Using blended-learning strategy in mathematics to strengthen the teaching of geometric 2D shapes and their properties to primary 6 learners[1]

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ABSTRACT

Mathematics remains an indispensable pivot for technical and analytical skills that are relevant to other fields and everyday living experiences. Most learners experience challenges in comprehending mathematical concepts due to teachers' teaching strategies; hence, this paper focuses on the use of blended learning as a strategy. The study aimed to enhance learners' mathematical knowledge using the blended pedagogical strategy in two different private primary schools in Imo State, Nigeria. A quasi-experimental research method was chosen, and it incorporated the pre-test, post-test non-equivalent control and experimental groups. Three research questions and three hypotheses were formulated as guides in this study. 165 learners were randomly selected from the two private primary schools to participate in the study. The Mathematics Achievement Gain Test (MAGT), which consisted of 30 item-objective test questions on the topic '2D shapes and their properties' with a reliability coefficient of 0.85, was used as the statistical tool, determined through Pearson's Product Moment Correlation method. The research questions were answered using mean and standard deviation while the hypotheses were tested using the ANCOVA with 0.05 as level of significance. The research results show that the blended-learning approach enhanced learners' understanding and performance in mathematics. Based on these results, the researchers recommend that primary school mathematics teachers be well trained and encouraged to use blended-learning strategies to achieve improved understanding, knowledge and appreciation of the subject.

Keywords: mathematics, learners, geometric 2D shapes, blended-learning strategy, properties

INTRODUCTION

The importance of mathematics in fields of professional practice such as science, technology, commerce and economics is non-negotiable. Its principles are widely applied in all spheres of life and in the ever-evolving, ground-breaking technological advancements that are gaining popularity across the globe (Sullivan, 2011). The field of mathematics is the hub of the technical and analytical skills relevant to other fields. It is regarded as the mother of arts and sciences, hence an international language represented in

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all walks of life. Senthamarai-Kannan, Sivapragasam and Senthikumar (2015) reported that mathematics forms the basis upon which the critical-thinking, analytical and problem-solving skills of children develop. The undeniable importance of mathematics will not be complete if there are no learners who are interested in learning its principles and applications (Senthamarai-Kannan, Sivapragasam & Senthikumar 2015; Wanner, 2015). Nevertheless, the understanding of mathematics vis-à-vis learners' performance has been truncated in many ways resulting in a high failure rate and generally very poor performance in the subject (Department of Basic Education, 2011a). The high failure rate in mathematics is greater when compared to other subjects because the subject is considered an abstract and intricate one; since much of its language is made up of signs and symbols (Department of Basic Education, 2011b).

This matter does not exclude the teachers whose understanding of the subject content and teaching methods do not effectively convey knowledge to the learners. In 2009, the Nigerian National Mathematics Centre reported that the obvious poor performance of learners in mathematics examinations has more to do with methods of teaching than shortcomings in the curriculum. Bature and Bature (2005) recorded that learners who fail in mathematics blame teachers' poor teaching methods. Teachers, on the other hand, have chosen to stick to traditional, chalk-and-talk teaching methods that make learners passive in the learning of mathematics (Anaduka & Okafor, 2013). Furthermore, teachers lack the creativity in their chalk-and-talk methods to stimulate learners' interest in learning and understanding the subject as is expected (Anaduka & Okafor, 2013). The researchers consider the blended pedagogical strategy as a possible solution in mediating teachers' poor teaching methods, especially because of its use of technology.

The dawn of technology and its continuous improvement have given birth to the need to adapt to innovations in teaching and learning. Facilitation of learning through technology can take various forms, such as online learning, computer-assisted learning, web-based distance learning, the use of the internet and blended learning, which is significantly advancing the teaching and learning space (Venketsamy & Wilson, 2020). Facilitating learning through the use of technology in mathematics was recommended as an outcome of research on the effect of e-learning and traditional learning (Annie Kavitha & Sundharavadivel, 2012). The effective use of technology and skills in designing its curriculum provides an advantage to mathematics teachers in the achievement of computer-assisted blended learning. According to Wilson (2018), the integration of interactive learning objects for instruction with the aid of information and communication technology (ICT) enriches the learning experience as abstract concepts become more real. The advantage of using blended learning is that it accommodates different learning styles such as visual, auditory and kinaesthetic (Annie Kavitha & Sundharavadivel, 2012). Therefore, mathematics teachers are advised to adopt spontaneous teaching approaches, such as blended-learning methods, that are learner friendly to spur learners' interest in appreciating the subject. This learning approach that incorporates technological devices (audio and visual aids) has increased academic performance due to its effectiveness in teaching and learning (Abdon, 2014).

The blended or hybrid learning approach entails a learning environment that involves teaching or delivery methods through a combination of media (audio or visual) formats, online sessions, face-to-face methods, or all of these (Saritepeci & Cakir, 2015). This teaching strategy is scarcely used in some Nigerian private primary schools due to teachers' inability to use or lack of knowledge and understanding of technology for teaching and learning. The blended-learning approach is a combination of the traditional teaching approach and the use of technology in fostering learning (Wilson, 2018). This approach fosters effective rapport between the teacher and the learners as it employs the use of audio, visual and online aids to enhance the process of learning (Krauss, 2007; Poon, 2013). Blended learning employs tools of interactive learning in an environment that synchronously and asynchronously serves both the teacher and learners (Abdon, 2014).

Omer (2012) investigated and reported that blended-learning approaches have a highly positive impact on the learners who were used to lecture-based instructional approaches. His results show that the differences in the learners' learning aptitude are not due to individual differences, but rather to the learning environment provided by the blended-learning approach. In 2014, Abdon surveyed and found that the effect of using the blended-learning methods in teaching algebra in Malayan colleges in Laguna showed that students who learned with blended methods received better grades than those taught using the conventional chalk-and-talk method. Alruwuch (2015), Saritepeci and Cakir (2015) avow that there is evidence in research that indicates significant differences in results among learners taught using the blended-learning approach, regardless of gender. Furthermore, the economic and technological needs of Nigeria require individuals who are taught and well-equipped with such critical-thinking and problem-solving skills as embedded in the study and application of mathematical principles. Therefore, the need to apply innovative strategies in teaching and learning mathematics cannot be overemphasised (Serdyukov, 2017).

STATEMENT OF THE PROBLEM

The traditional chalk-and-talk approach of facilitating learning is predominant in the Nigerian school system. This method of teaching and learning, as noted by Alruwuch (2015) and Saritepeci and Cakir (2015), has impacted negatively on learners' academic gains. This is because learners become passive in the learning process; hence, they do not understand the concepts being taught. Over the years, Nigerian students have performed poorly in mathematics (Krauss, 2007; Poon, 2013). Evidence shows that, in addition to the unconducive learning environment, teachers' approach to lesson delivery is also a reason for the low performance of students in mathematics (Krauss, 2007; Poon, 2013). Due to these problems in Nigeria, the teaching strategy of mathematics teachers requires a review.

The priority in contemporary Nigerian society to improve learners' understanding and performance in mathematics requires the effective use of modern technological tools, resources and devices. To palliate the limitations of the traditional teaching methods that are responsible for learners' lack of interest, and the associated poor achievement in the subject, a learning approach that advocates for a combination of various learning strategies is inevitable. Therefore, the thrust of this study is to enhance young learners' learning in mathematics using the blended-learning pedagogical strategy.

PURPOSE OF THE STUDY

The purpose of this study is to explore the learning gains of young learners in 2D geometric shapes and their properties in mathematics using the blended-learning strategy. The study sought to determine whether

- there will be any noticeable difference in learning gains in the topic '2D geometric shapes and their properties' between learners taught using the blended pedagogical strategy and those taught in the traditional chalk-and-talk method
- there will be any appreciable difference in the learning gains of male and female learners in the topic '2D geometric shapes and their properties' using the blended pedagogical strategy
- learners who achieve low and high scores in the topic '2D geometric shapes and their properties' using the chalk-and-talk method will show any significant difference when taught 2D geometric shapes and their properties using the blended pedagogical strategy.

RESEARCH QUESTIONS

For this study, the following research questions were formulated:

1. What is the difference in learning gains in the topic '2D geometric shapes and their properties' of learners taught using the blended pedagogical strategy and those taught in the conventional chalk-and-talk method?

2. Is there any appreciable difference in the learning gains of male and female learners who were taught 2D geometric shapes and their properties using the blended pedagogical strategy?
3. Do learners who achieve low and high scores in 2D geometric shapes and their properties using the chalk-and-talk method show any significant difference when taught 2D geometric shapes and their properties using the blended pedagogical strategy?

HYPOTHESES

Using a 0.05 level of significance, the following hypotheses were formulated for this study:

1. The mean learning gains of learners taught 2D geometric shapes and their properties using the blended pedagogical strategy and those taught using the chalk-and-talk method showed no significant difference.
2. The mean learning gains of male and female learners who learned 2D geometric shapes and their properties using the blended pedagogical strategy showed no significant difference.
3. The mean learning gains showed no significant difference between low learning gains and high learning gains for achievers who were taught 2D geometric shapes and their properties using the blended-learning instructional approach.

RELATED LITERATURE

The researchers conducted a review of related literature. This review included (i) the conceptualisation of blended-learning strategy, (ii) the teacher factor in the blended pedagogical strategy, (iii) the integration of GeoGebra in the blended-learning approach, (iv) an ideal environment for the blended pedagogical strategy and (v) a theoretical framework that anchors in Vygotsky's theory of social constructivism. The literature assisted the researchers to situate their augment for the use of a blended-learning approach to facilitate geometric 2D shapes and their properties for primary 6 learners in Nigerian private schools.

The conceptualisation of blended-learning strategy

In the available literature, various scholars outlined definitions of blended learning; however, the most prominent among the definitions is that blended learning acknowledges a combination of the virtual and physical environments (Picciano, Dziuban & Graham, 2013). In 2013, Picciano et al. avowed that the integration of a face-to-face setting, human interactions, ICT (synchronous and asynchronous settings) and text-based, independent learning are all embedded in the blended-learning strategy. In support of Picciano et al. (2013), Hrastinski (2019) opined that blended learning comprises the inclusion and infusion of various technological dimensions of online and face-to-face approaches as well as the traditional learning approach in a learning environment that allows for hands-on reflections by the learner and teacher. However, in this study, the authors adopted the ideological concept of blended learning as described by Hrastinski (2019). The combination of online and classroom settings simplifies the complex concept that is taught in the traditional learning setting and meets the needs of several learners. Furthermore, the use of blended learning advocates for a learning environment wherein the learner is in control of the learning process, and in which the teachers are considered facilitators of learning (Alammary, Sheard & Carbone, 2014; Hockly, 2018).

The use of blended learning accommodates different blends of learning programmes, pedagogy and technologies in different learning environments (Bower et al., 2015). This is evident in the use of e-portfolios, podcasting, vodcasting, internet-based video and audio, and blogs, among many others. Anecdotal evidence shows that blended learning is suitable for learners with various cultural backgrounds because of its inclusivity. It is, therefore, noted that blended learning, which is now rapidly substituting the chalk-and-talk teaching method, implies integration of technology into teaching and learning (Bower et al.,

2015). The attainment of learning objectives using blended learning has shown to be profitable, especially considering the characteristics that surround 21st-century dynamics. Learning in itself is a continuous process, hence the concept of blended learning being rooted in the idea of learning dynamics (Slevin, 2008). As teachers facilitate learning, they are expected to provide guidance, a variety of examples and a high level of interaction with the learners (Allen, Seaman, Lederman & Jaschik, 2012).

The teacher factor in blended pedagogical strategy

Facilitating learning using the blended pedagogical strategy provides enormous benefits to both the learner and the teacher, and even more so when the teacher incorporates technology in the learning process (Anderson, 2008). However, teachers are reluctant in the use of technology possibly because of their inadequate skills in integrating technology into the learning process (Anderson, 2008). Research by Shrestha, May and Burke (2009) posits that students are more enthusiastic in the use of technology to learn than their teachers. This further confirms the position of both Anderson (2008) and Venketsamy and Wilson (2020) who noted that teachers are reluctant in the use of technology because of their inadequate skills in integrating it into the learning process. Furthermore, a report by Allen, Seaman, Lederman and Jaschik (2012) maintains that there is low motivation for the use and integration of technology in the learning process worldwide by academics. Inadequate support and training, fear of failure and time constraints on the development of learning materials were among the identified challenges that demotivate teachers in the use of technology in the blended-learning process (Venketsamy & Wilson, 2020).

Mansvelt et al. (2009) note in their research that management support, different beliefs and time allocation predisposed the confidence of teachers in their use of technology in teaching. Annie Kavitha and Sundharavadivel (2012) assert that teachers claim that their reluctance in the use of technology stems from the apprehension for the educational wellbeing of their learners. In their claim, they noted that the use of technology in blended learning decreases teachers' interactions with their learners, hence socially isolating learners, which has an impact on teachers' job security (Annie Kavitha & Sundharavadivel, 2012). Teachers who do not recognise the benefits of blended learning are not likely to implement it when facilitating learning. It is for this reason that the researchers of this study have provided guidance to enable teachers to facilitate learning using the blended-learning approach.

Integration of GeoGebra in blended-learning approach

With the evolution of technology comes the integration of some mathematical software such as GeoGebra, Geometer's Sketchpad, and Mathematica into the classroom space. GeoGebra, according to Arbain and Shukor (2015), is a programmed software application directed at facilitating learning in geometry, algebra and calculus. Similarly, Abramovich (2013) affirms that GeoGebra is an online software learning tool for the study of geometry, algebra and calculus at various teaching education levels. Zulnaidi, Oktavika and Hidayat (2020) noted that the use of GeoGebra is central to the creation of meaningful learning experience for teachers and learners of mathematics.

Furthermore, Zulnaidi, Oktavika and Hidayat (2020) acknowledge that a significant number of educators agree that the software is appropriate for a vivid explanation of concepts and procedures in mathematics. This is due to the accessibility of the software, which allows for interaction between learners because it is participatory and engaging. Furthermore, it captures the visual appreciation of learners through its graphics, images and symbols. The software is learner centred and learner friendly as it allows learners to carry out practical exercises as they follow the procedures shown in the learning exercise (Abramovich, 2013). The researchers considered the use of GeoGebra in this study as they applied it to the experimental group that was sampled for the study. Its use created an ideal environment that characterised blended learning among learners.

An ideal environment for blended pedagogical strategy

There are considerations that teachers need to acknowledge when planning to use the blended-learning pedagogical approach. Among these considerations are the organisation of the learning environment. The learning environment needs to be inviting and free from psychological and physical harm, hence promoting interaction and collaboration among learners (Hockly, 2018; Precel, Eshet-Alkalai & Alberton, 2009; Slevin, 2008). Establishing a friendly teacher-student relationship, equipping the physical environment in a way that elicits and encourages discussions, and engaging learners in projects are ways to create this environment (Venketsamy, Sing & Smart, 2020). Teachers need to have a strong grip on their subject content and the different methods that can be used to facilitate content to the understanding of their learners (Ní Raghallaigh & Cunniffe, 2013). Schools and learning centres that desire to implement the blended-learning strategy need to provide for digital and print text materials as the provision of both solve difficulties some students may have with reading digital texts (Precel et al., 2009).

Another consideration is the use of audiovisual aids in lesson delivery. Learners grasp concepts easily from what they see and hear. A blend of audio and video positively help to sustain and motivate learners' interest in the learning process. To attain the learning outcomes in the blended-learning strategy, the assessment needs to be adapted (Slevin, 2008). Assessments, such as portfolios, projects, regular class activities, observation schedules and essays, among many others, should be adapted to assess learners' progress in the use of blended learning (Omer, 2012). In arranging the learning environments, teachers should keep in mind learners' characteristics and learning context while planning for learning (Venketsamy et al., 2020). A community of practice (COP) among learners and teachers helps to create a stimulating learning environment that aims at developing the potentials in both teachers and learners (Luguetti, Aranda, Enriquez & Oliver, 2018). Furthermore, such a COP allows learners to connect and collaborate with their peers and to create a learning environment that integrates social, cognitive and teaching elements in a way that will precipitate and sustain critical reflection and discourse (Ekeh & Venketsamy, 2020). Another benefit of creating a COP environment among learners and teachers is that it fosters healthy relationships beyond the school and classroom environments (Ekeh & Venketsamy, 2020). Luguetti, Aranda, Enriquez and Oliver (2018) maintain that creating a COP environment helps learners to investigate, confirm, analyse and construct knowledge. In this study, learners progress from basic learning to in-depth and meaningful learning experiences as teachers approach learning through a COP among learners while using the blended-learning approach.

As evidenced by the review of literature, in the conceptualisation of blended learning, the teacher and the environment are key factors the researchers focused on. The concept of blended learning is seen from various perspectives by different scholars, but for the purpose of this study, the researchers adopted the definition proposed by Hrastinski (2019). This definition maintains that blended learning comprises the integration of ICT, face-to-face settings and human interactions, and that it is text-based. The implication is that teachers who facilitate learning are expected to utilise technology in a face-to-face, interactive, human setting (Venketsamy & Wilson, 2020). The teacher as an important factor in the blended pedagogical process needs to be abreast of their learning content and of different methods of facilitating learning whilst considering the characteristics and context of their learners. Lastly, a learning environment that promotes blended learning has to be psychologically and physically conducive. Creating a COP environment wherein learners and teachers in their groups collaborate among themselves in the learning process is very important (Venketsamy et al., 2020). Considering that the present study was both socially and cognitively demanding, the researchers opted for Vygotsky's theory of social constructivism as a theoretical framework to support the study.

Theoretical framework

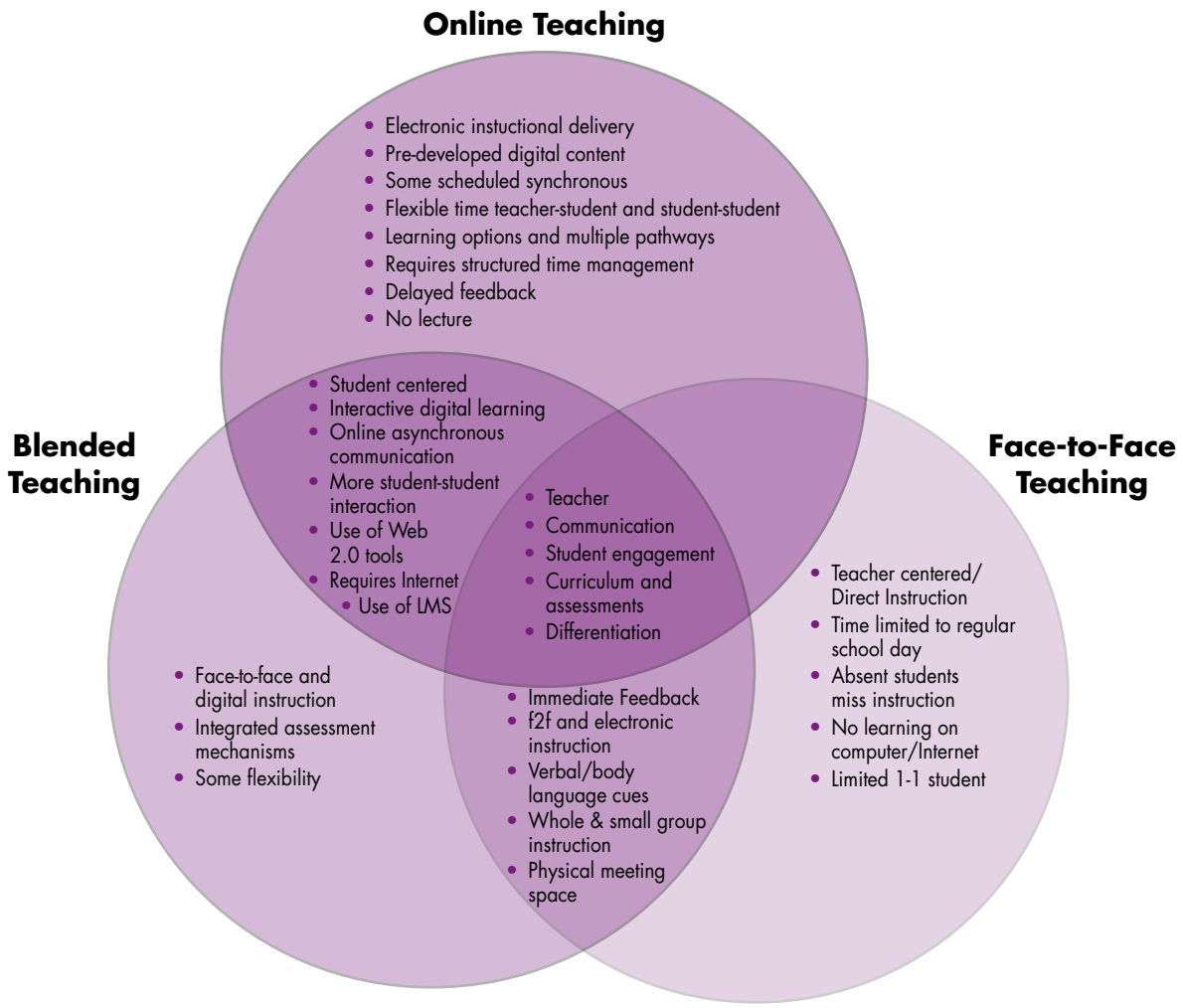
Vygotsky's theory of social constructivism explains that interactions that emanate from teachers, peers, parents and others all lead to the development of cognitive functions. The implication of this is that

learning emerges as the learner interacts and collaborates with the people in the context of their learning environment or in an educational community (McInerney & McInerney, 2002; Schunk, 2012). For Vygotsky, learning is not just the assimilation of new knowledge into the head (cognitively) but also the ability of learners to adapt with others in the learning environment in which they find themselves (socially), hence social constructivism. This makes the learner a balanced fellow in society and the world at large. Using a blended-learning approach vis-à-vis social constructivism in this study was significant in that it allowed learners to interact with their peers, teachers, and technological devices, such as computers, audiovisual aids, cell phones, and other learning resources. Furthermore, learners were able to gain knowledge and understanding as they experienced the construction of 2D shapes and their properties during the lesson.

Social constructivism asserts that nothing is learned from scratch; whatever needs to be learned has existed and what is considered new knowledge is the expansion of a body of knowledge that has existed before. This, therefore, means that new knowledge is only integrated into an existing network of knowledge for clearer understanding (Hyslop-Margison & Strobel, 2008). A learner is, therefore, considered to be successful in learning when the learner is able to integrate a new idea into an already existing body of knowledge, hence expanding the existing body of knowledge while accommodating new experience. Therefore, a social constructivist learner will always remain subjective in their views because the individual interpretation of experiences depends on different pre-existing frameworks of understanding, which helps the learner to develop their own, unique view of the world (Draper & Macleod, 2013; Hyslop-Margison & Strobel, 2008). In this study, learners' prior experience of 2D shapes was of immense advantage. This prior knowledge provided the basis for their understanding, and they could relate what they already knew about 2D shapes and apply this knowledge in the new learning context.

Social constructivism upholds that learning is grounded on shared experiences among learners in a social manner. Such experiences show the perspectives of individual learners' ability to solve problems and how they are able to integrate their newly found knowledge into the existing body of knowledge (Amineh & Asl, 2015; Samson, 2015). Learners, therefore, show dexterity in how sensible their new ideas are and how best their ideas can be adapted into the world around them. Every individual learner, in the social constructivist paradigm, is considered as a part of a social group and not as an isolated learner. This implies that learning emerges as a result of social interactions in the group in which learners find themselves (Amineh, & Asl, 2015; Samson, 2015). Therefore, learning takes the form of active engagement in a social setting rather than a passive response in the learning process (Ní Raghallaigh & Cunniffe, 2013; Wanner, 2015). To social constructivists, the significance or meaning of learning lies in the experiences which individual learners share in social learning settings. Therefore, social constructivism recognises the distinctiveness and intricacies of different learners, the values they share and utilise, and the reward it brings as a fundamental part of the learning process (Amineh & Asl, 2015).

Figure 1:
The blended, online, face-to-face pedagogical strategy



Source: https://sites.google.com/site/wagnerkarend/designing-a-class-discussion

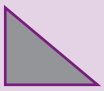
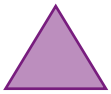
The use of social constructivism in this study supports the premise that teachers who view blended learning as a relatively new pedagogical approach in facilitating learning can gain its skills and add to their pre-existing body of pedagogies. The assimilation of this pedagogical approach for teachers who were used to the traditional chalk-and-talk method is much easier because Hrastinski (2019) had earlier noted that blended learning comprises the inclusion and infusion of various technological dimensions of online, face-to-face and the traditional learning approaches in a learning environment, which allows for hands-on reflections by the learner and teacher. Furthermore, learners in their COP do not only stand to benefit cognitively as they collaborate with their peers in their learning spaces, but also develop their social perspectives as they interact with others in the learning process. Blended learning in the social constructivist nature of learning provides learners with opportunities to relate abstract concepts into real-life situations more easily. This is because of the use of technology and different forms of learning opportunities that are blended into the learning process.

METHODOLOGY

The research paradigm used for this study was quantitative while a quasi-experimental design was used. In this study, a pre-test, post-test non-equivalent control type was adopted to examine the data collected. The

total population of primary 6 learners (aged 9-10) from nine different private primary schools in Owerri West local government areas of Imo State, Nigeria was 3 266. In selecting the research participants, a sample size of 165 learners, made up of 75 males and 90 females from two randomly selected private primary schools, was used for the study. From each of the selected schools, two classes were chosen at random and further classified into experimental and control groups, respectively. The experimental group was made up of 81 learners (47 females and 34 males) while the control group had 84 learners (43 females and 41 males). The instrument for data collection was a test made by the researchers. The researchers formulated 30 item-objective test questions titled: 'Mathematics Achievement Gain Test' (MAGT). It was drawn from the topic '2D shapes and their properties'. The learners were taught the basic concept in identifying a 2D shape. Thereafter, the properties of 2D shapes were taught. Among the 2D shapes that were taught are circle, right-angle triangle, equilateral triangle, Isosceles triangle, scalene triangle, square, rectangle, rhombus, parallelogram, trapeze, pentagon, hexagon, heptagon, among many others. The objectives of the lesson were, cognitively, for learners to (i) correctly detect properties in each variety of 2D shapes, (ii) correctly recognise the different types of angles and their shapes, and (iii) become familiar with how lines form angles. The construction of the test instrument was guided by a table of specifications endorsed by two experts, one in mathematics education and the other in measurement and evaluation. An example of the test items is shown in the table below.

Table 1:
Instruction: correctly provide an answer to the missing shape, name of shapes, number of sides of shapes and their angles, an example has been provided for you

S/N	Shapes	Name of shapes	Number of sides	Number of angles
Example		Circle	0	0
1				
2				
3			5 sides	
4		Hexagon		
5				

The reliability of the instrument was piloted on a group of 20 learners outside the study group but with the same characteristics, within a two-week interval using the test-retest method. A reliability coefficient of 0.85 was derived through the Pearson Product Moment Correlation coefficient formula. The two groups were administered with a pre-test to ensure equity in their cognitive backgrounds.

The experimental group was taught by their usual mathematics teachers trained in the use of the blended pedagogical strategy in teaching. Mathematics software (GeoGebra) on 2D shapes was projected on the board for the learners after the normal introduction of the topic. The teacher guided them through

step-by-step tutorial sessions on the features of 2D shapes. In addition, solutions to problems on area and perimeter of shapes were projected on the board. The software could reverse the solutions to problems on 2D shapes displaying the steps for the learners to follow suit. Learners were also allowed to present mathematical problems that were solved by the software and compared with their book solutions.

The control group was taught the same topic by their regular mathematics teacher through the conventional chalk-and-talk approach. The process lasted for two weeks, after which a post-test assessment was done on both groups using a rearranged version of the pre-test instrument. The data were analysed using the mean and standard deviation formats to answer the research questions, while the hypotheses were tested using the one-way ANOVA with $P < 0.05$ level of significance as the statistical tool.

The University of Pretoria's ethical principles were applied throughout the study. Voluntary participation was secured through letters of consent. Parents and school authorities gave their consent to conduct the research using their children, and their learners and schools, respectively. Creswell (2014) maintains that ethical principles must include honesty, privacy, confidentiality and avoidance of harm on participants. These principles were upheld during the research process.

RESULTS

Research Question 1: What is the difference in the learning gains in the topic '2D geometric shapes and their properties' of learners taught using the blended pedagogical strategy and those taught in the conventional chalk-and-talk method?

Results from Table 2 below reveal that the experimental group had 20.86 as the mean achievement gain unlike the control group which barely gained 0.57. This result shows that the experimental group was 20.29 higher than the control group.

Table 2:
Learners' learning achievement gains using mean and standard deviation

Group	Test	N	Mean	SD	Mean gain	Diff. in mean gain
Expt.	Post-test	81	59.40	15.53		
	Pre-test		38.54	12.22	20.86	20.29
Control	Post-test	84	40.13	13.42		
	Pre-test		39.56	12.45	0.57	

Research Question 2: Is there any appreciable difference in the learning gains of male and female learners who were taught 2D geometric shapes and their properties using the blended pedagogical strategy?

Table 3:
Summary of male and female learners' mean achievement gains

Group	Test	N	Mean	SD	Mean gain	Diff. in mean gain
Male	Post-test	34	59.69	15.52		
	Pre-test		38.51	21.42	21.18	

Group	Test	N	Mean	SD	Mean gain	Diff. in mean gain
Female	Post-test	47	59.82	15.56		0.99
	Pre-test		39.50	20.50	20.19	

In Table 3, it is shown that males in the group had a mean achievement gain of 21.18, whereas the females in the group had 20.19 mean achievement gain. With a very slight mean difference of 0.99, the males in the group learned better than the females.

Research Question 3: Do learners who achieve low and high scores in 2D geometric shapes and their properties using the chalk-and-talk method show any significant difference when taught mathematics using the blended pedagogical strategy?

Table 4:
Summary of low and high achievers' post-test achievement gains

Group	Test	N	Mean	SD	Mean Diff.
High Achievers	Post-test	30	60.24	15.63	
Low Achievers	Post-test	51	58.65	15.26	1.59

Table 4 shows that high-achieving learners had 60.24 as their mean score in the post-test of the experimental group, whereas the mean score of low achieving students was 58.65. The high-achieving students fared better with a slight mean difference of 1.59.

HYPOTHESES

H0ı: No significant difference was recorded between the mean achievement scores of learners taught 2D geometric shapes and their properties using the blended-learning instructional and the chalk-and-talk method.

Table 5:
Summary of learners' achievement gains from the ANOVA analysis

Source	Type in sum of squares	DF	Mean square	F	Sig.
Corrected model	26640.797	6	4440.133	75.353	.000
Intercept	1078.154	1	1078.154	18.297	.000
Covariate	2008.091	1	2008.091	339.553	.000
Method	461.316	1	461.316	7.829	.006
Sex	137.027	1	137.027	2.325	.129
Achievers	47.924	1	47.924	.813	.369
Method sex	9.681	1	9.681	.164	.686

Source	Type in sum of squares	DF	Mean square	F	Sig.
Method achievers	110.425	1	110.425	1.874	.173
Error	9310.112	158	58.925		
Total	509025.000	165			
Corrected total	3590.909	164			

Table 5 gives 7.829 as the calculated f-value for method, and this is greater than the table value which stood at 93.847. Also, the p-value is 0.006 and it is less than the 0.05 oc-value. Therefore, the null hypothesis is rejected and the alternative accepted following from the result. The implication of this is that the mean achievement scores of the learners taught mathematics using a blended-learning instructional method and those taught conventionally show a significant difference.

HO_2: No significant difference exists in the mean achievement scores of the male and female learners who learned 2D geometric shapes and their properties using the blended-learning instructional approach.

In Table 5, it is shown that the achievers had a calculated f-value of 0.813. It is also less than the table value, which stood at 93.847. The p-value stood at .369, which is greater than the oc-value of 0.05. The null hypothesis is also upheld from the above result. Hence, the implication is that the male and female learners who were taught mathematics using the blended-learning instructional method show no significant difference in their mean achievement scores.

HO_3: No significant difference is seen in the mean achievement scores of the low learning gains and high learning gains achievers who were taught 2D geometric shapes and their properties using the blended-learning instructional approach.

Table 5 presented .813 as the calculated f-value for the achievers, and it is less than the table value 3.847. Similarly, the p-value stood at .369, which is greater than oc-value of 0.05. The null hypothesis is upheld following this result. It, therefore, draws the implication that the high and low achievers who learned mathematics using a blended-learning instructional method show no significant difference in their mean achievement scores.

DISCUSSION OF FINDINGS

Given the findings of this study for research question 1 and H0I, it can be said that the mean achievement gain scores of learners who learned mathematics using the blended pedagogical strategy in the experimental group were better than their counterparts who were taught using the conventional chalk-and-talk approach. This finding is a pointer to the teaching methods teachers used in facilitating 2D shapes and their properties. Having noted earlier that the experimental group that was taught using the GeoGebra mathematical software, the findings, therefore, corroborate the opinions of Zulnaidi, Oktavika and Hidayat (2020), who noted that the use of GeoGebra is central to the creation of meaningful learning experience for teachers and learners of mathematics. The findings further affirm the views of Bature and Bature (2005), who assert that learners fail mathematics as a result of inappropriate teaching methods used by teachers. Furthermore, the findings show that the learners' understanding and interest in 2D shapes and their properties were deepened and better enhanced by the blended pedagogical strategy than by the conventional chalk-and-talk approach of the same topic. It also reveals that the use of a blended-learning approach allowed the learners to participate freely in the subject and even appreciate it because it is learner centred (Zulnaidi, Oktavika & Hidayat, 2020). Similarly, the findings of the present

research confirmed the findings of Saritepeci and Cakir (2015), who recorded a positive effect on the use of a blended-learning instructional approach and environment on the learning engagement of students in middle school. Findings from their study showed that there was a meaningful impact and an increase in the average learning gains of students taught in the blended-learning environment, unlike the learners who were taught in a traditional face-to-face learning environment.

The findings for research question 2 and H02 revealed that male and female students who were taught 2D shapes and their properties using the blended instructional teaching method and learning process achieved similar results and showed no statistically significant difference in their mathematics gains. This is partly due to different rates of individual assimilation, which are not dependent on the teaching method – since the teaching method gave them all an equal learning opportunity. This report aligns with the findings of Alruwuch (2015) where he asserted that male and female students who had access to blended instructional packages did not significantly differ in their performance but had very similar results. Additionally, these results corroborate the findings of Abdon (2014), who surveyed the effect of using blended-learning methods in teaching algebra in Malayan colleges in Laguna and found that the students who learned with blended methods achieved better grades than those taught using the conventional chalk-and-talk method.

Finally, for research question 3 and H03, this research revealed that there was no marked difference in the learning gains or learning ability of the high-gaining and low-gaining mathematics learners in 2D shapes and their properties (above- and below-average learners) because they all had equal opportunity to partake in the multimedia instructional approach adopted in the blended instructional teaching method. As noted by Annie Kavitha and Sundharavadivel, (2012), the use of blended learning accommodates different learners, such as visual, auditory and kinaesthetic learners. In the case of this study, blended learning presents a fair and level learning ground for learners with different levels of learning abilities.

RECOMMENDATIONS

From the findings of this research, it is pertinent to make the following recommendations:

1. Teachers who teach mathematical contents such as geometry should be given proper in-service training and orientation on how to effectively use GeoGebra in the blended pedagogical strategy in teaching learners in primary schools.
2. Educational stakeholders should provide ICT facilities in primary schools so that teachers can use them in teaching to enhance the learning gain of learners in mathematics.
3. Teachers of mathematics in primary schools should ensure that they are proficient in the use of modern technology so that they can freely use ICT facilities in their teaching process and environment.

CONCLUSION

This research investigated the use of a blended-learning approach to facilitate the learning of geometric 2D shapes and their properties for primary 6 learners who were aged 9-10 years. Results from this study explicitly revealed that the learning gains of learners in geometric 2D shapes and their properties can be greatly enhanced across all genders and levels of learning abilities when they are taught using GeoGebra in a blended-learning pedagogical approach.

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