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Digitalizing the Teaching and Learning of Mathematics at the Senior High Schools in Ghana; the Case of Flipped Classroom Approach

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Abstract

Introduction: The 21st century comes with its own challenges so far as the teaching and learning of mathematics is concern. This is because most of the senior students have access to digital devices that allow them to navigate the social media channels like the WhatsApp, Twiter, instagram, SnapChat, Facebook, TikTok and the likes. Unfortunately these handles are loaded with various forms of videos and other stuffs that these innocent young ones turned to love to follow more than their studies, thereby affecting their academic achievements.

Purpose: The motive of this study was to enhance students' conceptual understanding in circle theorems using the flipped classroom approach.

Methodology: A sample of Fifty (50) Remedial students from the Bekwai Municipal Assembly in the Ashanti Region of Ghana was selected by means of purposive sampling method for the study. With the use of quasi- experimental design, a pretest post test method was use to gather the data on the students to ascertain the impact of the interventional design. In addition to the tests, a questionnaire was also used to find out how students feel about the flipped classroom pedagogy in teaching and learning.

Findings: The analysis of the questionnaire came out that students enjoyed the lessons and their performance appreciated as a result. A statistical significant improvement in the students' performance made the researcher reject the null hypothesis and concluded that flipped classroom approach impacted positively on students' performance.

Recommendations: It was therefore recommended that the flipped classroom should be adopted as one of the pedagogical strategies in teaching mathematics at the Senior High school.

Keywords: *Digitalize, constructivist, flipped classroom.*

Introduction

Since the introduction of Information Communication Technology (ICT), Communication and human interaction have become very interactive because of enhanced technology. As the word goes digital there is the need to digitize the teaching and learning especially, mathematics at the Senior High Schools. A lot of Students at this level have access to digital devices like; the android phones, Smart phones, Tablets and others that enable them use the various social media handles (Asare-Donkoh, 2018; Mingle & Adams 2015; Mehesah et al., 2021). According to the studies, students rather spend a lot of hours surfing, taking selfies and posting them on facebook, Instagram, tiktok, whatsApp and the likes, instead of spending time to solve some mathematics problems (Ampofo, 2021). In order to break the monotony in the learning of mathematics, the lessons can be made accessible to the students on the digital devices so as to make mathematics appeal to the students. By presenting mathematics in this mode, the students will see mathematics as fun and will endeavor to learn it either consciously or unconsciously. Unlike the traditional classroom situation, the students learn at their own pace, since the lessons can be taken at the comfort of their homes, and the normal class hours are used for active discussions and problem solving (Amoako-Atta & Aseidu-Addo, 2021). One of the modern pedagogical strategies that make the teaching and learning of mathematics digital is the flipped classroom.

Flipped classroom, as observed by Bishop and Verlager; (2013), is a kind of pedagogical approach to teaching which takes the form of web-based video lectures delivered at home and normal class time devoted to problem solving, discussion, debates, case studies, and other activities. Flipped classroom can be recognized as a pedagogical approach whereby direct instruction moves from the group learning space (classroom) to the individual learning space (home), and the resulting group space is swapped with a dynamic, interactive learning environment (Lo & Hew, 2021). The educator then guides students as they apply concepts and engage creatively in the subject matter (The Flipped Learning Network, 2014). Practically students are provided with the subject matter to be learned in class in a form of audio or video to be learned by the students at their own pace and convenience. In some cases, the content is uploaded on a particular website and students are directed to login and study on their own (Persky & McLaughlin, 2017).

In places where internet connectivity is limited in access, the information can be put on some other storage devices for student to play through various devices (Yeboah, Ampadu, Ahwireng, & Okrah, 2020). For instance, DVD, VCD, mobile phones and other digital gadgets. The teacher's main duty during instructional period is to engage the students in discussions and exercises among other things (Fisher & Rixon 2020). This affords the students opportunity to express themselves and also ask any questions that might be bothering them after going through the activities with the aid of the videos provided (Cabi, 2018). One of the best features of the flipped classroom is that, it is more of a student-oriented approach and user friendly. The student has the leisure to stop, pause or rewind, and watch the video or audio again; actions which are not possible in the traditional classroom. The interactive nature of the flipped classroom allows the students to learn at their own pace and with an unimaginable rate of relish (Fleischmann 2021; Singh 2020).

The study was premised on the constructivist theory of learning. The term constructivism refers to the idea that learners construct knowledge for themselves (Bada & Olusegun, 2015). Each learner individually and socially constructs meaning as he or she learns. Social constructivism for instance places high priority on language in the process of intellectual development. Kusuma et al., (2021) observed that language as a discourse is the vehicle by which mathematical concepts, ideas and skills are developed. It is just proper that at the senior High School level, students are given the opportunity to discuss and communicate mathematically.

In recent years, mathematics educators and researchers have endorsed the constructivist theory of learning (Duit, 2016; Gravemeijer, 2020). However there have been suggestions to bring about innovative ways of using the constructivist theory. This implies a modification of teaching tasks and strategies, learning tasks and strategies, and the criteria for assessing learning achievements. That is, there is the need for a paradigm shift of the teacher's role from knowledge provider to learning facilitator and that the student's role shifts from information collector to the active practitioner (Borko et al., 2021).

The benefits of mathematics in our daily lives in this modern era cannot be stretched enough. Mathematics has been the catalyst for technological advancement in this 21st century (Agah, 2020). It has become a common practice for researchers across the globe to find modern instructional strategies of teaching mathematics that will enhance smooth learning and application of mathematical skills and concepts (Ina et al., 2016; Haji, 2019). This modern era, demands the study of Science, Technology Engineering and Mathematics (STEM) as the only way to promote economic growth and development (Gough, 2015; UNESCO, 2015). Mathematics as a science subject, influences the development of science in all of its kind; Medicine, Physics, Biology, Technology, among others (McHugh et al., 2018). This is the reason why mathematics has been made a compulsory subject in most of the countries across the globe including Ghana (Ina et al., 2016). In addition to Critical Thinking and Problem Solving (CP), the mathematics curriculum of Ghana observes Personal Development and Leadership (PL) as an essential part of the mathematics education (NaCCA; Ministry of Education, 2019).

Circle theorems is an aspect of geometry that plays an essential role in helping how mathematicians as well as learners of mathematics appreciate and understand the space, shape and orientation of various bodies and objects in this world (Bozkurt & Ruthven, 2017). That is, Geometry provides a complete appreciation of the world we live in. The concepts in geometry are used in developing students' spatial awareness, intuition, visualizations and to solve practical problems (Badu-Domfeh, 2020). Studies have revealed that geometry is applicable and relevant to work places and in everyday life. More so the knowledge of geometry is a prerequisite for other subjects in the curriculum such as science, arts, and technology. (Özgür & Taş 2019; Mifetu, Kpotosu, Raymond, & Amegbor, 2019)

The unfortunate part is that, some Secondary School students in Ghana perform poorly in circle theorems and in geometry in general. The condition has been captured in several Reports of the Chief Examiner for the West Africa Examination Council (WAEC), listing circle theorems as one of the areas that students have difficulty (WAEC, 2012, 2018, 2019). The Reports further stated that the students who write the West Africa Senior School Certificate (WASSCE) have been performing poorly in Circle Theorem questions. Interestingly, students avoid questions on Circle Theorems when they have other alternatives according to the reports. Students' difficulty

in circle theorem has been around for decades. Some researchers believe that the problem stem out from students' poor conceptual understanding of geometry at the Basic school (Anamuah-Mensah, Mereku & Asabere-Ameyaw, 2004). Modern researchers have tried to find out the causative factors of this age-old difficulty associated with geometry concepts. The following are some of the factors enumerated so far; language of geometry, visualization abilities, non-availability and obsolescence of instructional materials, ineffective instruction, poor reasoning skills and students lack of interest in geometry (Baffoe & Mereku, 2010; Aysen, 2012; Fabiyi, 2017). Some researchers believe that students lack of understanding in circle theorems and poor performance in mathematics is as a result of teachers neglect and improper handling of the topic (Nabie et al, 2013; Assan-Donkoh et al. 2019). Arthur, Asiedu-Addo and Assuah, (2017) revealed that adopting modern pedagogical strategies that can stimulate the students to learn can enhance conceptual understanding. Meanwhile, the twenty first century provides an array of opportunities including enhanced technology such as Flipped classroom that mathematics teachers can properly utilize to promote realistic mathematics instructions (Zeybek, 2020; Amoako Atta & Aseidu-Addo, 2021).

Methodology

Fifty students from the Bekwai Municipality of Ashanti Region who were not successful in their mathematics at the West Africa Senior High School Certificate Examination (WASSCE) were selected for the study. The motive of the study was to use the flipped classroom approach as an instructional pedagogy to provide remedial teaching to the participants. Before the interventional design was implemented a pre-test was administered to find out students' level of understanding of the circle theorems. The test consisted of five questions which aimed at testing basic conceptual understanding in circle theorems. This was followed by a step by step three weeks of intensive teaching and learning using the flipped classroom approach. The intervention was in three stages.

The first stage was where the lessons were given to students to watch before the normal class time. Each video was not more than thirty munities, but was fully loaded with activities. These were teacher made videos, where the step by step approach in developing the circle theorems has been worked out for students to observe and practice. Students could paused the video and try some of the activities before continuing. Likewise, they could play the videos as many times as possible or at their own pace that could help them grasp the concepts. There were three videos in all covering all the six (6) theorems with their corresponding activities for practice. Each week was devoted to one video.

The next stage was the normal class hours for lessons which were used for discussions and solving of varied practical application questions. Each and every student actively contributed to the discussions. This afforded the facilitator the opportunity to observe as students responded to questions and issues raised by their colleagues. The facilitator only came in when there were certain concepts that needed clarification. Finally, students were put into groups for a quiz competition. It was marvelous, fantastic, enjoyable and interesting how students were exhibiting mathematical thinking skills, applying concepts and communicating ideas. The post test was administered in the fourth week to find out the efficacy of the flipped classroom approach.

Results

Table 1: Summary of students' responses of the questionnaire

Frequency	A	NA	NAA	Total
	N (%)	N (%)	N (%)	N (%)
I was previously good in mathematics	4(8)	10 (20)	36(72)	50(100)
Mathematics make me nervous previously	30(60)	18 (36)	2 (4)	50(100)
Teacher commends me previously	4(8)	8(16)	38(76)	50(100)
Mathematics was boring to me	39(78)	7(14)	4(8)	50(100)
I have access to devices to play the videos given to me by the teacher	50(100)	0(0)	0(0)	50(100)
The videos make the lesson very interesting.	44(88)	6(12)	0(0)	50(100)
The concepts are well explained in the videos	41(82)	6(12)	3(6)	50(100)
I was able to follow the lessons with understanding	38(76)	10(20)	2(4)	50(100)
I was able to solve the practice question in the video	44(88)	6(12)	0(0)	50(100)
I was able to solve more question in textbook after watching the videos	43(86)	5(10)	2(4)	50(100)
I was able to make contributions during class discussions	38(76)	12(24)	0(0)	50(100)
The class discussions made me understand certain concepts better	38(76)	10(20)	2(4)	50(100)
The teacher's explanations in class were useful	50(100)	0(0)	0(0)	50(100)
Watching the videos made the lessons very interactive	34(68)	16(32)	0(0)	50(100)
the face to face lessons were just superb	50(100)	0(0)	0(0)	50(100)

A = Always, NA = Not Always, NAA = Not at all, N = number of respondents, (%) = percentage of respondents

Table 1 provides the summary of responses from the respondents. The purpose of the questionnaire was to find out how student embraced the flipped classroom approach and the impact it had on their studies. For instance the first four questions showed that most of the students were not performing well in mathematics and because of that they lost interest in the subject. The next six questions also revealed that students had access to digital devices that enable them played and enjoyed the videos. The responses indicate that learning at the comfort of their homes was quite good for the participants and that helped them in the assimilation of the

concepts. The last five questions depict how practical and interactive the classroom lessons were. Most students were active, contributing to discussion. Unlike the traditional approach whereby the teacher does most of the talking, reducing students to mere recipients of already cooked information.

Table 2: Analysis and Interpretation of Pre and Post Test Scores with t-test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error
Pair 1	PRE-TEST SCORE	39.9200	50	12.05911	1.70542
	POST-TEST SCORE	58.9800	50	15.99042	2.26139

Table 2 provides statistical perspective of the tests conducted. A sharp comparison between the pre test and post test indicate there was an improvement. While the pretest had mean score of 39.92, the post test recorded a mean score of 58.98 with a standard deviation of 1.70 and 2.26 respectively. This shows clearly that the mean performance of the students after the intervention was better than their performance in the control mode.

Table 3: Paired sample t-test of pre test and post test

Paired Samples Test

		Paired Differences							Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T	df	One-Sided p	Two-Sided p
Pair 1	Post-Test – Pre-Test	19.06	4.34	.61506	20.296	17.824	30.989	49	<.001	<.001

The pair sampled-test was conducted in table 3 above to find out if the difference in performance was statistically significant. Since the p-value or the significant value is less than 0.5, it is an indication that there was statistically significant difference between the two tests, hence there was an improvement in the students' performance.

Discussion

The results from the post test as analyzed have proven that the flipped classroom approach has positive impact on students' conceptual understanding. This goes a long way to confirmed the recommendations made by modern researches such as (OECD 2019; Ina et al., 2016; Rowly 2020; Bartolini & Martingnone, 2020; Andamon & Tan, 2018) (Luevano & Collins, 2020).

Conclusion

It was expedient to conclude that the flipped classroom approach in teaching and learning has proven to be enhancing students' conceptual understanding. Since it gives the student opportunity to practice, they turn to appreciate the lesson, understand the concepts and retain the knowledge gained. The discussion sessions held during the class periods urged the students to build mathematical language skills and also enable them to think reason and communicate mathematically.

Recommendations

Based on the outcome of the studies, the following recommendations were made;

- Senior High School mathematics teachers should adopt the flipped classroom as an instructional strategy.
- The parents, guardians and other stakeholders much provide the students with needed gadgets and accessories to enhance the smooth implementation of the flipped classroom.
- Further research must be carried out to find out the practicability of hosting the flipped classroom online.

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