African Journal of Educational Studies in Mathematics and Sciences Vol. 12, 2016

Effect of the inquiry-based teaching approach on students' understanding of circle theorems in plane geometry

T. Mensah-Wonkyi[1] & E. Adu[2]

Abstract

This study investigated the effect of inquiry based teaching approach on senior high school (SHS) students' conceptual understanding of circle theorems. It utilized mixed method approach involving quasi-experimental design in which 79 home economics students in two intact SHSs classes were purposively sampled and assigned to control and experimental groups. The experimental group was treated with a teaching approach that integrated inquiry-based teaching into classroom discourse. Tests (pre- and post-), for assessing students' understanding of circle theorems and a questionnaire for measuring the students' perception of motivation to learn were given to the two groups before and after the treatment. An independent sample t-test run on the results of the circle theorems tests for the two groups revealed that students in both groups showed an increased in their understanding of circle theorems in the post test as compared to the pre-test. However, students in the experimental groups achieved better results compared to those in the control group. Also the experimental group's perception of motivation in classroom learning environment during the treatment was higher than that of the control group. It was recommended among others that inquiry-based teaching approach should be integrated into classroom teaching and learning

Keywords Inquiry-based teaching; Circle theorems in plane geometry

Introduction

It is obvious that the compulsory nature of mathematics in curriculums worldwide confirms its usefulness in the development of individuals. Mathematics competence is a critical determinant of the post-secondary education and career options available to young people (Okereke, 2006). Stressing on the importance of mathematics, Bassey, Joshua, & Asim (2011) described mathematics as a vital tool for the understanding and application of science and technology and serves as a base for national development and the world at large. In Ghana for instance, one must obtain a pass in mathematics before he or she can gain admission into any tertiary institution. Mathematics has however been made a core subject both at the basic and the secondary levels of education in Ghana. Mathematics is made up of a galaxy of content domains, Examples of these content domains are arithmetic, geometry, algebra, trigonometry, calculus etc. Geometry is the main focus of this study and places emphasis on circle theorems.

[1]Thomas Mensah Wonkyi is a researcher in Mathematics Education, and currently a Principal Superintendent of Education working with the Ghana Education Service. Email: thomaswonkyi@yahoo.com
[2]ElizabethAdu is a reader at the Department of Mathematics Education, University of Education, WinnebaWinneba, Ghana. Email: elizabethadu21@yahoo.com

Effect of the inquiry-based teaching approach on students' understanding of circle theorems in plane geometry

T. Mensah-Wonkyi & E. Adu

Geometry is a branch of mathematics that provides a rich source of visualization for understanding arithmetical, algebraic, and statistical concepts (Drickey, 2001).The teaching and learning of geometry is very essential in everyday life since it provides a more complete appreciation of the world we live in since it appears naturally in the structure of the solar system, in geological formation some rocks and crystals, in plants and flowers, and even in animals (Lie & Hafizah, 2008).Circle theorems is considered as a very important aspect of geometry. It is very useful in ship navigation.

According to Ministry of Education (2010), the objectives of teaching and learning circle theorems are that Students should be able to find:

i) the relationship between the angle subtended at the center and that at the circumference by an arc.
ii) the value of the angle subtended by a diameter at the circumference.
iii) the relationship between opposite angles of a cyclic quadrilateral.
iv) the tangent is perpendicular to the radius at the point of contact. the alternate angle theorem by drawing

Because of its usefulness in everyday life, it is not surprising most international examinations always have some aspect of geometry. Examples of these examinations are the Trends in International Mathematics and Science Study (TIMSS), West African Senior School Certificate Examination (WASSCE), etc.

Because of its usefulness, the methods of teaching the subject should be of great importance to mathematics educators. Generally, teaching requires that, the teacher creates an environment in which students are active leaners. It also requires that the teacher integrates a range of assessment methods into their instruction to enhance students understanding (National Board for Professional Teaching Standards, 2009). Understanding mathematics means being able to justify procedures used or state why the process works in other words real understanding of mathematics concept is achieved when it is taught through proofs (Wiggins, 2016). Unfortunately, mathematics teachers in sub-Saharan Africa use the traditional method of teaching in their lessons where concepts are taught by giving a set of rules to students to be followed without the students knowing how those concepts came about (Akyeampong, Lussier, Pryor, & Westbrook, 2013).

According to Wood & Gentile (2003), educators are beginning to recognize that there are better ways to learn other than through the traditional methods. The traditional methods of teaching according to experts is passive rather than active. Students are made to act as spectators rather than partakers in the learning process. Also, the traditional method of teaching does not enhance critical thinking and collaborative problem-solving since chew and pour is the order of the day.

A number of authorities in mathematics education have from time to time emphasized that the goal of mathematics education reform is to produce students who are skilled in resolving problems, in addition to fostering attitudes, interests and a high motivation towards mathematics. Students should be exposed to skills in creating their own knowledge in order to enhance understanding of mathematical concepts rather than providing them with a set of rules without understanding. In order for the students to think mathematically, students should be exposed to various strategies of problem solving. One of such strategies is to create a conducive

learning environment where students can learn through inquiry where students are placed at the center of the learning process.

Statement of the Problem

Several research studies have revealed that students have difficulties in learning circle theorems (NCTM,1999). Evidence from the West African Examination Council's chief examiner's report on West African Senior School Certificate Examination in core mathematics has for about a decade revealed candidates' difficulties in tackling problems relating to circle theorems. Also, a personal study conducted by the researcher on circle theorems when he was a tutor at Half Assini in Ghana in 2013 revealed that senior high school students really experience such problems. For instance, the end of term examination scripts the researcher marked showed that out of the total number of 93 students who answered the questions, only 30 students representing 32.3% of the number had all answers right. The remaining 67.7% of the SHS students showed high level of difficulty in identifying angles subtended at the center and at the circumference by an arc.

Likewise, in questions relating to angles subtended by a diameter at the circumference, data again gathered in the exams indicated that, out of 93 SHS students who solved these questions, only 15 of them, representing 16.1% of the number had all answers right whiles majority of the students encountered difficulties in the area of recognising the theorem to be used as well as writing the correct mathematical statements. Other information on students' answers in other areas of circle theorems such as the relationship between opposite angles of a cyclic quadrilateral, the tangent being perpendicular to the radius at the point of contact and the alternate angle theorem gave a clear indication that SHS students still had various levels of difficulty.

Observation made by Mereku (2010) brings to light the teaching approach used by mathematics tutors. He elaborated further that these difficulties may be probably due to the ineffective teaching methods and lack of appropriate use of teaching resources in the traditional Ghanaian classrooms. Ferguson (2010) recommended that the implementation of inquiry-based instructional methods should be encouraged by administrators and embraced by tutors in an effort to continually improve public education. Therefore, in an attempt to seek for a teaching strategy that can improve SHS students' achievement in circle theorems, this study investigated the effect of the inquiry-based Instruction on SHS students' achievement in circle theorems which is taught in Ghanaian SHSs.

Purpose of the study and research hypothesis

In view of senior high school students' poor performance in circle theorems and their teachers' inability to vary their classroom teaching methods, the study sought to know whether or not the introduction of the inquiry based teaching approach will improve students' understanding circle theorems. Objectives of the study were to:

(i) Investigate the effect of inquiry-based teaching approach on students understanding of circle theorems.
(ii) Find out students' perception of how motivating they find their mathematics classroom learning environment under the traditional and inquiry-based teaching approaches.

In answering the first research question, the hypotheses below were formulated for the study:

H_0: There is no significant difference in the understanding of circle theorems between the control and experimental groups in the post-test

Theoretical Framework: Constructivism

The constructivist believes that students construct their own understanding and knowledge of the world through experience by continually asking questions or through inquiry. Generally, the constructivism concept means encouraging students to use active techniques such as experiments and real-world problem solving to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing. The teacher makes sure that he understands the students' pre-existing conceptions, and guides the activity to address them and then build on them. Constructivism modifies the role of the teacher to that of a facilitator who helps students to construct knowledge rather than to reproduce a series of facts (Khalid & Azeem, 2012).

In a constructivist learning environment, the teacher guides the students through problem-solving and inquiry-based learning activities with which students put together and test their ideas, draw conclusions and inferences, group and convey their knowledge in a collaborative learning environment. One of the most important strengths of the constructivist approach to instruction is that it transforms the student from a passive recipient of information to an active participant in the learning process. Always guided by the teacher, students construct their knowledge actively rather than just mechanically ingesting knowledge from the teacher or the textbook. The task of the instructor is to translate information to be learned into a format appropriate to the learner's current state of understanding (Khalid & Azeem, 2012).

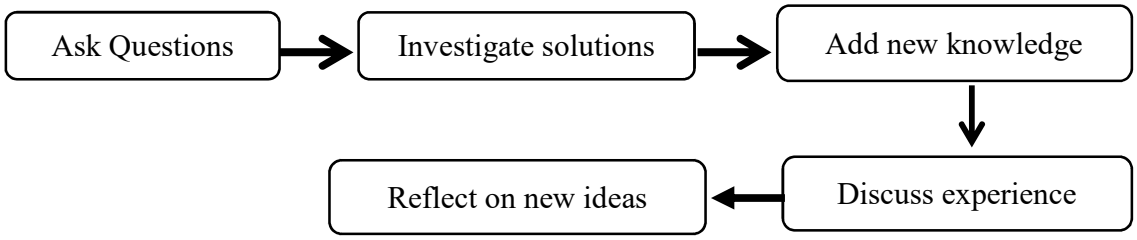

Figure 1. Inquiry-based Learning Model

Inquiry–based learning is a pedagogy which enables students experience the processes of knowledge creation and the key attribute is learning stimulated by an inquiry a student centered approach, a more to self-directed learning and an active approach to learning (Spronken-Smith, 2007). Inquiry-based learning can also be defined as an approach to teaching and learning that places students 'questions, ideas and observations at the center of the learning experience (Friesen & Scott, 2013). Educators play an active role throughout the process by establishing a culture where ideas are respectfully challenged, tested, redefined and viewed as improvable, moving students from a position of wondering to a position of enacted understanding and further questioning (Scardamalia, 2002). Once students are challenged, they are expected to

engage in creating conjecture, analyzing conjecture, communicating, working collaboratively, and engaging in mathematical argument (Stonewater, 2005).

Through the inquiry learning students can achieve relational understanding of mathematical concepts since the meaning of 'knowing' has shifted from being able to remember and repeat information to being able to find and use it (National Research Council, 2007).

Popular discourse on education as well as recent findings in the learning sciences tell a similar story. The model of education typical of 20th century classrooms was effective for that era of human history, but the 'knowledge society' we live in requires new thinking and approaches to teaching and learning. This new approach means that "former conceptions of knowledge, minds and learning no longer serve a world where what we know is less important than what we are able to do with knowledge in different contexts." (Friesen, 2009).

According to Crombie/(2009), in inquiry based learning, the teacher acts as the facilitator of the students learning rather than the provider of information. As well as having an excellent understanding of the content the teacher needs to carefully plan their learning units. This planning will involve the teacher developing an open ended question or devising a topic based on the curriculum for the students to determine their own questions. It also involves exploration type activities to activate prior knowledge and also engage the students.

Typically, the lesson will start with an open ended question devised by the teacher, student or sometimes both, through the use of carefully planned activities the teacher will encourage the students to discuss the question and search for their own answers. Proponents of inquiry based methods suggest that there needs to be some sort of declaration of real world math concepts before any elementary skill sets are committed to memory (Thompson, 2006). It is during this process that students gather resources, do their own research and synthesise their information. They then present and share their findings and will finally need to be given the opportunity to reflect on their learning. Through this process students build their own knowledge.

Naturally, every class is different and the approach of the teacher varies according to the ability of the class and the topic to be taught. Teachers are able to utilize different levels of inquiry from structured to open inquiry. There are essentially three levels of inquiry namely, structured, guided and open inquiry. Crombie (2009) defined these levels as:

> *Structured inquiry:* This is where the teacher mainly directs the inquiry, the teacher provides the question to be investigated and will then provide a step-by-step instruction to help student arrive at the answer. This kind of inquiry is important because it enables students to gradually develop their ability to conduct more open ended inquiry. It is also algood level to start/for teachers/who are.new.to inquiry-based .teaching method.
>
> *Guided Inquiry:* Here the teacher chooses the question and the students will take more responsibility for establishing the direction and methods of the inquiry. The teacher plays an important role in guided inquiry, this could be through feedbacks or posing further questions to help lead the students in the right direction. Open Inquiry: This is where students take the lead in establishing the question and methods while the teacher takes on a supportive role. Having students to ask questions is key to open inquiry and requires a high order thinking. However, it is possible to use a combination of the types mentioned above and it is called the coupled inquiry.

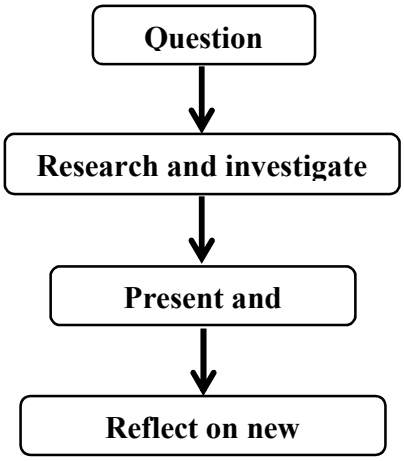

Figure 2. The concept of inquiry-based learning

Effects of Inquiry based teaching approach

Inquiry is a process of active learning that is driven by questioning and critical thinking. The understandings that students develop through inquiry are deeper and longer lasting than any pre-packaged knowledge delivered by teachers to students. According to (Ferguson, 2010) the inquiry based teaching approach has a positive effect on the mathematics achievement of students. In his study, two high school geometry classes were taught area formulation using a traditional lecture based approach to instruction. A third geometry class was taught area formulation utilizing inquiry-based instructional methods. Students in both groups took both a pre-test and post-test. At the end of the exercise, Students involved in the inquiry-based lessons exhibited better retention, a better ability to problem solve, and better performance on decontextualized mathematical problems than their peers who were taught in the traditional fashion. He therefore recommended that teachers of mathematics should apply the inquiry based teaching and learning approach in both at the junior levels through to the tertiary levels. In the study by Ferguson (2010), the inquiry based mathematics instruction improve mathematics achievement. In his study, two classes were instructed using inquiry based method and the traditional method, each class was taught the same concepts, but through the different methods as mentioned above. Pupils were given both Pre-test and Post-test. Results of the SPSS analysis showed that both classes made improvement from their pre-test to their post-test for both units but students receiving instruction through inquiry-based Instruction showed significantly more improvement on the second unit. Ferguson therefore entreated curriculum developers to adopt the inquiry based mathematics instructions to enhance student conceptual understanding. Other studies by (Crawford & Snider, 2000; Riordan & Noyce, 2001) also found comparable results. In their study, it was found that students taught through inquiry scored higher than the group taught through the traditional method which indicate a very good understanding of students of the inquiry instructions than their traditional group counterparts.

Also based on the research by Oliver (2007) and Prince & Felder (2007), the inquiry-based teaching style presents students with problems to be solved and it increases student's motivation. More importantly, the inquiry based learning actively involves the students in the learning process and allows the students to learn the contents on their own, which provides more opportunities for the students to gain a deeper understanding of the concepts and become better critical thinkers (Wang & Posey, 2011).

Students' perception about their mathematics learning environment

In Ghana, students' rating of teachers' instruction are widely used in colleges and universities. However, there are limited studies which have investigated teachers teaching practices by examining students' perceptions of their teacher's teaching at the basic and secondary education

-level. How individuals perceive an object, a person or the environment in which they find themselves has quite often tended to influence their subsequent behavior. Fisher and Webster (2003) noted that "the social ecological setting in which students function can affect their attitudes and moods, their behavior and self-concept and general sense of well-being". These findings give an indication that how an individual perceives the learning environment may have certain consequences on the individual's subsequent behavior and his achievement. According to the Theory of Reasoned Action Ilevbare (2008), "attitude is an independent measure of affect for or against the attitude object, which is a function of belief, strength and evaluative aspect associated with each attribute" (p.123). What this means is that any attempt to improve students' achievement in mathematics must take into account the classroom environment since the classroom environment can serve as an attitudinal object. This was confirmed by Eshun (2000) that, the perception of most students about mathematics is that mathematics is the most feared subject. According to his study the fear factor is due to the classroom learning environment students are exposed to.

Results of studies conducted in the past three decades provided convincing evidence that the quality of classroom environment in schools is a significant determinant of student learning perception and achievements (Fraser, 1994, 1998 as cited in Murugan & Rajoo 2013). Past research in Indonesia by Margianti, Fraser and Aldridge (2001), Singapore (Fraser and Chionh, 2000; Goh and Fraser (1998), Riah and Fraser (1998) (as cited in Murugan and Rajoo 2013) support this general view. These studies suggest that students learn better when they perceive the classroom environment positively.

Methodology

Design and sample

The study was a design-based research that employed quasi-experimental study methodology with two intact classes from two different schools comprising 79/students (Control group=38, Experimental group=41). The classes for the study were purposively sampled. A simple random sampling technique was used in assigning the experimental and the control group classes According to Vanderstoep and Johnson (2009), quasi-experiment is an empirical study used to estimate the causal impact of an intervention on its target population. The quasi-experimental design chosen for this study was the Pretest-Posttest non-equivalent group strategy. The purpose of this strategy was to use qualitative data and results to assist in explaining and assigning reasons for quantitative findings.

Qualitative methods were used in the study in order to provide a more profound understanding of the effect of inquiry-based teaching approach on the variables being investigated.

Quantitative research on the other hand, utilizes experimental methods and quantitative measures to test hypotheses and generalize the outcomes. In this study, the quantitative methods (data collection and analysis) were used to establish the relationship between the performance of the students in the Pre-test and Post-test results. The researcher tested the efficacy of a supplementary teaching approach that integrated inquiry-based teaching into the pedagogical discourse in the classroom. The study is aligned with the curriculum topic "plane geometry II" (Circle theorems) and carried out in the same weeks in which the regular lessons were taught.

Instrumentation

The instruments used for the data collection were: tests, questionnaire and an unstructured interview. The test was made up of 20 questions (10 pre-tests and 10 post-test) which were answered by each student before and after the treatment. The pre-test assessed students on their ability to use the properties of special triangles, calculate the sums of interior angles and exterior angles of a polygon, identify various plane shapes (including the special triangles) by their geometric properties and above all the concept of circle theorems. This is because, the areas mentioned above are all aspects of geometry (Ministry of Education, 2010). The questions were in written form and students were expected to work and come out with their own solutions to all questions.

The aspect on students' perception about their mathematics learning environment was a Likert scale from 3 =Often 2 =Sometimes and 1 =Never. Where some statements were made on what goes on in their mathematics classroom environment (Traditional and Inquiry-based) and students were made to indicate whether the statement or the activity occurs sometimes, often, or does not occur at all. This was administered after the students were taken through some lesson using the Traditional approach and the Inquiry-based approach for group A and group B respectively. Where group A is the control while group B is the experimental group.

Results

Research Question 1: What is the effect of inquiry-based teaching approach on students understanding of circle theorems?

As indicated above, the students were given a pre-test, on questions based on what they knew about geometry with majority of the questions based on circle theorems. After experimental and the control groups were taught using the two approaches i.e. the inquiry-based approach and traditional approach for the experimental and control groups respectively, a test on circle theorems was answered by both groups. An independent samples t-test was used to detect whether or not there is a significant difference in the scores of the two groups in the pre and posttests. Table 1 shows the results of the independent samples t-test performed by the researcher.

Table 1 Independent Samples t-test for Group A and Group B

Test	Groups	Mean	Stand Dev	t-value	P-Value
Pre-test	Group A	12.61	9.1692	0.82	0.525
	Group B	10.71	2.1437		
Post-test	Group A	18.65	5.4492	0.89	0.001
	Group B	33.00	6.3251		

Table 2: Paired sample t-test for group B in pre-test and post test

Groups	Mean	Stand Dev	t-value	P-Value
Group B pre-test	10.71	2.1437	1.82	0.000
Group B post test	33.00	6.3251		

Table 3: Paired sample t-test for group A in pre-test and post test

Groups	Mean	Stand Dev	t-value	P-Value
Group A pre-test	12.61	9.1692	1.40	0.085
Group A post test	18.65	5.4492		

From Table 1, the Group B had a mean score 10.71, while that of the Group A was 12.61 in the Pre-test. The results indicated that there was no significant difference in the level of conceptual understanding between Group A and Group B in the Pre-test at $p=0.525>0.05$. This means that Group A and Group B were almost of the same level of conceptual understanding of geometry (circle theorems) before the start of the treatment. In the Post-test however, Group B had a mean score of 33.00, while that of Group A was 18.65. The t-test results revealed that there was significant difference in the understanding of students in circle theorems in favor of the students of the various schools in the Post-test at $p= 0.001<0.05$ which indicate that there has been a tremendous improvement in the understanding of students of Group B in circle theorems in plane geometry. A paired sample t-test (Table 2&3) was conducted to test the effectiveness of the two approaches used in teaching. Results of the paired sample t-test revealed that there was no statistically significant difference in the mean score of the control group at $p=0.085>0.05$. There was however a statistically significant difference between the mean scores of the students in the experimental group in the post test at $p=0.000<0.05$.

Research Question 2: What is the perception of Students' on how motivating their mathematics classroom learning environment is, under the traditional and inquiry-based teaching approaches?

Each student in the two classes were made to respond to a questionnaire after the two lessons. This was done to know how they perceive their classroom learning environment and how it motivates them to learn circle theorem.

Table 4 Weighted means, standard deviation and level students' perception for Traditional and Treatment groups

	Traditional group			Treatment group		
Subscales	**Mean**	**S.D**	**Level**	**Mean**	**S.D**	**Level**
Student cohesiveness and Co-operation	1.79	0.42	Low	2.68	0.40	High
Teacher support	1.43	0.47	Low	2.77	0.45	High
Overall Perception of motivation	1.60	0.45	Low	2.70	0.43	High

The results from Table 4 shows that students who were taught using the traditional approach perceive their mathematics learning environment as low in motivation. Students who were taught using the inquiry-based approach on the other hand perceive their mathematics learning environment as high in motivation.

The researcher interviewed some of the students in the treatment group using an unstructured interview and analyzed using contextualization method. The purpose of the interview was to confirm the perceived high motivation learning environment by the treatment group and also to show that the results in the post test was solely due to the inquiry-based approach used. Below are some of the responses by the students in the interview:

Students' category 1: I find this circle theorem lesson interesting and free from fear and confusion because I am free to ask questions from group members and the teacher. Also, during the group activities my friends explain some things I don't understand to me.

Students' category 2: I understand these concepts better and learning has been made easier because now I don't need to do "chew and pour" as I used to.

Discussion

The results show that, students who underwent the inquiry-based instruction approach of teaching performed better in the post test than their counterparts who underwent the traditional method of instruction. The level of significance recorded in the independent samples t-test after the treatment was p=0.001<0.05, indicating a statistically significant difference in the conceptual understanding of students taught using the two approaches in favor of the inquiry-

based approach. The results of this study are consistent with the earlier studies by Riordan & Noyce (2001) which showed that students in schools using inquiry-based programs as their primary mathematics Curriculum performed significantly better than student taught using the traditional approach. The effectiveness of the inquiry –based teaching approach was tested using paired sample t-test. A p-value of 0.015 was recorded which indicated that the inquiry-based teaching approach was effective.

Also Crawford and Smider (2000) as reported by Ferguson 2010 of an inquiry-based curriculum and traditional curriculum found comparable results. In their study it was found that students taught through inquiry based approach scored higher than the group taught through the traditional method which indicates very good understanding of students of the inquiry instructions then their traditional group counterparts.

The results also showed that, students who were taught using the inquiry-based approach have a high/positive perception on motivating their learning environment while those taught using the traditional method perceived the motivation of their learning environment as low/negative.

The result is also consistent with some other studies conducted in Ghanaian context. In Eshun (2000) for example, the perception of most students about mathematics is that mathematics is the most feared subject as a results of the kind of environment mathematics is taught. Eshun in his study concluded that as a results of the high perception of students about how motivating their learning environment is, can increase students' willingness to participate fully in class by working in groups, which promote learning and understanding of the concept being taught by the teacher.

Lastly the results of this research confirms the observation made by Wang & Posey (2011) that the traditional approaches of mathematics instruction do not seem to help students achieve the intended learning outcomes in the curriculum.

There is an urgent need to change the traditional mode of geometry instruction to one that is more rewarding for both teachers and students. Specifically, learners must be given opportunities to personally investigate and discover geometry to enable understanding of the subject in-depth and also in relation to other fields of mathematics.

Conclusions and recommendations

The research has shown that, many students in both groups did not understand basic theorems used in circle theorems as seen in the Pre-test. This low conceptual understanding of circle theorems according the students was due to the traditional methods used in teaching mathematics since the method does not encourage creativity and critical thinking in the mathematics class. To overcome the low understanding of students in circle theorems and mathematics as a whole, it is recommended that teachers and curriculum developers introduce more innovative approaches to teaching and also the topics in the syllabus be reduced to create a favorable condition for the inquiry-based teaching to be implemented by the teachers in the senior high schools.

References

Akyeampong, K., Lussier, K., Pryor, J., & Westbrook, J. (2013). Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal of Educational Development, 272-282.

Bassey, S. W., Joshua, M. T., & Asim, A. E. (2011). Gender Differences and Mathematics Achievement of Rural Senior. Mathematics Connection, 1-8.

Crawford, D. B., & Snider, E. (2000). Crawford, D. Effective mathematics instruction: the importance of curriculum. Education and Treatment of Children.

Drickey, N. (2001, January 14). A comparison of virtual and physcial manipulatives in teaching visualization and spatial reasoning to middle school mathematics students. Retrieved from Dissertation Abstracts International.: http://www.lib.umi

Eshun, B. A. (2000). Sex-Differences in attitude of students towards mathematics in secondary schools. Journal of the Mathematical Association of Ghana,, 12, 1-13.

Ferguson, K. (2010). Inquiry Based Mathematics Instruction Versus Traditional Mathematics Instruction:The Effect on Student Understanding and Comprehension in an Eighth Grade Pre-Algebra Classroom. Cedarville: Cedarville University.

Fisher, D. L., & Webster, B. J. (2003). School-level environment and student outcomes in mathematics. Learning Environments Research.

Fraser, B. J., & Chionh, Y. H. (2000). Classroom environment self-esteem achievement and attitudes. New Orleans: American Educational Research Association.

Friesen, S., & Scott, D. (2013). Inquiry-Based Learning:A Review of the Research Literature. Alberta: Alberta Ministry of Education.

Goh, S. C., & Fraser, B. J. (1998). Teacher interpersonal behaviour classroom environment and student outcomes in primary mathematics in Singapore. Learning Environments Research, 199-229.

Ilevbare, F. M. (2008). Psychosocial factors influencing attitudes towards internet piracy among Nigerian university students. Ife psychologia, 16 (2),136- 151.

Lie, K. M., & Hafizah, H. (2008). Malaysian Students' Achievement in solid geometry. Recent Researches in Education, 141-147.

Margianti, E. S., Fraser, B. J., & Aldridge, J. M. (2001). Classroom environment and students' outcomes among university computing students in Indonesia. American Educational Research .

Ministry of Education. (2010). National Syllabus for Senior High School mathematics. Accra: Ministry of Education.

Murugan, A., & Rajoo, L. (2013). Students' Perception of Mathematics Classroom Environment. Journal of Social Science Research,, 325-337.

Okereke, S. C. (2006). Effect of prior Knowledge of Implications of Mathematical Task/Concepts to Carrer and Gender on Student'Achievement,Interest and Retention. STAN Procedure of 47th Annual Conference, (pp. 253-259). Nzewi .

Oliver, R. (2007). Exploring an inquiry-based learning approach with first-year students in a large undergraduate class, Innovations in Education and Teaching International. Chicago: Chicago Works Press.

Prince, M., & Felder, R. M. (2007). The many faces of inductive teaching and learning. Journal of College Science Teaching, 14-20.

Riordan, J. E., & Noyce, P. E. (2001). The impact of two standards based mathematics curricula on student achievement in Massachusetts. Riordan, J. E., & Noyce, P. E. (2001). The impact of two standards based mathemaJournal for Research in Mathematics Education, 32,368-398.

Scardamalia, M. (2002). Collective cognitive responsibility for the Liberal education in a knowledge society. Chicago.

Spronken-Smith, R. (2007). Experiencing the Process of Knowledge Creation:The Nature and Use of Inquiry-Based Learning in Higher Education. Journal of Educational Research.

Stonewater, J. K. (2005). Inquiry teaching and learning: the best maths class stInquiry teaching and learning: the best maths class study. Chicago: School Science and Mathematics.

Vanderstoep, S. W., & Johnson, D. D. (2009). Research methods for everyday life: blending qualitative and quantitative qpproaches. . Hoboken: Wiley.

Wang, H., & Posey, L. (2011). An inquiry-based linear algebra class,online submission. US-China Education Review, 489-494.

Wiggins, G. (2016, November 10). Retrieved from https://grantwiggins.wordpress.com/2014/04/23/conceptual-understanding-in-mathematics/

Wood, W. B., & Gentile, J. M. (2003). Teaching in a Research Context. Science. 302:1510.