The Use of Dynamic Geometry Software on Pre-Service Mathematics Teachers' Geometry Achievement and their Opinion about Properties of Software

By

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Abstract

Researchers and education stakeholders in South Africa point the need to improve on pre-service teachers' knowledge of mathematics concepts that they teach to their learners in this 21st century. Preparation of pre-service mathematics teachers to use technology is a critical issue facing teacher education programmes. In this research, the researcher explored how dynamic geometry software, influenced pre-service teachers' achievement in Euclidean geometry. This study also elicited participants' opinion of the most important properties of three different software used in this research. Data were generated from the written responses of 130 participants to an assessment as well as short questionnaire to find out most important properties a dynamic geometry software must have in accordance with participants' opinion. The result showed that pre-service mathematics teachers taught Euclidean geometry using Geometer Sketchpad and GeoGebra software had greater improvement than their counterpart taught same content using Cabri 2 plus software. This result show that the PMTs users of Geometer Sketchpad and GeoGebra software developed a robust understanding of Euclidean Geometry concept that they will be required to teach in future. Findings from the qualitative data provided evidence that GeoGebra, Geometer Sketchpad and Cabri 2 plus software possess the necessary properties required to supplement for effective teaching and learning of Euclidean geometry. The study recommends that pre-service teachers should be provided with more structured technology-oriented opportunities to help develop and improve on their knowledge of basic mathematics concepts that is in line with the 21st century skill.

Keywords: *Cabri 2 plus; Dynamic software; GeoGebra software; Geometer Sketchpad; Geometry achievement test; Pre-service mathematics teachers; Quasi-experimental design*

Introduction

Digital technologies such as computers, graphic calculators and the Internet is widely acknowledged, but technology through software packages still plays a limited role in many mathematics classroom instruction (Bennison & Goos, 2010; Borba, Askar, Engelbrecht, Gadanidis, Linares & Aguilar, 2016). South Africa is not an exception in the peripheral role played by software packages in the mathematics classrooms. The inclusion of technical mathematics (offered first time in Grade 12 NSC Examination) is a move towards a technologically enhanced curriculum and instruction in South Africa (Department of Basic Education, 2018). Admittedly, mere encouragement by curriculum documents does not guarantee effective adoption and utilisation of technology for instructional purposes. Possible solutions to the mathematics crisis in South Africa are on additional support for teachers to improve on their professional development. Research observed that in quest for teacher enrolment in schools, developing economies such as South Africa, recruited into the teaching profession students that do not have sufficiently robust knowledge of mathematics contents because of the large demand for qualified teachers (Bowie & Reed, 2016; Deacon 2016; Ndlovu, 2016). However, inadequate adoption of digital technologies in the teaching of mathematics means that learners are deprived of opportunities for enhanced understanding of complex mathematical contents like Euclidean geometry, which technology can help to simplify and make more understandable.

Consequently, during the researchers' experience of teaching as a pre-service teacher, the most problematic topic for both teachers and learners is Euclidean geometry, because it creates doubt in the minds of their learners. Atebe and Schafer, (2009); Ndlovu, (2014); DBE, (2011) noted that teachers avoided the teaching of geometry in school because of their poor mastery of Euclidean geometry. In 2008, Euclidean Geometry in its traditional form of theorem recognition, solving riders and proofs construction, was made optional in South African Grade 10, 11 and 12 curricula, because mathematics teachers were not familiar with the content (Bowie, 2009; DBE, 2011; Ndlovu, 2014). It became part of the optional third mathematics paper, which most schools chose not to teach. The latest Curriculum and Assessment Policy Statement (CAPS) brought it back as part of the core mathematics curriculum in Grades 10 – 12 because of its importance as a significant tool for a learner to give meaning to his/her environment (DBE, 2011; NCTM, 2000).

Despite geometry being an important branch of mathematics, the poor performance of South African learners in geometry has been of great concern over the past four decades (Ndlovu, 2014; Alex & Memmen, 2015). According to the Van Hiele theory, the main reason for the poor performance of learners in high school geometry is that the curriculum is presented at a higher level than that of the learners (Alex & Memmen, 2016; De Villiers, 2004). For this reason, the learners often cannot understand the teacher, nor can the teacher understand why the learners cannot learn. Some teachers find the Euclidean geometry section difficult, even if they studied Euclidean geometry in high school and at tertiary level; let

alone those who did not study Euclidean geometry at these levels at all. Many pre-service teachers, at the institution where this research was conducted, fall into the category of those who did not study geometry in school. Many of these students were anxious and afraid because of the expectation to teach the content when they start their teaching careers (Atebe & Schafer, 2009). Therefore, the question was whether the main reason for making geometry voluntary has been resolved or not. In this regard, this research specifically focuses on pre-service mathematics teachers (PMT) use of geometry software to learn and to solve Euclidean geometry-based mathematics tasks, their opinion about the properties of each software.

Statement of the Problem

The review of the literature revealed a small amount of research on use of dynamic geometry software on pre-service mathematics teachers' Euclidean geometry achievement and their opinion about properties of software. The studies reviewed could not identify the best education software which is crucial for determining the borders of a good and an effective teaching and learning of Euclidean geometry. Moreover, Rapid changes in many developing countries including South Africa demand a technology friendly environment for exploring the use of dynamic geometry software in Euclidean geometry instruction. Hence there was a need to explore the pre-service teachers' opinion about the most important properties of dynamic mathematics software (Cabri II Plus, the Geometer's Sketchpad, GeoGebra) selected for interrogation and the relationship between learners' academic achievement and their use of these software. This research study provides an exploratory framework that can be used to find out more about most important properties a dynamic geometry software must have in accordance with pre-service mathematics teachers' opinion.

Research Questions:

This study intends to respond to the research questions:

1. What are the mean achievement scores of pre-service mathematics teachers taught Euclidean geometry through GeoGebra, Geometers' Sketchpad and Cabri 2 plus?

2. What are the most important properties a dynamic geometry software must have in accordance with pre-service mathematics teachers' opinion?

Methodology of Research

This section explores the research design, selection of participants, methods of data collection, intervention and the method of analysis of data used in this study.

Research Design

A mixed-method approach (qualitative and quantitative design) that involved exploratory and quasi-experimental features were used to find out the mean achievement scores of pre-service mathematics teachers taught geometry

through GeoGebra, Geometers' Sketchpad and Cabri 2 plus and the most important properties a dynamic geometry software must have in accordance with pre-service mathematics teachers' opinion. The quasi-experimental design was chosen because it controls the internal validity threats of the initial group difference and researcher selection bias, since there was no randomisation of the subjects into groups. Qualitative research method in general and case study approach permit an in-depth investigation of single or small number of units at a point (over a period) in time (Hsieh & Shannon (2005).

Selecting Participants

This exploratory study was carried out with 130 pre-service mathematics teachers (purposively sampled) who were enrolled in a mathematics method course forming part of their bachelor's in education (B.Ed.) degree at a South African University. The 130 participants were purposively sampled according to their familiarity with any of the software packages and placed into the three groups based on this information. In this research, the participants for the interview were selected based on the purposeful sampling strategy. The purpose of purposeful sampling is to select information-rich cases whose study will illuminate the questions under study (Ratcliff, 2016). Six pre-service teachers were selected for the semi-structured interview based on their responses to the written test administered.

Data Collection

Data to gauge pre-service mathematics teachers' knowledge of geometry was obtained from the participants' responses to a 100-item geometry achievement test (GAT) and a short questionnaire. The instruments for data collection were validated by experts in mathematics education department of the selected university. A pilot testing of the instrument was conducted with 60 pre-service teachers who learned to use the 3 dynamic geometry software from different courses in the same university. There were 10 items in the scale but, after the pilot testing and factor analysis, 5 of the items were eliminated. The Cronbach's alpha for pilot testing was calculated as 0.78 for 10 items and 0.90 for 5 items. The questionnaire consisted of 5 items which required the PMTs to either agree or disagree with each item. The same questionnaire was later used as a data gathering tool at the end of the semester and the researchers obtained each subscale score by adding the responses of the items in each group.

Intervention

This research was conducted in 2016-2017 academic year with 130 pre-service mathematics teachers that attended a geometry workshop and methods course, as part of the courses availed to them in their four-year pre-service programme. The design of the programme was such that the pre-service teachers would complete the intensive workshop for a period of three months (semester method course) where they used geometry software to learn geometry which

involved tutorials, activities and applications to problem solving. The course was exclusively on Euclidean geometry content, but the instructional approach based on the use of educational software was different from one group to the next. The researchers were very conscious not to influence or manipulate participants' views and use of any software. The instructors (researchers) of the course devoted an equal amount of time to each software, and pre-service teachers were free to choose any software. They were given an equal number of dynamic geometry software activities, with questions in each activity. The instructors provided extra guidance to the students in case they needed help during their learning. At the end of instruction, the questionnaire and the geometry achievement post-test were administered to all the participants.

Data Analysis

Analysis of data entails breaking down the information gathered into elements to obtain responses to research questions (Sauro, 2015). In this research, the quantitative data from written responses was analysed using descriptive statistics, mean gain and analysis of covariance (ANCOVA) tested at .05 alpha level. ANCOVA was considered an appropriate statistical tool for the analysis in this research because it reduces error variance and gets rid of the effects of the covariate thereby increasing the power of the result of the F-value by adjusting the means on the dependent variables. The scores obtained from pre-GAT served as covariate in the study. When means on the covariate differ significantly, calculating different scores does not eliminate the variation in the pre-test but ANCOVA takes care of this variation and remove it from the group. However, post-hoc analyses were used to determine the instruction method that is most significant. The pre-GAT and post-GAT scripts were collected and marked using the marking scheme already prepared and validated for marking by the researchers. The data obtained from open-ended questions in the short questionnaire was analysed by qualitative analysis techniques (content and descriptive analysis). The details of the result of the written task are presented below in Tables 1, 2 and 3.

Results of Research

Overall summary of the results of the written responses

In reporting the results, data collected from the pre-service mathematics teachers written responses to the GAT consisting of twenty test items marked over 100 points were analysed. The details presented below in Table 1, 2 and 3.

Table 1. Mean scores and standard deviation in geometry achievement test of PMTs in the three groups

Teaching Method	Types of Test	N	Mean	*SD*	Mean Gain
Geo Ge bra	Pre -test Post -test	45 45	2.62 15.31	1.30 3.39	12.69
Sketchpad	Pre -test Post -tes t	38 38	2.87 15.63	1.61 3.02	12.76
Cabri 2D	Pre -test Post -test	47 47	2.86 8.89	1.44 2.09	6.03
Total		130			

The table 1 above shows the pre- test mean, post -test mean and standard deviations of GAT scores of PMTs in the groups. The Pre-test GAT Scores for the Cabri 2 plus group was 2.86 with standard deviation of 1.44, the pre-test mean GAT score for the Sketchpad group was 2.87 with standard deviation of 1.61 while the pre-test mean GAT score for the GeoGebra group was 2.62 with standard deviation of 1.30. The post- test mean GAT score for the Cabri 2 plus group was 8.89 with standard deviation of 2.09, the post- test mean GAT score for Sketchpad group was 15.63 with standard deviation of 3.02 while the post-test mean GAT score for the GeoGebra group was 15.31 with standard deviation of 3.39. The post-test means of GAT scores for the three groups indicated that all groups improved on their mean GAT scores after the intervention. However, the difference between the pre-test and the post-test mean GAT scores of PMTs in the three groups were 6.03, 12.76 and 12.69 in same order. This implies that the Sketchpad group had greater improvement than their counterparts who were taught using either GeoGebra or Cabri 2 plus software.

Table 2. Summary of one-way analysis of covariance of achievement scores for the three groups

Source	Type III Sum of Squares	df	Mean Squa re	F	p	Remark
Corrected Model	4028.05[a]	3	1342.68	184.29	.01	S
Intercept	3713.32	1	3713.32	509.68	.01	S
Pre	12.97	1	12.97	1.78	.19	NS
Group*	3840.35	2	1920.17	263.56	.01	S
Error	917.98	126	7.29			
Total	21478.00	130				
Corrected Total	4946.03	129				

a. R Squared = .81 (Adjusted R Squared = .81)

b. Computed using alpha = .05

Table 2 shows the result of one-way ANCOVA of post-test scores as the dependent variable with the pre-test as the covariate used in the analysis. From the table, the results from the groups revealed a significant difference between the mean achievement scores of students taught Euclidean geometry in the three groups. This was because significant-value (p- value) is less than .05, the dependent variable indicates a significant difference suggesting that we reject the null hypothesis. Therefore, the need arose to statistically find out which software caused the most significant difference, hence the use of pairwise comparisons test (post hoc test).

Table 3: Resultof ANOVA Analysis of Pairwise Comparison of Means (post hoc test).

Pairwise Comparisons

Dependent Variable: Post

(I) Group	(J) Group	Mean Difference (I-J)	SE	p	Remark
GeoGebra	Sketchpad	.27	.60	.66	NS
	Cabri 2D	11.34*	.57	.01	S
Sketchpad	GeoGebra	.27	.60	.66	NS
	Cabri 2D	11.60*	.60	.01	S
Cabri 2D	GeoGebra	-11.34*	.57	.01	S
	Sketchpad	-11.60*	.60	.01	S

a. *The mean difference is significant at the 0.05 level of significance
b. Adjustment for multiple comparisons: Least Significant Difference

Table 3 shows the summary of the post-hoc tests using the pairwise comparisons to show exactly where the difference among the groups occurs. The groups (I) compares with group (J) in each case. From the column labelled the mean difference, the asterisk (*) next to the value listed means that the two groups being compared are significantly different from one another at the $P < .05$. From the table, GeoGebra and Sketchpad groups were not significantly different from one another, but these groups were significantly different from the Cabri 2 plus group. The mean difference of GeoGebra group and Sketchpad group was 0.27, while the mean difference of GeoGebra group and Cabri 2 plus group was 11.34, the mean difference of Sketchpad and Cabri 2 plus was 11.60. The table 3 analysis showed that the GeoGebra and Sketchpad groups performed better than the Cabri 2 plus group. Conclusively, the students taught Euclidean geometry using GeoGebra software performed same as the PMTS taught geometry using Geometer Sketchpad while the Cabri 2 plus group recorded least significant increase in performance in GAT.

Overall summary of the results of the PMTs positive responses to the questionnaire

Pre-service mathematics teachers' responses to the short question was answered based on five main categories: Language of the software, clarity of the software, guidance for users, package and purpose of its use. Researcher categorised participants' answers by qualitative techniques and calculated their frequencies and percentages of each group total (GeoGebra = 45 participants, Geometer Sketchpad = 38 participants while Cabri 2 = 47 participants). The details presented below in Table 4, 5 and 6.

Table 4. Participants' positive views of the most important property of a dynamic geometry software package in terms of language.

Categorie s of responses	Number and Percentage (%) response in favour of Geo Gebra software	Number and Percentage (%) response in favour of Sketchpad software	Number and Percentage (%) response in favour of Cabri 2 plus
It is in user's spoken language	7 (15.6)	4 (1 0.5)	7 (14.9)
Has appropriate language of the curriculum	6 (13.3)	5 (13.2)	5 (10.6)
Has mathematical language and symbols	24 (53.3)	20 (52.6)	25 (53.2)
Has good translation	3 (6.7)	3 (7.9)	3 (6.4)
Clear and understandable language	5 (11.1)	6 (15.8)	7 (14.9)

Table 4 revealed that, among the three groups, the most important property of a dynamic geometry software, in terms of language, is that the software should contain mathematical language and symbols, while the least important property that the software should have good translation. Hence, most participants in the three groups supported the assertions.

Table 5. Participants' views of the most important property of a dynamic geometry software package in terms of clarity.

Categories of responses	Numbe r and Percentage (%) response in favour of GeoGebra software	Number and Percentage (%) response in favour of Sketchpad software	Number and Percentage (%) response in favour of Cabri 2 plus
Clear and readable instruction	24 (53.3)	20 (52.6)	7 (14.9)
Use display icon	6 (13.3)	5 (13.2)	6 (12.8)
Accordance of colours and visual integrity	5 (11.1)	6 (15.8)	24 (51.1)
Interesting and attractive image	6 (13.3)	4 (10.5)	6 (12.8)
Used of bright colours	4 (8.9)	3 (7.9)	4 (8.5)

The analysis in Table 5, revealed that the participants for GeoGebra and Geometer Sketchpad group viewed the use of clear and readable instruction as the most important property of a geometry software package in terms of clarity, while accordance of colours and visual integrity is the most important property for participants that used Cabri 2 plus software. Table 6. Participants' views of the most important property of a dynamic geometry software package in terms of guidance for users.

Categories of responses	Number and Percentage (%) response in favour of GeoGebra software	Number and Percentage (%) response in favour of Sketchpad software	Number and Percentage (%) response in favour of Cabri 2 plus
It has detailed user manual.	8 (17.8)	4 (10.5)	11 (23.4)
Detailed explanation of its use in the help menu	18 (40.0)	9 (23.7)	12 (25.5)
Enough examples given to the users.	6 (13.3)	3 (7.9)	5 (10.6)
It is clear and understandable	8 (17.8)	20 (52.6)	11 (23.4)
It is accessible and helpful	5 (11.1)	2 (5.3)	8 (17.0)

Table 6 revealed that revealed that the participants for GeoGebra group viewed the use of detailed explanation of its use in the help menu as the most important property followed by clear and understandable as well as detailed user manual. Geometer Sketchpad group showed that clear and understandable is the

most important property in terms of guidance to users, followed by detailed explanation of its use in the help menu. The Cabri 2 plus group observed that detailed explanation of its use in the help menu, clear and understandable and detailed user manual are most important property with respect to guidance for users.

Table 7. Participants' views of a dynamic geometry software in terms of packaging.

Categories of responses	Number and Percentage (%) in favour of GeoGebra software	Number and Percentage (%) response in favour of Sketchpad software	Number and Percentage (%) response in favour of Cabri 2 plus
Ease of use	18 (40.0)	10 (26.3)	25 (53.2)
Has additional tools like spreadsheets.	4 (9.1)	2 (5.3)	6 (12.8)
Keeps users' computers running fast	1 (2.2)	2 (5.3)	5 (10.6)
The ability to calculate and draw.	4 (9.1)	3 (7.9)	6 (12.8)
Appropriate for geometry proof and problem solving.	18 (40.0)	21 (55.3)	5(10.6)

Table 7 revealed that among the GeoGebra group, important properties of a dynamic geometry software according to software packaging is ease of use and appropriate for geometry proof and problem solving. Geometer Sketchpad group is of the opinion that the most important property of a dynamic geometry software according to its packaging is appropriate for geometry proof and problem solving followed by ease of use while Cabri 2 plus group is of the opinion that ease of use, is the most important properties according to packaging.

Table 8. Participants' views of a dynamic geometry software package in terms of most important purpose of use.

Categories of responses	Number and Percentage (%) in favour of GeoGebra software	Number and Percentage (%) response in favour of Sketchpad software	Number and Percentage (%) response in favour of Cabri 2D
To present subject matter in terms of tutorial	2 (4.4)	3 (7.9)	2 (4.3)

Categories of responses	Number and Percentage (%) in favour of GeoGebra software	Number and Percentage (%) response in favour of Sketchpad software	Number and Percentage (%) response in favour of Cabri 2D
To give students some materials that they can use to study at home.	6 (13.3)	2 (5.3)	6 (12.8)
To make applications and to reinforce	3 (6.7)	2 (5.3)	4 (8.5)
To learn geometry alone (self-study)	10 (22.2)	6 (15.8)	12 (25.5)
To facilitate the learning process	24 (53.3)	25 (65.8)	23 (48.9)

Table 8 revealed that that among the three groups of participants, the most important property of a dynamic geometry software according to purpose of use is to facilitate the learning process. However, the least important purpose of use is to present subject matter in terms of tutorial.

In conclusion, the findings of the qualitative study revealed that GeoGebra, Geometer Sketchpad and Cabri 2 plus users' opinion on most important property of geometry software in terms of language is that dynamic geometry software contain mathematical language and symbols. In terms Geometer Sketchpad and Cabri 2 plus possess the most important properties required of dynamic geometry software to improve on students' achievement and use in teaching and learning of Euclidean geometry. In terms of clarity GeoGebra and Geometer Sketchpad users believe that clear and readable instruction is the most important property of dynamic software with respect to clarity while Cabri 2 plus users believe accordance of colours and visual integrity is the most important property.

In addition, GeoGebra users believe detailed explanation in the help menu, clear and understandable as well as detailed user menu are most important property of dynamic software with respect to guidance for users. Geometer Sketchpad users believe clear and understandable software followed by detailed explanation of its use in the help menu are most important property while Cabri 2 plus users are of the view that detailed explanation of use in the help menu, detailed user manual is most important property with respect to guidance for users.

However, with respect to packaging, ease of use and being appropriate for geometry proof and problem solving are most important property by GeoGebra users while Geometer Sketchpad users believe that appropriate for geometry proof and problem solving followed by ease of use are most important property under packaging. Cabri 2 plus users noted that ease of use is the most important property with respect to packaging. Moreover, in terms of purpose of use, the participants in Geogebra, Geometer Sketchpad and Cabri 2 plus Groups, are of the view that the most important property of a dynamic geometry software according to purpose of use is to facilitate the learning process.

Discussions

The research findings from written task showed that Geometer Sketchpad users had greater improvement than GeoGebra and Cabri 2 plus users. This finding is in line with Sandir and Aztekin, (2016), that pre-service teachers found Geometers' Sketchpad more effective than others in the positive development of the students' attitudes and in teaching high level geometry. However, ANCOVA statistics revealed a significant difference in the mean achievement scores of PMTs taught Euclidean geometry under different dynamic software hence a post hoc analysis revealed that GeoGebra software and Geometer Sketchpad are most effective technology software for greater achievement in Euclidean geometry instruction. This finding is similar to the findings of Saha, Agub and Tarmizi (2010) who found that students taught geometry using GeoGebra was significantly different from those taught geometry without GeoGebra. On the contrarily, the findings do not concur with Karakus and Peter (2015) result of the research on effect of dynamic geometry software and physical manipulatives on pre-service teachers' that showed there was no difference on the post-test of the two groups related to the van Hiele levels and spatial abilities. However, Yilmaz (2015) research revealed that Cabri II Plus is more effective at increasing transformational geometry achievement than other software contrarily to this research findings.

In this research, findings with respect to most important properties expected of a dynamic geometry software in accordance with pre-service mathematics teachers' opinion, five main categories were identified. First, in terms of language, most important property based on the opinion of users of GeoGebra, Geometer Sketchpad and Cabri 2 plus users is mathematical language and symbols. Interms of clarity, GeoGebra and Geometer Sketchpad users are of the view that use of clear and readable instruction is the most important property of dynamic software while Cabri 2 plus users view accordance of colours and visual integrity as most important property. However, GeoGebra users are of the view that detailed explanation in the help menu followed by clear and understandable menu as well as detailed user menu are most important property of GeoGebra software with respect to guidance for users. Geometer Sketchpad users were of the view that clear and understandable menu is the most important property of Geometer Sketchpad software. Then its use in the help menu, while Cabri 2 plus users observed that detailed explanation of its use in the help menu, detailed user manual, clear and understandable are most important property of Cabri 2 plus with respect to guidance for users.

Moreover, the most important property of GeoGebra software in terms of packaging is ease of use and problem solving by GeoGebra users while Geometer Sketchpad users are of the view that the most important property of Geometer Sketchpad in terms of packaging is appropriate for geometry proof and problem solving followed by ease of use. The Cabri 2 plus users was of the view that the most important property of Cabri 2 plus I terms of packaging is ease of use. This finding is similar to Jones (2005) finding that the use of DGS has highlighted how diagrams play an ambiguous role in geometry instruction. However, a little different to the

findings of Takar, (2013) where GeoGebra software concurrently gives graphic and spreadsheet representation of mathematical objects. Consequently, the most important property viewed by GeoGebra, Geometer Sketchpad and Cabri 2 plus users in terms of purpose of use is that each software facilitates learning process. The findings of the current research are parallel to the findings reported by Zengin et al. (2017), who observed that the use of dynamic geometry software could improve on visualization, facilitating comprehension, retention and concretization.

In fact, technological learning environments allow teachers to select learning methods tailored to the needs of students and to apply them in their classes (NCTM, 2000). This finding is an indication that computer software can aid in visualizing abstract concepts and create new environments that extend beyond students' physical capabilities. It is often employed as a fertile learning environment in which students can be actively engaged in constructing and exploring mathematical ideas (Karakus & Peter, 2015). Software such as the Geometer's Sketchpad, GeoGebra, Cabri 2 provide a flexibly structured mathematics laboratory that supports the investigation and exploration of concepts at a representational level, linking the concrete and the abstract (Saha, Ayub & Tarmizi, 2010; Thomes, Hong & Oates, 2017). Using dynamic software is helpful in the teaching of geometry, because it allows dynamic and interactive manipulations of figures (Hohenwarter, Jarvis, & Lavicza, 2009). The learner can move, rotate, reflect, or stretch geometric figures and observe which properties are the same and which do not.

As research on use of technology in mathematics instruction indicates, there is much more than just using any dynamic software to learn and teach Euclidean geometry, Atebe and Schafer (2009) concur that there is need to provide geometry intervention programmes for PMTs in the university setting. This research showed that pre-service mathematics teachers (PMT) can use at least one geometry software to supplement their teaching. The conditions under which the pre-service teachers learnt the use of geometry software may be a factor that has made it difficult for them to acquire the necessary skills. Perhaps learning opportunities that are more conceptually and practically grounded instead of theory-based method may be more successful and hence programs for pre-service teachers may need to offer such opportunities to students with poor mathematics content backgrounds.

This research has provided significant insights to the existing literature by identifying and analysing pre-service teachers' knowledge of Euclidean geometry and use of dynamic software in mathematics classroom instruction. The indebt analysis of the short questionnaire provided evidence of pre-service mathematics teachers' opinion about the properties of each software. The research recommended that pre-service mathematics teachers be exposed to good technology environment and skills to help them improve on their use of digital technology in their future teaching career. This recommendation agree with Kilic (2009) finding that suggested; teacher education programs need to offer courses that provide pre-service teachers with opportunities to effectively teach secondary school mathematics topics.

Conclusion

This research focused on the written responses of 130 pre-service mathematics teachers to two items based on Euclidean geometry. The result showed that pre-service mathematics teachers taught Euclidean geometry using Geometer Sketchpad and GeoGebra software had greater improvement than their counterpart taught same content using Cabri 2 plus software. This result show that the PMTs users of Geometer Sketchpad and GeoGebra software developed a robust understanding of Euclidean Geometry concept that they will be required to teach in future. However, the findings from the qualitative data provided evidence of pre-service mathematics teachers opinion about the most important properties of each dynamic software with respect to language, clarity, guidance for users, package and purpose of its use. The results point to the fact that GeoGebra, Geometer Sketchpad and Cabri 2 plus possess the necessary properties required of a software to supplement for effective teaching and learning of Euclidean geometry.

As noted in the introductory remarks in this paper, that in some countries such as South Africa, students who do not have a sufficiently robust knowledge of basic mathematics are recruited into the teaching profession because of the large demand for qualified teachers (Bowie & Reed, 2016; Deacon 2016; Ndlovu, 2016). This raises a concern about whether it is possible for mathematics teacher education programmes to help pre-service teachers improve their understanding of the school level concepts they will need to teach using dynamic software. Most university programmes focus on developing knowledge of advanced mathematics because of the need for compliance with university accreditation structures. The assumption is that pre-service teachers have developed an understanding of the school mathematics content they need and hence this cannot form the focus of instruction at university. Based on this reality, it is important that pre-service teachers be given opportunities to improve on their knowledge of basic mathematics concepts in supportive of a well-structured intervention program that is in line with the 21st century skill for increased and sustained mathematics knowledge for teaching.

Recommendation

The study recommends that pre-service teachers should be provided with more structured technology-oriented opportunities to help develop and improve on their knowledge of basic mathematics concepts that is in line with the 21st century skill.

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