What are GeoGebra's effects on secondary students' attitudes towards geometry?

2. What research designs are the most employed by authors to determine GeoGebra's effects on secondary students' attitudes towards geometry?
3. What is the attitude the mostly reported by the majority of authors about GeoGebra's effects on secondary students' attitudes towards geometry?

## **Methodology**

### *Research design*

The present study employed a systematic review as developed by Wu (2003), to answer to the research questions. The researcher conducted a comprehensive search for all journal papers and theses about the effects of GeoGebra on secondary students' attitudes towards geometry. Within this context, the researcher referred to Chrome browser to download journal papers, conference proceedings articles, and thesis from different databases such as Google Scholar, Research gate, Academia, Research for life, and Education Resources Information Center (ERIC). The downloaded papers are those published in peer-review journals from 2013 to 2021. The document search was done from 27<sup>th</sup> November to 30<sup>th</sup> November 2021.

### *Inclusion criteria*

The researcher set criteria to determine documents for analysis. For instance, the journal papers had to be written in English and related to secondary students' math education. Note that books, book chapters, and editorial materials, were excluded during document analysis. The researcher had to

read carefully the abstract and the conclusion before deciding which article to be considered for analysis or not.

### *Data analysis*

We used keywords such as "the effects of GeoGebra on students' attitudes towards geometry, GeoGebra in changing students' attitudes towards geometry, the attainment of Geogebra on students' attitudes to learn geometry" to obtain papers. The initial search collected 96 articles. The duplicated papers were immediately deleted. Thus, we remained with 68 article papers, conference proceedings papers, and theses.

To provide an effective comprehensive review, the researcher had to read and reread the document to make sure that the paper is fitting with the study's research questions. As a result, 23 papers remained for analysis including 22 journal articles and one thesis. All final samples were identified, including the content related to GeoGebra's effects on students' attitudes towards geometry, authors' names, the year of publication, and methodology used.

## **Results**

This section represents the analysis of journal papers, conference proceedings articles and thesis downloaded. The section is made of three parts including the effects of GeoGebra on students' attitudes towards geometry, the research design employed to investigate students' attitudes toward geometry, and the number of authors for each category of attitudes.

### *Effects of GeoGebra on students' attitudes towards geometry*

The first research question is analyzed in Table 1. Although the reviewed attitudes seem to be interrelated, the reviewed category shows that students became more engaged and learnt actively (Bayaga, et.al,

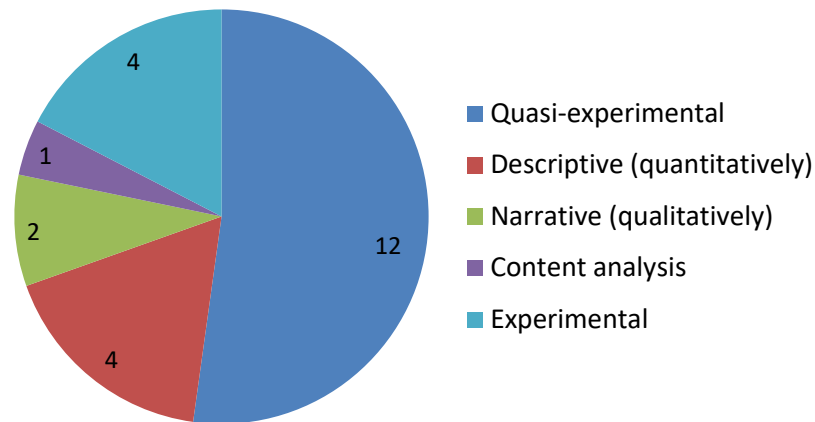
**Table1 Authors and the attitude studies identified**

SN	Authors (years)	Attitudes found
1	Arbain and Shukor (2015); Reis and Ozdemir (2010); Celen (2020); Daulay, Syafipah, Nasution, Tohir, Simamora, Saragih (2021); Murni, Sariyasa and Ardana (2017); Nzaramyimana, Mukandayambaje, Iyamuremye, Hakizumuremyi, and Ukobizaba (2021); Tamam and Dasari (2020); and Wah (2015).	Increase in students' interest to learn
2	Bayaga, Mthethwa, Bossé, and Williams (2019); Karmelita Pjanić and Liđan (2015); Kutluca (2013); Sariyasa (2016); and Shadaan and Leong (n.d)	Students' engagement and active learning
3	Hidayati, and Kurniati (2018); Şeker and Erdoğan (2017); and Zetriuslita, Nofriyandi, and Istikomah (2020)	Students' self-efficacy and self-regulation
4	Adegoke (2016); Almeqdadi (2018); Komar (2019); Septian, Suwarman, Monariska, and Sugiarni (2020); Sudihartinih, and Purniati (2018); Samur and Akyuz (2016); and Vasquez (2015)	Increase in students' positive attitudes (attitudes not specified)

literature was put into four categories of attitudes as shown in the Table 1. These categories are: An increase in students' interest to learn, students' engagement and active learning, students' self-efficacy and self-regulation, and an increase in students' positive attitudes. The Table 1 is comprised of the authors (years) and the type of attitudes found by researchers.

The reviewed literature shows that scholars started being interested on the effects of GeoGebra on students' attitudes towards geometry since 2013. In the first category, the table shows that students interested in mathematics in general and in geometry in particular, was increased after being taught through GeoGebra (Arbain & Shukor, 2015; Reis & Ozdemir, 2010; Celen, 2020; Daulay, Syafipah, Nasution, Tohir, Simamora, & Saragih, 2021; Murni, Sariyasa & Ardana, 2017; Nzaramyimana, et.al, 2021; Tamam &

2019; Karmelita Pjanić & Liđan, 2015; Kutluca, 2013; Sariyasa, 2016; Shadaan and Leong, 2013). For some authors in the third category, students' attitudes towards geometry were expressed as self-efficacy and self-regulation (Hidayati, & Kurniati, 2018; Şeker & Erdoğan, 2017; Zetriuslita, Nofriyandi, & Istikomah, 2020). Although not specified, in the fourth category, it was generally found that students' attitudes became positive after being taught through GeoGebra (Adegoke, 2016; Almeqdadi, 2018; Komar, 2019; Septian, et.al, 2020; Sudihartinih, and Purniati, 2018; Samur and Akyuz, 2016; and Vasquez, 2015). It is shown that the use of GeoGebra in teaching and learning of geometry has generally and positively changed students' attitudes toward geometry in a positive way.



**Figure 1: Research designs used with the corresponding number of authors**

*Research designs employed by authors to investigate students' attitudes toward geometry*

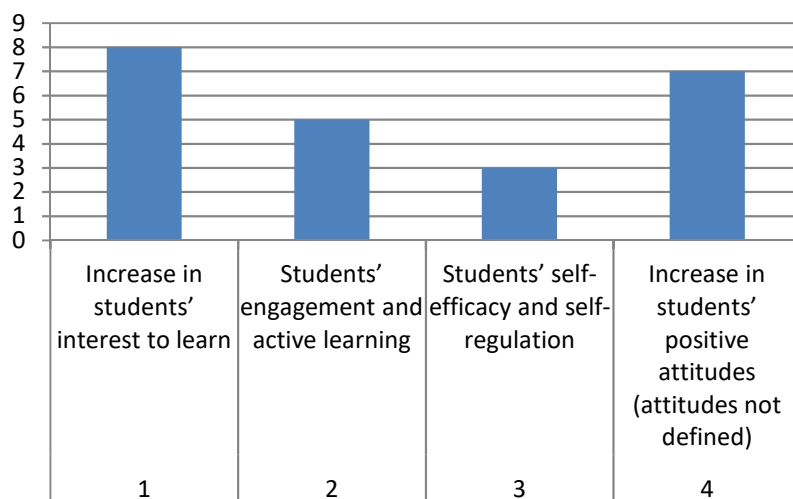
In respect to the second research question, the Figure 1 illustrates the research designs employed by different authors to investigate the students' attitudes toward geometry. These research designs include quasi-experimental, descriptive, narrative, content analysis, and experimental research designs (see Figure 1).

The Figure 1 shows five research designs employed by different authors. The quasi-experimental was employed by 12 out of 23 authors. The quantitative descriptive research

design was employed by four authors, while the narrative research design was used by two authors. However, one author referred to content analysis to determine students' attitudes, while four authors were found employing experimental research design. It is clear that the quasi-experimental research design dominated, whereby more than a half of authors (12 out of 23) used this research design.

*The number of authors and the corresponding attitudes*

To answer to the third research question, the Figure 2 displays the number of authors about the four identified categories on students' attitudes toward geometry.



**Figure 2** Number of authors with corresponding attitudes

When analyzing based on the number of authors for each category about the students' interest towards geometry, it is shown that eight out of 23 authors found the increase in students' interest to learn geometry. Five out of 23 authors reported students' engagement and active learning, while three authors found students' self-efficacy and self-regulation. On the other hand, seven out of 23 authors reported the increase in students' positive attitudes towards the learning geometry. It is generally shown from the Figure 2 that the majority (15 out of 23) of authors found the increase in students' interest to learn geometry and positive attitudes toward the topic.

### Discussion

The current study explored students' attitudes towards geometry after being taught through GeoGebra. As results, the reviewed literature showed that there are positive effects on students' attitudes towards geometry in terms of interest, engagement and active learning, self-efficacy and self-regulation, and enhanced positive attitudes. Within this regard, the current findings are in line with

the previous studies (eg. Arbain & Shukor, 2015; Septian, et.al, 2020; Sudihartinih & Purniati, 2018; Samur & Akyuz, 2016). For instance, Komar (2019) in his study on the effect of GeoGebra and web-based practice on attitude and performance in coordinate geometry among students of Colleges of Education in North West Zone, Nigeria, the author used a quasi-experimental research design and found that there is a significant change in students attitudes towards coordinate geometry when students were taught by using GeoGebra. Similarly, while Samur and Akyuz (2016) was studying on the effects of dynamic geometry use on eighth-grade students' achievement in geometry and attitude towards geometry on triangle topic, the author used a quasi-experimental study and found that GeoGebra has an impact on positive attitudes towards geometry compared to traditional teaching.

Indeed, GeoGebra was found to be an effective option for schools from urban areas to rural areas since it is freely downloaded and used within schools where internet connection is still a dream (Bhagat & Chang,

2015). Thus, there is an increase in students' confidence whereby students enjoy and feel satisfied using GeoGebra during teaching and learning (Abu, Fauzi, Ayub, Su, & Ahmad, 2010; Daulay, et.al, 2021; Tamam & Dasari, 2020). Through GeoGebra, students developed positive attitudes in constructing their knowledge and understanding (Thambi & Eu, 2013; Yimer & Feza, 2019). Students' motivation and attitudes to learning are shown in learners' commitment to do tasks, having an interest in the subject where students take responsibility for their learning, even making an effort to tackle the difficult tasks (Cox et al., 2004). Thus, with the integration of technology in teaching and learning of geometry, students have to show their competences through an active learning (Majerek, 2014; Mehdiyev, 2009). To this end, students will use ICT tool like computers, whereby these tools will become mediators between learners and the task in place (Alqahtani & Powell, 2016).

In relation to the second research question, it is shown that the majority of authors (12 out of 23) referred to quasi-experimental research design to explore the effects of GeoGebra on students' attitudes toward geometry. This design consisted on identifying two groups, the experimental and a control group. Thus, both groups have to be given a pre-test before the intervention, and later given the post-test after the intervention to see the effects. The intervention in this context is the integration of GeoGebra in teaching and learning of geometry for the experimental group (e.g., Adegoke, 2016; Arbain & Shukor, 2015; Bayaga, et.al, 2019; Kutluca, 2013; and Zetriuslita, Nofriyandi, & Istikomah, 2020). Note that the authors can at the same time conduct both students' performance and students' attitudes.

In regards to the third research questions, the number of all the reviewed literature about students' attitudes seems to be balanced. For instance, if the second category is merged

with the second category since they both almost mean the same (see Figure 2), the number of authors in this merged category will become eight out of 23, while the first category has also eight authors, and the fourth category has seven authors. Although not specified which attitudes were exhibited by students, the majority of authors (8 out of 23) reported that there is an increase in students' interest to learn (eg. Arbain & Shukor, 2015; Celen, 2020; Daulay, et.al, 2021; Murni, Sariyasa & Ardana, 2017; and Reis & Ozdemir, 2010). However, all the identified attitudes are interrelated in a way that they may prevent us from putting them into categories. For instance, once students are interested, this means that they also have positive attitudes towards the subjects, which leads to active learning (engagement) and self-efficacy (self-regulation), as also supported by Vygotsky's social constructivism cognitive development learning theory (Yimer & Feza, 2019).

## Conclusion

This study aimed at reviewing studies on the effect of GeoGebra on students' attitude towards geometry. Twenty-three among 96 journal articles, conference proceedings papers and theses were downloaded and subjected to analysis. The results analysis of the reviewed literature showed a significant impact in using dynamic geometric software (DGS) on students' attitudes towards geometry, based on the evaluated DGS's attributes such as students' interest, engagement and active learning, self-efficacy and self-regulation, and enhanced positive attitudes. More than a half of authors (12 out of 23) referred to quasi-experimental research design to explore the effects of GeoGebra on students' attitudes toward geometry. Also, based on categories of attitudes identified, the majority of authors (7 out of 23) reported that, students' attitudes increased after being taught geometry through GeoGebra. We conclude that secondary students can learn

effectively with enhanced attitudes towards geometry when GeoGebra is used.

### **Limitations**

The present study explored the effect of GeoGebra on students' attitude towards geometry. This study may provide the research-based evidences to mathematics teachers and educationists in general about the correlation between the usage of GeoGebra and students' attitudes towards geometry. Although during the study different databases were used, intending to reach the wide range of the literature, there are limitations to be considered. First, the visited databases are still limited and did not maximize the literature related the effect of GeoGebra on students' attitude towards geometry. Once maximized, thus the results may differ. Second, papers related on students' attitudes in primary schools and universities were excluded from the analysis.

### **Recommendations**

Based on the identified limitations, the researcher suggests that more databases should be visited to maximize and get a wider range of the literature. This is intended to provide a more holistic view of scientific information about the effects of GeoGebra on students' attitudes toward geometry. Since we were limited only on secondary students, further studies may also be carried out on primary and university students about their attitudes toward geometry through DGS.

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