The Importance of Dynamic Geometry Computer Software on Learners' Performance in Geometry

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Abstract: The use of dynamic geometry computer software (DGCS) is important in educational environment, and it is more advantageous for learning mathematics comprehensively. This study examined the importance of dynamic geometry computer software on learners' performance in geometry. A quasi experimental, non-equivalent control group was used. The instrument used in this study was geometry achievement mathematics test (GMAT) that comprised 15 multiple choices items. The GMAT was administered to 87 grade nine learners in two secondary schools in Tshwane south district, Gauteng Province South Africa. One school was used as experimental group and the second school was used as the control group. Data analysis employed the use of the statistical t-test independent sample. The result of the study shows that using DGCS is important in geometry whereby it improves the performance of learners. In addition, the results show that the software affects the female learners' mathematics performances more positively than the male learners. Hence, the results of this study showed that there is great potential in using the DGCS (GeoGebra) to teach secondary schools mathematics. The study recommends that the use of technology in teaching and learning of mathematics should be a priority in the schools.

Keywords: Dynamic Geometry Computer Software, GeoGebra, Geometry Mathematics Achievement, Mathematics Performance, Information and Communication Technology

1. Introduction

For quite a number of years now, technology has become part of almost all area of our lives. Recently, Information and Communication Technologies (ICTs) are being integrated into the learning environment as well. In South Africa, National Department of Education (NDoE) and Department of Communication (DoC) came with a strategy on ICT in education which was the foundation of e-Education White Paper that was adopted in 2004. According to the White paper, it was proposed that, every learner in primary and secondary schools sector should be capable of ICT (Isaac, 2007). This indicates that, ICTs should be used assertively and creatively to help individuals to develop the skills and knowledge that are needed to meet the expectations of the 21st Century education and society. In addition, the use of ICT helps achievement of individual personal aims and objectives as well as enabling individuals to participate fully internationally (Department of Education, 2004). In line with the policy, many schools in various provinces in South Africa were equipped with ICT devices such as computers, internet connectivity, tablets and mobile devices to conduct teaching and learning (Farley, Gerard, Sayre and Carter, 2015). This technology integration also provides training for school educators in order to use the equipment and to facilitate teaching and learning in the class through modern technology (Gauteng Department of Education 2016).

In Mathematics classroom, the use of technology helps learners and teachers to perform better calculations, analyse data and enhances the exploration of mathematics concepts, thus resulting in permanent and effective learning in Mathematics (Akgul 2014). Since ICT is significant in educational environments, there is a need to resolve which way of using technology is more advantageous for learning mathematics comprehensively. Integration of technology in mathematics education is mainly done through the use of computers in the learning environment (Akgul 2014). Web-based interactive learning objects, interactive applets, spreadsheets, and graphing programs are some types of computer applications, which are currently being used in mathematics education through computer (Shields and Behrman, 2000).

In South Africa, the integration of technology to teach at both primary and secondary schools has improved learners' achievement in mathematics and some other subjects (Naidoo and Govender, 2014). Nevertheless, general report on learners' performance in mathematics has not been encouraging (Spaull, 2013). This has

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been a cause of concern to educators, government, parents and the public. Research studies have reported a number of defects in teaching and learning of mathematics (Howie, 2003; Mji and Makgato, 2000). For example, the Trends in International Mathematics and Science Study (TIMSS) 2011 reported that South Africa demonstrated low performances at grade 9 levels for both mathematics and science. School-leaving National Senior Certificate (NSC) matriculation examination poor performance was a cause of concern to the general public (Spaull, 2013). Reports revealed that there is a decrease in proportion of learners taking mathematics and decrease in number of learners passing NSC mathematics (DBE, 2015; 2016).

The research reports presented revealed that there is a critical issue regarding teaching and learning mathematics in South Africa (Mji and Makgato, 2006; Yilmaz, Altun and Olkun, 2010; Dhlamini, 2012; Luneta, 2015; Arbain and Shukor, 2015). Mathematics can be regarded as a challenging subject; also, learning mathematics involves understanding the theories and formulae in order to describe the given concept (Arbain and Shukor 2015).

In the typical classroom of mathematics, the challenges of learners are; difficulties to comprehend and psychosocial factors. The challenges include; negative attitudes, mathematics anxiety, poor study habits, and poor problem-solving behaviour (Department of Basic Education, 2014). For a learner to have difficulties to comprehend a concept of mathematics is a challenge that requires attention. Hence there should be a way of improving learners' ability to understand and elevate their performances in mathematics. This study therefore investigates the importance of dynamic geometry computer software (technology) on grade nine learners' performances in geometry.

Research questions

The research questions for this study are as follows:

- Is there a significant difference between learners' mathematics performance in experimental and control groups after the intervention of dynamic geometry computer software?
- Is there a significant difference between male learners' mathematics performance in experimental and control groups after the intervention?
- Is there a significant difference between female learners' mathematics performance in experimental and control groups after the intervention?

2. Review of literature

An essential factor of quality mathematics education is the appropriately use of technology in teaching and learning mathematical concepts (Yanik, 2013). According to Principle and Standards for School Mathematics documents [NCTM], (2000), technology is very crucial in teaching and learning mathematics; this influences mathematics that is taught and enhances learners' learnings. Use an alternative term Technology, according to Clark-Wilson and Mostert (2016) facilitates mathematics teachers to construct lessons' resources that include a precise mathematical content and illustration. In addition, it gives a prospect for learners to be propelled to mathematical ideas and perceptions in new ways. In the classroom, technology is used for exploring the mathematics curricula (Clark-Wilson and Mostert, 2016:3). It is essential to teach mathematics concepts with technology which can be the way that will give learners the capability to solve factual problems encounter with conventional method (Tezer and Cumhur, 2017). One of the essential areas of mathematics curriculum that can be explored by technology is geometry.

As far back as 1844 geometry was listed as university entrance requirement in the United State. Since then, geometry has been a stable part of secondary school mathematics curricula (Hollebrands and Stohl Lee, 2011). The reason for including geometry is mainly based on its applicability to the world around us. Geometrical tools have been an important part of learning geometry. These tools have transformed from physical objects, such as a compass and straightedge (ruler), to technological tools such as computer and handheld like graphing calculators and iPad (Hollebrands and Stohl Lee, 2011).

Further, geometry is generally collected with study of abstract idea, such as points, that have no dimension or lines of one dimension that go on without end. These objects can only be imagined in the mind. Geometry is a visual subject and it is difficult to imagine thinking geometrically without sketching a picture or using some variety of visual objects to represent an abstract geometric idea. Learners often have difficulty reasoning about representation of different geometric objects. Also, representation can sometimes difficult for learners to interpret (Hollebrands and Stohl Lee, 2011).

Geometry textbooks in schools provide representation of figures or shapes only with pencil and paper. Textbook-based illustration may not be comprehensive, because there will be no detail visual description of a complete dynamic process needed for the construction of geometrical concept (Denbel, 2015). Textbook cannot visualize the dynamic nature of geometrical figures on paper. As a result, learners are compelled to mentally look into the possible properties of geometrical objects without an external way to increase understanding of the related concepts (Denbel 2015). Therefore, learners often fail to develop insights into the taught concept (Mehdiyev, 2009; Denbel, 2015). This problem remains persistent in teaching and learning in geometry environment which lacks dynamic feature that may facilitate the justification and validation of definitions, axioms and theorems in a perspective manner (Mehdiyev, 2009).

To supplement the pencil and paper in teaching geometry and to bring motivation on the part of learners, a new environment was proposed by researchers (Laborde, 2001; Flores 2002; Hohenwarter and Jones, 2007). The researchers suggested that the use of technology improves learners' understanding and therefore recommends dynamic geometry environment for teaching and learning geometry (Ding and Jones 2006). Dynamic geometry environments (DGEs) are particular technology tools that have been used in the teaching and learning of geometry to assist learners in moving beyond the specifics of a single drawing to generalisations across figures and shapes (Hollebrands and Stohl Lee, 2011). Dynamic geometry environments (DGEs) have been used in mathematics classrooms, mostly in secondary schools and colleges setting, since the late 1980s. Dynamic geometry environments (DGEs) provide ways of representing and manipulating geometric objects that are not possible with paper, pencil, compass, and straightedge alone. These various environments allow different opportunities for learners to employ with geometric objects and their procedures. Also, the environments have the potential to help learners develop different understandings of many properties and theorems. In contrast to the conventional environments that can be called paper-pencil environment, DGCS provides learners with potential prospects in terms of making assumptions, testing and exploring theorems and relations (Guven and Kosa, 2008).

In the dynamic environments, learners explore mathematics because the environment provides learners with a sense of control, which means there is no timidity among learners if anyone makes mistake. Also, learners gain confidence in solving mathematical problems; and the use of dynamic geometry computer software is likely to change the attitude of learners to mathematics even when they experience difficulties (Naidoo and Govender, 2014). The understanding of the concept will offer a base from which learners develop insights into the geometry concepts and ideas as well as skillfully apply them in solving problem (Uddin, 2011). Hence, teaching and learning mathematics with dynamic geometry computer software tool will help the learners to understand geometry concepts.

According to Kilic (2010) learning of geometry involves visualisation and constructions of images (shapes and patterns) of geometric concept. Similarly Kutluca (2013) and Özçakir (2013) also agreed that in learning geometry learners should be able to develop some basic skills. These skills comprise of logical thinking abilities, spatial intuition about the universe, comparing and generalising, being careful and patient, reading and comprehending of geometrical concept. Hence the intervention with dynamic geometry computer software will increase learners' understanding in logical reasoning in mathematical concepts and enhances their performance.

2.1 Dynamic geometry computer software in mathematics

The use of computer software in geometry is becoming widespread gradually in advanced countries like USA, UK, Nepal, India, China, Malaysia, most especially in Turkey. In most of these advanced countries' schools, mathematics curricula are being supported by the use of dynamic computer software to carry out mathematics instructions (Guven and Kosa, 2008; Akgül, 2014). However, in developing country such as South Africa, technology tools have not been used in teaching geometry. Dynamic Geometry Computer Software (DGCS) focuses on the teaching and learning of Geometry, mainly Euclidean Geometry, and solving the problems with respect to geometry concepts (Doktoroglu, 2013). It also focuses on the relations among points, lines angles, polygons, circles and other geometrical concepts (Sangwin, 2007). The term "dynamic'" means to manipulate, resize and to drag the figure to examine the differences. Dynamic geometry computer software (DGCS) are the computer software which allow the users to construct geometry figures or shapes, to measure the variables of the shapes and determine the properties of them (Akgul, 2014). It allows the users to drag figures through the screen, make geometric constructions, explaining facts about these constructions and test them so that the user will make generalization about the facts. Dynamic geometry computer software includes GeoGebra, Cabri 3D, Geometer's sketchpad and Cinderella, all offers teachers and learners a useful facilities for using both Computer Algebra System (CAS) and Dynamic Geometry systems (DGS) together (Hohenwarter and Lavicza, 2009; Akgul, 2014).

Naidoo, (2014) claim that the integration of DGCS in learning geometry enhances the construction knowledge, in addition, the communication and dissemination of ideas in the geometry classroom. The interactive learning environments of DGCS support the teaching and learning of abstract geometrical concept in mathematics (Naidoo, 2014). According to Naidoo and Govender (2014) DGCS influenced learners in two ways, which are; learner-centred education and self-regulation. These researchers claim that DGCS make learners think independently, therefore teachers act as facilitators, who only assist learners when encountering problems. Through the use of DGCS, learners apply self-regulation since they work on their own. According to Yaacob, Mohamed and Ariffin (2016) DGCS help learners in mastering the computer technology and improve their skills in geometry. Koparan and Yilmaz (2015) concluded that DGCS contributes more to the prospective teachers in the setting of intersection surfaces (3D objects) than the process in which pencil and paper are used. Therefore, the DGCS has been found to be an effective tool in teaching 3D objects in geometry. DGCS can be expressed as: Cabri geometry, Geometers' sketchpad, Cinderella and GeoGebra. GeoGebra is particular appropriate DGCS for this study.

2.2 GeoGebra

GeoGebra is interactive computer software that has played a very important role in teaching and learning of geometry in secondary schools. The software can be downloaded by teachers or students or any individual to use at home and explore the idea without an instructor. GeoGebra computer software application can be run without an internet connection when installed on a personal computer, it can run within a web browser as well. GeoGebra provides a platform for high-level of thinking particularly for the teachers while learners engage with the interactive features of the software such as learning from the feedback, seeing patterns, making connections and working with dynamic images (Edwards and Jones, 2006).

GeoGebra is able to work across various platforms, including *Windows*, *Macintosh*, *Linux* and *UNIX*. The advantage of the software is that it is free software developed for teaching and learning mathematics in primary and secondary even on to the tertiary level. The application software supports an extensive ranging of mathematics from algebra and geometry construction to calculus and 3-D. GeoGebra could be used with technological devices such as interactive smart boards and tablets. The GeoGebra computer software encourages multiple representations (graphs, equations as well as tables). In other words, GeoGebra provides to see graphical, numerical and algebraic representations of mathematical object on the same screen with the graph been displayed on the graphic view. Therefore, different illustrations of the same object are brought together dynamically and any alteration in one of these illustrations is automatically changed to the other ones. The basic objects in GeoGebra are points, vectors, segments, polygons, straight lines, all conic sections and functions in x and with GeoGebra dynamic constructions can be done like in any other DGCS (Hohenwarter and Fuchs, 2004). The software could be used for flipped classroom and differentiated instruction. It also improves teachers' professional development in preparing lesson materials that could be used as a collaboration and illustration tools. The software was developed by Hohenwarter and Yves Kreis in 2001 and incorporates multiple mathematics trends into one single, open-source and user-friendly software. Figure 1 shows the displayed graphic view in the GeoGebra window

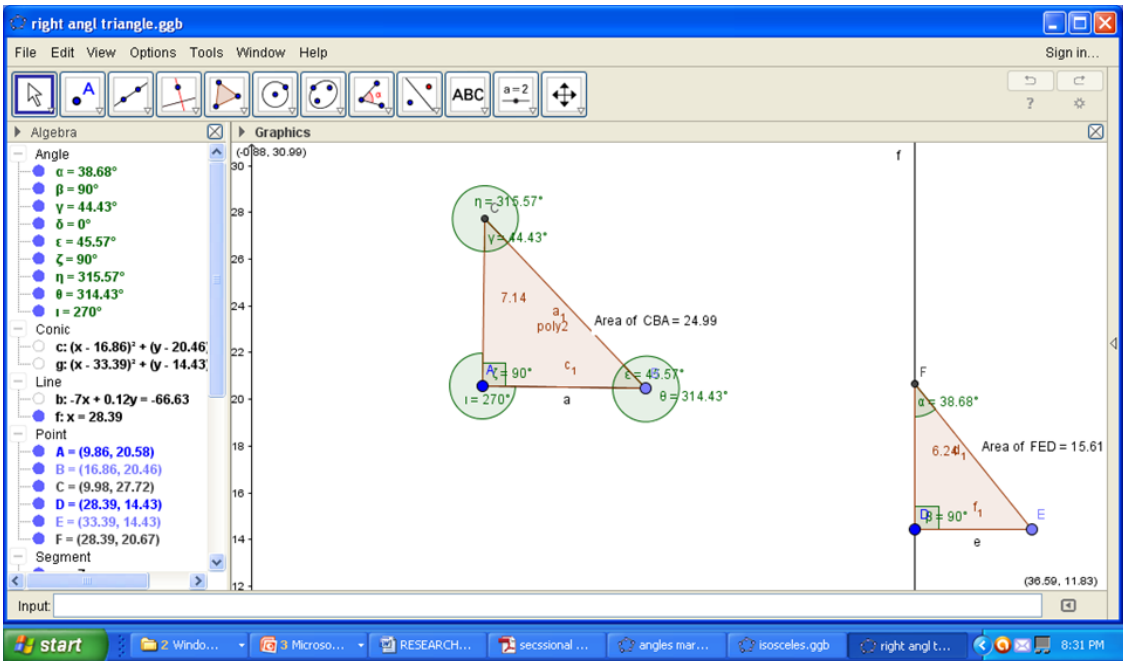

Figure 1: The displayed graphic view in the GeoGebra window

Previous research studies have shown that GeoGebra computer software in teaching mathematics contents is more effective than the conventional teaching that is pencil and paper. Some of the studies that have been undertaken in an attempt to understand the effects of the software on learners' performance and attitude are explored.

Zengin, Furkan and Kutluca (2012) deduced in their research that the used of GeoGebra is more effective on learners' learning than conventional method in mathematics education. Martinez (2017), conducted a quasi-experiment non-equivalent research study where the null hypothesis was accepted. However, the experimental group post test scores were higher than the control group. The researcher concluded that GeoGebra computer software could have positive effect on learners learning the high school geometry standards, though the researcher suggested more research on this aspect. According to Arbain and Shukor (2015), teaching and learning mathematics should not be focused purely on the theoretical, but also a diversity of learning approaches that involve the use of teaching materials confirmed to help stimulate learners' interest in mathematics. Therefore, the conclusion of these researchers is that dynamic geometry computer software has positive impact on the learners' achievements especially in statistics. Also, learners have positive opinion about the software in terms of enthusiasm, confidence and motivation. A quasi experiment conducted by Zulnadi and Zamri (2017) showed statistically significant differences in procedural and conceptual knowledge of learners who use dynamic geometry computer software (GeoGebra) and learners taught using conventional method in mathematics functions. These researchers claimed that using GeoGebra strengthens and enhance procedural and conceptual knowledge of the learners than conventional method in mathematics functions.

Selvy, Johar and Ansari (2016), concluded that experimental group was in very good category and individual learners are in the excellent category. This means that dynamic geometry computer software (GeoGebra) enhances the understanding of the learners about reflection. The use of the software also motivates and creates interest in the learners to learn mathematics. Adegoke (2016) concluded the non-equivalent pre-post control group design research that incorporating DGCS (GeoGebra) in learning mathematics improves learning outcome and performance of learners. The finding of Dijanic and Trupcevic (2017) showed that computer guided discovery learning model by using dynamic geometry computer software interactive applets in mathematics teaching had certain perspectives which resulted in better acquisition of both procedural and conceptual knowledge than does conventional teaching of mathematics.

2.3 Gender differences in using technology for learning mathematics

Considering gender differences in the use of technology (computer) studies indicated that male learners have advantage over female learners in the use of technology (Kay, 2006; 2007; Batol and Aspray 2006). In the ability to use computer, females reported feeling helpless, nervous and uncomfortable around computers. Also, male was rated higher than female in technological skills and ability (Wong and Hanafi, 2007; Houtz and Gupta, 2001; Shashaani and Khalili, 2001). Another study indicated that most females tend to view technology as a tool while males tend to view technology as a toy (Eck, Hale, Ruff, and Tjelmeland, 2002; Bebetsos and Antoniou, 2009). On the contrast, according to Fatemi, Rostamy-Malkhalifeh and Behzadi (2012), the use of software and electronic context in mathematics education has positive efficiency for female learners. The researchers concluded that the feedback was better among female than male learners, however, the use of software and electronic procedure helps both male and female in mathematics. Furthermore, the study of Caliskan and Kesan (2013) revealed that there was no significant difference between geometry achievement and retention levels of learners in experimental and control group after the application of DGCS in terms of gender. The researchers concluded that both conventional method and teaching geometry with DGCS have not produced a difference on male and female learners' achievement and retention levels. In contrast to this, the study conducted in two schools in Australia by Forgasz, Leder and Vale (2009) indicated that male learners were more likely than female learners to believe that computer software used would improve their mathematical understanding. The researcher also, claimed that, the effects of computer usage in lower grades are more likely to be advantageous to males' learning mathematics.

3. Research design and methods

In order to address the research questions, a quantitative approach with the use of case study quasi experimental research design was employed. A quasi experimental, non-equivalent control group was used. In the quasi-experimental design, groups are considered non-equivalent as they are not randomly selected. Therefore, non-equivalent groups specifically mean that participant individuality may not be balanced equally among the control and the experiment group (Cohen, Manion, and Morrison, 2007). Non-equivalent groups also means that participant' experiences differ during the study that is; some receive treatment and some may not receive (Heiman, 1999). The reason for using a quasi-experiment was that it was not possible the researcher to assign the learners randomly into two groups because of differences in the schools. The study was conducted in Tshwane South District Gauteng Province South Africa. Convenient and purposive sampling were used to select the participants of the study. Two schools with regular grade nine learners were conveniently and purposively selected. One of the two schools was used for the experimental group because there was availability of computer laboratory, while the other school was used as the control group because computer laboratory was not available. A total number of 87 regular grade nine learners participated in the study.

The instrument used in this study was Geometry Mathematics Achievement Test (GMAT). The GMAT was used as pre-test and posttest to examine learners' performance in both experimental and control group. Fifteen (15) items of a standard geometry test was adopted to form the (GMAT) test. The control group was taught geometry (similarity and congruent triangle) by the teacher using conventional method while the experimental group was taught geometry by the researcher through the use of DGCS. Prepared activities on similarity and congruent triangles were given to the learners in the experimental group through the computer software, while the control group used textbook and chalkboard for their activities. The Learners were guided to learn and ensured their understanding on these aspects of geometry. The pre-test (GMAT) was administered to both groups at the beginning of the experiment. The topics were very new to the learners at the commencement of the experiment, though, they might have had the knowledge of such in their lower grades. The GMAT was administered to both experimental and control groups again as posttest to compare learners' performance. The time allocated for the test was 30 minutes and the study lasted for eight weeks.

Reliability of the instrument was established using Cronbach's alpha coefficient which was 0.9. The distribution of participants to experimental and control groups is illustrated in table 1 below.

Table 1: Number of learners in the study

Group	Male	Female	Total
Experimental	19	18	37
Control	23	27	50
Total	42	45	87

Using DGCS (GeoGebra) as intervention in this study, the experimental groups of learners were introduced to the computer set of task within GeoGebra. The section was done for the first and second lesson of the study. The main aim was to orientate the learners to the computer software (GeoGebra); exploring and introducing different menu options as well as familiarising them to the use of the software. Specifically, orientation was on basics icons used within the software for geometry. The major idea of the researcher at this section of the experiment was to let learners experience the features of the software and to create motivation and interest in learners towards the use of the software and mathematics. Dynamic geometry computer software [DGCS] (GeoGebra) was used to create applets representing similar and congruent triangles taught in this research study. Twelve applets were designed to represent the planned similar and congruent triangles by the researcher. The data collected from both groups was analyzed using statistical t-test to find the improvement of learners' performance.

To analyze the quantitative data collected during the research, statistical t-test for two independent samples was performed. For that purpose, Microsoft Excel 2016 was used to observe whether there is significant difference between the two groups. The significance of the difference between the mean scores of the groups interpreted as $p < 0.05$.

4. Results

Analysis of the pre-test and posttest geometry mathematics achievement test scores were conducted using Microsoft Excel 2016. The pre-test result for both experimental and control group are presented in Table 2.

Table 2: Results of the statistical t-test independent sample on the pre-test of experimental and the control groups

Group	N	Mean	SD	T-value	DF	P(2 tailed)
Experimental	37	31.11	8.75	0.788	85	0.433
Control	50	29.36	10.99			

T-value significant at $p<0.05$

The statistical t-test independent samples' results indicates that there is no significant difference between the experimental group (M = 31.11, SD = 8.75) and control group (M =29.36, SD = 10.99). The t value (85) = 0.788, $p = 0.433 > 0.05$. This result answered the first research question whether there is a significant difference between mathematics performance of learners in experimental and control groups before the intervention. The indication means both the experimental and control group were in the same level of mathematics performance before the commencement of the experiment.

To answer the first question, is there a significant difference between learners' mathematic performance of experimental and control groups after the intervention of dynamic geometry computer software? Table 3 shows the computed results of statistical t-test independent sample on the post-test of both groups.

Table 3: Results of the statistical t-test independent sample on the post test of experimental and control groups

Group	N	Mean	SD	T-value	DF	P(2 tailed)
Experimental	37	41.81	9.27	2.970	85	0.004
Control	50	34.88	11.54			

T-value significant at $p < 0.05$

The statistical t-test independent samples' result indicates that there is statistically significant difference between the post-test mean scores of the experimental group (M = 41.81, SD = 9.27) and the control group (M = 34.88, SD = 11.54). The t value (85) = 2.970, p = 0.004 < 0.05. Therefore, there is a statistically significant difference between the two groups with regards to their performance in geometry after using DGCS to teach the experimental group. This implies that learners who use DGCS achieved higher scores than the learners taught by the conventional method (control). Furthermore, the mean score of the experimental group is substantially higher than that of the learners from the control group.

Table 4 shows the result of statistical t-test independent sample on the posttest of male learners score in experimental and control groups to answer the third questions whether there is a significant difference in their performance after the intervention.

Table 4: Results of the statistical t-test independent sample on the posttest of male learners' scores in experimental and control groups

Group	N	Mean	SD	T-value	DF	P(2 tailed)
Experimental	19	40.05	8.38	1.235	40	0.224
Control	23	36.17	10.98			

T-value significant at p < 0.05

The statistical t-test independent samples' result shows there is no significant difference between the posttest mean scores of the male of the experimental group (M = 40.05, SD = 8.38) and the control group (M = 36.17, SD = 10.98). The t value (40) = 1.235, p = 0.224 > 0.05. The indication of this result means that the dynamic geometry computer software does not have effect on the male learners' mathematics performance in the experimental group. Even though, the mean score in experimental group (40.05) is higher than the mean scores in control group (36.17) but the level of significant is greater than 0.05, hence there is no statistically significant difference between both groups on male learners.

Table 5 shows the result of the statistical t-test independent sample on the posttest of female learners score in experimental and control groups to answer the fourth questions whether there is a significant difference in their performance after the intervention.

Table 5: Results of the statistical t-test independent sample on the posttest of female learners' scores in experimental and control groups

Group	N	Mean	SD	T-value	DF	P(2 tailed)
Experimental	18	43.67	9.79	2.862	43	0.0006
Control	27	33.78	11.89			

T-value significant at p < 0.05

The statistical t-test independent samples' result shows there is no significant difference between the posttest mean scores of the female of the experimental group (M = 43.67, SD = 9.79) and the control group (M = 33.78, SD = 11.89). The t value (43) = 2.862, p = 0.006 < 0.05. The result indicates that dynamic geometry computer software has effect on the female learners' mathematics performance of the experimental group. This indicates that female learners in the intervention group (experimental) taught through dynamic geometry computer software achieve higher scores than those female learners in the control group who were taught by the teacher.

5. Discussion

In this part of the study, findings collected through the analysis of the data gathered in the direction of research questions were explained and interpreted. Before the intervention the results revealed that there was no significant difference between the pre-test of the experimental and the control groups. The indication means that the two groups were equivalent in term of the mathematics performance as the statistical t-test result shown [t (85) = 0.788, p = 0.433 > 0.05]. Therefore, the grade 9 learners from the two secondary schools can be compared while assessing the teaching processes that apply using DGCS to learn mathematics and learning through the conventional method. However, after the intervention, the results revealed that there was a statistical significant difference between the mean scores of experimental and control groups. The indication of the result means DGCS increases the performance of the experimental group learners in the subject of similarity and congruent triangle as the statistical result shown [t (85) = 2.970, p = 0.004 < 0.05]. This also indicates that DGCS increases their understanding in the subject area. The results obtained in this study are in agreement with the studies of Zengin et al (2012), Kesan and Caliskan (2013), Arbain and Shukor (2015), Adegoke (2016), Zulnadi and Zamri (2017). In these studies it was reported that learners exhibited good motivation, better understanding and higher performance when learning mathematics with dynamic computer software than conventional method.

It was also found that, there was no significant difference between male learners' mathematics performance of both the experimental and the control group [t (40) = 1.235, p = 0.224 > 0.05]. The indication of this result means, both male learners of the experimental and the control groups were equivalent even, after the use of DGCS (GeoGebra). This indicates that the DGCS did not cause any significant difference between the mathematics performances of male learners. On the other hand, it was also found that there was statistical significant difference between the female learners' mathematics performance of the experimental and control groups [t (43) = 2.862, p = 0.006 < 0.05]. This means DGCS (GeoGebra) increases female learners' mathematics performance in similarity and congruent triangles. The indication of the two results is that DGCS increases the understanding of female learners more than the male learners.

In this study the use of DGCS (GeoGebra) makes female learners' performance better in mathematics than the male learners. These findings are in contrast with other research findings which proved that there were no significant differences between mathematics performance of learners in term of gender within the same group using dynamic geometry computer software (Kesan and Caliskan 2013; Yildiz and Aktas 2015). However, there were limited research study shown result in term of gender comparing experimental and control groups. In this study when comparing the male and female learners of both experimental and control groups, DGCS affected the female learners of the experimental group in a positive way than female learners in the control group.

6. Conclusion

Mathematics can be regarded as a challenging subject. Mathematics especially geometry involves understanding the theories and formulae in order to describe the given concept. The use of technology (DGCS) provides extensive opportunities for facilitating, supporting and enriching mathematics learning in schools. The study explored how Dynamic Geometry Computer Software (DGCS) is important on learners' performance in geometry. The study indicated that using the DGCS can improve the Grade 9 learners' performance in mathematics. In particular, the use of GeoGebra as an intervention during the study facilitated the understanding and improved the performance of the learners in the experimental group. Learners appeared to be satisfied with the dragging of the figures but sticking to the basic computer software tools. Hence, the use of DGCS has more advantage on learners' performance in mathematics than using conventional method (paper and pencil).

The use of the DGCS motivates learners to learn mathematics without anxiety, gives them enthusiasm to learn without any negative attitude towards mathematics and solves the problem of difficulty in understanding geometry concepts. Learners in the experimental group had advantages over the control group because the software enabled them to check the accuracy of the method used to determine their work on the computer screen which was a great success this could foster the retention level of learners. In addition, learners who used DGCS could revisit the activity several times while the control group could not be able to do so. In the control group teaching was limited to few examples, because drawing geometry shapes on the chalkboard spent time and space. Furthermore, not all teachers have the skill to illustrate good and excellence geometry shapes on the chalkboard. Therefore, with DGCS drawing and outlines are well-ordered and precise. DGCS allowed learners in the experimental group instantaneous exploration opportunities. The correct representation of objects and measurement brought a union and lead to understanding that might be different from a static paper – pencil environment (Sinclair, 2006).

The importance of using DGCS in learning geometry is that the software helped and improved learners understanding and performances. Hence, making DGCS available in the schools will make it more reasonable to use. The results of this study showed that there is great potential in using the DGCS (GeoGebra) to teach secondary schools mathematics in South Africa. Therefore, this study recommends that the use of technology in teaching and learning of mathematics should be a priority in the schools. Furthermore, to enable teachers to work with DGCS successfully, the study suggests that basic skills and knowledge of computer use are essential. Mathematics teachers should be trained beyond basic skills of computer use because extra support and training are required to sufficiently and confidently use DGCS. Mathematics teachers should also make use of the software as often as possible so that learners are encouraged to go beyond memorizing formulae and instead grasp the concepts. As a result learners can gain more understanding and improve their performances in mathematics. As a final point, the finding in this study served as the first step, therefore, to comprehend the effect of DGCS more on learners, there is need for further studies with bigger data set, which could accommodation more than 500 learners with duration of two years or more. In this regard, full standard geometry test could be used in at least 10 schools for further studies.

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