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Using Computer Based Educational Games to Assess Geometric Concepts in Mathematics in the Senior High Schools in Ghana

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Abstract

The study was to assess impact of computer based educational games as a teaching strategy on the academic achievement of Senior High School students in geometry as a concept in mathematics against the conventional teaching approaches. Population for the study consists of the Senior High School in the Bekwai Municipality. Cluster and Purposive sampling techniques were used to select two first year classes in Senior High Schools in the Bekwai Municipality for the study. Statistical estimation theory and statistical decision theory Factorial design (2 x 2 analysis of variance) were used for data analysis. Findings of the study indicated that, computer based educational games, as an instructional strategy improved students' achievement in mathematics. The study recommended that the teachers of different subject areas, especially from rural schools are to be trained in the use of information communication technology and computers in the classrooms.

Keywords

Computer, Educational Games, Geometry, Mathematics, Senior High Schools, Bekwai Municipality, Ghana

1. Introduction and Background

Developments in information technology and the constructional qualities of games has changed the thinking abilities of the learners [1]. Computer games have arisen as a significant strategy for the support of the new approaches in teaching and learning. Computer based educational games add more dynamic characteristics to the conventional teaching methods in which students watch and listen and enables them to learn by doing-living and enjoying [1]. Learning environment assisted with the strategies in computer games are beneficial in achieving an already determined instructional objectives by increasing students' interest and attention. Therefore, computer-based educational games have begun to be used as effective methods in many fields to teach subjects [2]. In this respect, such kinds of games used in education contribute to students' learning process by increasing their interest in the course [3, 4]. Since computer games contain such features as text, picture, sound, video, animation, graphic, and so on, the multi-situations in which these features are used develop and facilitate learning and save it from traditionalism [5]. However, few of those reports are based on rigorous testing methods. Despite this, the majority of researches have moved on the issues of how, rather than if games can be used in education [6]. There is considerable evidence that confidence and competencies interact, and low levels in either or both predict reduced participation in more advanced study [7].

Transition from later primary (equivalent of junior high school in Ghana) into early secondary school is accompanied by a sizeable reduction in students' confidence in mathematics [8]. Much of this decline in confidence can be attributed to the introduction of symbolic geometry in early secondary school [9]. The challenges in teaching geometry have been well documented and can in part be attributed to the quality of standard texts which tend to direct the nature of geometry learning. In particular, geometry resources found in standard texts frequently do not encourage teachers to enact appropriate pedagogy to foster Geometry thinking [10, 11]. In the classroom environments and geometry tasks develop students' minds is immeasurable [12]. Besides how to inculcate problem solving skills, students' thinking processes which lead to successful or unsuccessful problem solving and symbolic manipulation need pragmatic strategy. More so, to identify exotic techniques that will enhance the process of generalization, students use of representations to explore and express patterns is long overdue. Difficulties which students face in the process of generalizing the use of generic examples versus successions of particular cases in generalization processes and abstraction must be paid attention to. The designing of geometry curriculum, approaches to introduce geometry, students' understanding of geometry in the context of a particular curriculum and features of curricular material which supports students' geometric thinking are the iconic nods which need to be addressed timely [12].

The need to understand and to be able to use mathematics in everyday life and in the workplace has never been greater and will continue to increase. All students should have the opportunity and the support necessary to learn significant mathematics with depth and understanding. There is no conflict between equity and excellence [13], to create instructional environment that will harness the creativity of every student in mathematics class is to employ technology to link home such that students could not differentiate these two societies. Thus, the use of computer based mathematics games are often cited as an effective strategy for teaching mathematics. The use of computer based educational games in Geometry classrooms and its effectiveness addresses individual differences, students' capabilities in thinking geometrically and dealing with symbols and shapes. The possible replacement of the nature of paper-and-pencil based geometry with computer based educational games based geometry will be decisive based on research findings. Suitable modalities to foster growth in cognitive processes which will help in the role of representations and understanding of geometry goals are much more needed.

Senior high school students in Ghana find it difficult to deal with shapes and space and their understanding of geometry generalizations expressed either verbally or symbolically [14]. In learning geometry, it is the very difficult as geometry is all about shape and their properties. As with any language, difficulties may arise from features of the language itself and in translating from one language to another. Within the language of geometry, most linguistic difficulties are related to shapes and their properties. This inspired the researchers to investigate the use of computer based educational games to address the challenging issues in the teaching and learning of geometry in mathematics in Senior High Schools in the Bekwai Municipality. The study was guided by five (5) null hypotheses: H_{o1}: There is no statistically significant difference between the mean scores of the students taught shapes and space in core mathematics using computer based educational game and those taught using traditional teaching approach. H_{o2}: There is no statistically significant difference between the mean scores of the high achievers of experimental group and high achievers of control groups. H_{o3}: There is no statistically significant difference between the mean scores of low achievers of experimental group and mean scores of low achievers of control group. H_{o4}: There is no statistically significant difference between the mean scores of high achievers and low achievers of the experimental group. H_{o5}: There is no statistically significant difference between the attitudes of experimental group towards computer based educational game as instructional strategy and attitudes of the control group towards traditional teaching approach.

2. Review of the Literature

"What is mathematics associated with?" Many indicated, "Tasks solving". This kind of activity is one of fundamental part of mathematics teaching. The other part of this process is teaching of reasoning [15]. Mathematics is a language of science that entails concepts, practical skills and procedural knowledge which most students think makes mathematics difficult, complicated and a confusing subject because it involves formulae and calculations [16]. A study on "What is the object of encapsulation of a process"*?* published in Journal of mathematical behaviour postulated that others see mathematic as a boring subject which sometimes is unrelated to their real-life situations [17]. Findings on "the Effects of Drill and Practice Computer Instruction on Learning Basic Mathematics" claimed that, when the learner stops for a while, all the motivation is gone and he/she will need to regain focus from beginning if one wants to continue the study [18]. Therefore, there is the need to find a solution to help students understand mathematics better and make it interesting to learn.

Transformational activities focus on symbolic manipulation and include activities such as sorting, measuring, expanding, substituting, solving equations and simplifying expressions. Global/meta-level activities use geometry as a tool for problem solving and include modeling, noticing structure, generalizing, justifying and proving. Notably, the ability of learners to deal with properties as a critical component of the understanding of symbolic arithmetic and geometry and underlies the capacity to manipulate unclosed expressions [19]. A research finding on the topic "Expectancy-value theory of achievement motivation" felt that this topic could be more effectively taught as a set of clearly specified and connected rules for shorting shapes and rewriting an expression [19]. Rules must be connected to concepts in order to enhance their learning and retention. Since concepts occur as referents in the statement of rules, conceptual misunderstanding may lead to incorrect learning of rules. Learners need to be flexible in their application of rules and conceptual understanding that mediates such flexibility. Learning geometry is important in a student's mathematical development. It opens the door to organized abstract thinking and supplies a tool for logical reasoning. Geometry embodies the construction and representation of patterns and generalization, active exploration and conjecture. By itself geometry is the language of variables, operations, and symbol manipulation [7]. Geometry is the fundamental language of mathematics. It enables learners to create a mathematical model of a situation, provides the mathematical structure necessary to use the model to solve problems and links numerical and graphical representatives of data. Geometry is the vehicle for condensing large amounts of data into efficient geometric statements [20].

A journal titled "The effective combination of hybrid usability methods in evaluating educational applications of ICT: Issues and challenges" postulated that we can use notion of game as the action (the moves) executed by playing persons or teams (at least two), to agree peacefully with setting the rules, which is rationale behind the aim victory of one of playing persons (one of the teams) [21]. Mathematical game is a multiplayer game whose rules, strategies, and outcomes can be studied and explained by mathematics principles. Examples of such games are Tic-tac-toe and Dots and Boxes, to name a couple. On the surface, a game need not seem mathematical or complicated to still be a mathematical game. For example, even though the rules of Mancala are straightforward, mathematicians analyze the game using combinatorial game theory [22]. Mathematical games differ from mathematical puzzles in that all mathematical puzzles require mathematics to solve them whereas mathematical games may not require knowledge of mathematics to play them or even to win them [23]. Thus, the actual mathematics of mathematical games may not be apparent to the average player. Some mathematical games are topics of interest in recreational mathematics. Mathematics of games, the mathematical analysis of the game is more important than actually playing the game. To analyze a game mathematically, the mathematician studies the rules of the game in order to understand the inner-workings of the game, to determine winning strategies and possibly to determine if a game has a solution [24]. Game theory is a systematic study of the extent to which the assumptions made in mainstream evolutionary game theory for the sake of tractability are affecting its conclusions [25].

The most common criteria for selecting games as reported by teachers in the study were concerned with classroom management issues. Some of the comments related to trivial issues about pieces going missing or taking too long a time to set up and pack away. However, the authors do not wish to trivialize the impact on the smooth running of a lesson and the associated loss of teaching time [26]. There are conflicting comments about number of players. In two cases, teachers preferred to play the computer based educational games by the whole class while three teachers preferred playing games in small groups because it maximized the time learners would be thinking about the concepts embedded in the game. Short game period appeared to be favoured over longer ones. This allowed for more flexibility as to when and how games were used in the classroom. Simple rules were favoured as less time would be spent introducing the game and sorting out conflicts based on misinterpretation of rules, [27].

However, the idea of using games from a motivational point of view, they preferred the game to be linked to a specific skill or concept. Several factors appear to affect this concern. Teachers feel pressured to 'cover' a great deal of content and felt that devoting too much time to games without there being a direct link to specific content would erode their teaching time [19]. The introduction of a National testing program during the conduct of this research weighed heavily on teachers' minds. The need to justify the use of games in terms of concept or skill learning was apparent. The teachers reported pressure from parents for their learners to be seen to be completing some rigorous mathematics. In some cases, this translated into completing sets of algorithms on a page as evidence of having 'worked hard' in the lesson. The extreme case is the reported pressure to complete all the pages in a textbook before the end of the year. Most teachers would choose to use games as motivators for engaging in mathematics. Games are often employed to make practice more pleasant. Difficult concepts such as fractions may be embedded in a game format to encourage deeper thinking about the concept [28]. Once the challenge of a game is lost, motivation wanes and learners are less inclined to engage with the game [29].

The tools designed to help process information have to address a variety of individual differences among the learners [30]. Some of these individual differences include concentration level, quantity of information, different background, ideas or habits students bring into the learning environment, different learning styles, strategies and tactics [30]. For any information provided, computer based educational games need to be designed to help the students learn the material. These computers based educational games should embed motivational and creative strategies that enable students to handle the material in various ways using the available manipulatives provided in all sectional interfaces. Students spend appropriate time learning the material become active participants while processing the information and they are able to retain the information [30].

When designing computer based educational games to provide practice, developers should consider results found when comparing behaviorism and cognitive framework designs [31]. Computer based educational game designers operating under principles of behaviorism usually create almost error-proof practice, anticipating that total success would be most effective and motivating. Designers, working under a cognitive framework however, have found that practice which evokes misconceptions about newly learned information seems to stimulate learners' interest even more than successful experience. Designers should consider ways in which learners might misunderstand lesson content, then design practice experiences which allow learners to discover misconceptions and correct them. Good feedback can be presented in many ways, for example, through text, graphics or sound [31]. However, when used, feedback is an essential element of practice for learners to evaluate their progress against an established game goal. In addition to providing practice and sustaining learner interest, cognitive benefits of educational gaming are supported by Piaget's learning theory. Game formats provide opportunities for both play and imitation. Functions which serve as important accommodation and assimilation strategies considered as essential to the equilibration process that requires extensive critical thinking and problem-solving skills [32].

Simulations and games may improve several types of cognitive learning strategies. These include: organizational strategies (paying attention, self-evaluating, and self-monitoring), affective strategies (anxiety reduction and self-encouragement), memory strategies (grouping, imagery and structured review), and compensatory strategies (guessing intelligently). Computer based educational games which incorporate multimedia technologies improve other aspects of higher order skills. Multimedia is yet a relatively unexplored area, touted as many-faceted contributor to the development of cognitive skills. Educational software is the primary stimulus behind multimedia computer purchases for the home; with games comprising a large component of software considered for purchase [33]. Multimedia games may facilitate learning via structured discovery, improved students' motivation, opportunities for utilizing multiple learning styles, navigation of web-like representations of knowledge, learner authoring of learning materials and collaborative inquiry. Characteristics of learners, such as the preference to work in a group or alone, can affect their experience with computer based educational games, especially when the game is designed with a very open structure. The more control a student has over the game; the more likely it will be that a student's personality or style will affect the outcome and the converse is also true. Inconsistent findings of research in computer based educational games outcomes may be in part a result of this individual learner's characteristics [33].

Assessment methods and administration are also complex issues which may confuse efforts to measure the value of educational games [34]. Long lists of questions have been raised about students' assessment in computer based educational games. These include, but not limited to: use of inappropriate measurement instruments, using the same pre- and post-tests with only a short time interval between them and bias resulting from evaluating one's own game. Procedures used to demonstrate the learning effects of a game need careful consideration. Instructional objectives of a game are often not specified, especially in social sciences simulations [34]. A test for effectiveness needs to match what the game is teaching to avoid misleading results.

Finally, the most difficult issue in the assessment of games as cognitive tools is that games create environments which foster the learning of implicit knowledge. Implicit learning occurs when a subject is not consciously intended to learn, is not aware of what they have learned, and yet they acquire new knowledge. Implicit knowledge is not necessarily reflected in people's ability to answer written questions since they are not always consciously aware of what they have learned. Learners often cannot describe or readily demonstrate the benefits received from an activity, even when real benefits are achieved. A computer based educational games improves learners learning abilities, students in simulation situations often develop and use successful strategies that they cannot verbalize [35]. Literature on implicit and explicit learning is complex and other issues confound research findings. Factors such as stress or anxiety may affect explicit directions positively or negatively. Implicit and explicit learning are interactional and complex skills. Implicit learning presents a challenge to the computer based educational games' designers, since it must determine how the learner can demonstrate new knowledge or skills in order to make appropriate assessments.

3. Methodology

Experimental design was used in this study. The design was chosen as it was found to be most useful for the non-equivalent pre-test, post-test and experimental groups design. In the design, two groups of subjects are assigned to experimental and control groups. The following is the symbolic representation of the design:

Where E = Experimental group = 01 T O1

C = Control group = 03 T O2

O = Observation or measurement

T = The experimental treatment to which a group is exposed

i.e. independent variable.

The target population for study was Senior High school students from Bekwai Municipal. However, the accessible population was first year students in the two Senior High Schools in the Bekwai municipality. Sample and sampling techniques used for the were cluster and purposive sampling. Test (pre-test and post-test) was the main instrument used for data collection. Researchers' made tests were given to the sample as pre-test before teaching and as post-test immediately after the teaching was over. The purpose of the post-test was to measure the achievement of the students constituting the sample. The researchers made a thorough study of the core mathematics geometry and the techniques of test construction. The Researchers further constructed a test comprising multiple choice items and items to demonstrate students' thoughts. These items were based on geometry in core mathematics as: Relationships in Triangles; Proportions and Similarity; Quadrilaterals; Transformations; Circles; Area and Volume; Surface Area. All the test items were based on the text of the units taught to the sample students to ensure content validity. The split –half method (odd-even) was used to test the reliability of the post-test scores obtained from the students who formed the sample of the study. The coefficient of reliability was determined through the use of Spearman-Brown Prophecy formula estimating reliability from the comparable halves of the post –test and it was found to be 0.83. Statistical estimation theory and statistical decision theory Factorial design (2 x 2 analysis of variance) were used for data analysis. Students of both groups were divided into two halves- high achievers (above the mean score) and low achievers (below the mean score). This division was made on the basis of scores on pre-test. The factorial design was symbolized as in Table 1.

Table 1. *Experimental Control.*

High achievers	Cell 1	Cell 2
Low achievers	Cell 3	Cell 4

4. Findings and Discussions

This section presented the analysis of results and discussed jointly with the null hypotheses in series of tables. Considering the first null hypothesis;

H_{o1}: There is no statistically significant difference between the mean scores of the students taught geometry in core mathematics using computer based educational game and those taught using traditional teaching approach.

Table 2. *Comparison of Mean Scores on Previous Achievement Test of Experimental Group and Control Group.*

Group	N df	Mean SD	SE_D t-value
Experimental	30 29	71.90 1 0.38	2.32 0.24*
Control	30 29	71.25 10.31	

*Not significant
t at 0.05 =2.02

Table 2 indicates that the mean score of the pre-test in mathematics of the experimental group was 71.90 and that of the control group was 71.25. The difference between the two means was not statistically significant (i.e. 0.24 > 0.05) level. Hence, both groups could be treated as equal on the variable of previous achievement in mathematics which substantiates the first null hypothesis.

Table 3. *Comparison of Mean Scores on Post-Test of Experimental Group and Control Group.*

Group	N df	Mean SD	SE_D t-value
Experimental	30 29	80.40 9.11	2.99 2.14*
Control	30 29	72.00 9.77	

*Significant
t at 0.05 =2.02

It is evident from Table 3 that the mean score on the post-test of the experimental group was 80.40 and that of the control group was 72.00. The difference between the two means was found statistically significant (i.e. 2.14 > 0.05) level in favour of the experimental group. On the strength of the analysis, the null hypothesis was rejected. The Effects of Drill and Practice Computer Instruction on Learning Basic Mathematics study done by [36] also found that students who received computer based educational games showed greater increases in their achievement scores. When the results of analyses for experimental group were compared with traditional educational approaches further, it was observed that the learning environment supported with computer based educational games increased students' achievement in the geometry in core mathematics. There are a lot of studies in the literature review showing how learning environments supported with games increase students' achievement [37, 38].

H_{o2}: There is no statistically significant difference between the mean scores of the high achievers of experimental group and high achievers of control group

Table 4. *Comparison of Mean Scores on Pre-Test of High Achievers of Experimental and Control Groups on Pre-Test.*

Group	N	df	Mean	SD	SE_D	t-value
High achievers of experimental	17	16	78.5	4.76	2.02	0.37*
High achievers of control	17	16	7.75	5.15		

* Not significant
t at 0.05 = 2.07

Table 4 reflects that there was no significant difference between the mean scores of high achievers of experimental group and high achievers of the control group on the variable of previous achievement in mathematics. This portrayed mean score of 78.50 for high achievers of experimental group and mean value of 77.75 as an average score for high achievers of control group. Hence, the comparison of these two means was not statistically significant (i.e. 0.37 > 0.05) which treated both groups equal and affirmed the second null hypothesis stated.

Table 5. *Comparison of Mean Scores on Post –Test of High Achievers of Experimental and Control Groups.*

Group	N	df	Mean	SD	SE_D	t-value
High achievers of experimental	18	17	83.83	3.43	1.93	3.15*
High achievers of control	18	17	67.73	6.75		

*Significant
t at 0.05 =2.07

Table 5 indicates that the difference between the mean scores of high achievers of experimental group and that of control group on post –test was statistically significant since the computed t value 3.15 > 0.05) level in favour of experimental group. Hence, the null hypothesis is rejected. This result is in line with [1] who found that students with higher achievement levels in mathematics also had high interest in computers. The result especially about high achievers corroborate the observation of [39] regarding the research into students' use of back up approach to individualized learning. The study revealed that middle ability to better students make more use of and benefit more from individualized learning material than weaker students for whom the computer based educational game was mainly intended for.

H_{o3}: There is no statistically significant difference between the mean scores of low achievers of experimental group and low achievers of control group.

Table 6. *Comparison of Mean Scores of Low Achievers of Experimental and Control Groups on Pre-Test.*

Group	N	df	Mean	SD	SE_D	t-value
Low achievers of experimental	13	12	61.75	8.01	4.03	0.06*
Low achievers of control	13	12	61.50	8.09		

*Not significant
t at 0.05 = 2.14

Table 6 depicts that there was no statistically significant difference between the mean scores of low achievers of experimental and control groups on the variable of previous achievement in mathematics. Hence, the low achievers of both groups could be treated as equal since statistical evidence proved it. An average score of 61.75 for the low achievers of the experimental group and low achievers of the control group has approximately the same score as 61.50. Further, comparing the mean values proved not statistically significant (i.e. 0.06 < 2.14) which is in line with the third null hypothesis and must be accepted.

Table 7. *Comparison of Mean Scores on Post –Test of Low Achievers of Experimental and Control Groups.*

Group	N	df	Mean	SD	SE_D	t-value
Low achievers of experimental	12	11	80.25	6.96	4.27	2.54*
Low achievers of control	12	11	63.3	8.07		

* Significant
t at 0.05 =1.96

It is evident from Table 7 that the difference between the mean scores of low achievers of experimental group and low achievers of control group on post –test was statistically significant with the calculated t- value being 2.54 > 1.96 for two-tailed test. Hence, low achievers of experimental group perform better than the low achievers of the control group. In line with the analysis the third hypothesis is accepted. Computers engage students in some thinking and decision making that aided low achievers in experimental group to perform better than the low achievers in the control group. In addition, findings on Game ability and academic ability: Dependence on S.E.S. and psychological mediators concluded in a study that, expectations and traditional methods of teaching may need a change of perspective [35]. In particular, gaming may be an effective tool for teaching, but disadvantage to students whose language skills are not well developed which also affirms the findings of the study [1].

H_{o4}: There is no statistically significant difference between the mean scores of high achievers and low achievers of the experimental group.

Table 8. *Comparison of Mean Scores on Pre-Test of High Achievers of Experimental Group and Low Achievers of the Control Group.*

Group	N	df	Mean	SD	SE_D	t-value
High achievers of experimental	10	9	74.20	5.82	4.60	1.13*
Low achievers of control	10	9	69.40	13.35		

*Not significant
t at 0.05 =2.10

Table 8 reflects that there was no statistically significant difference between the mean scores on previous achievement in mathematics of the high achievers of the experimental and low achievers of the control groups and this stamped the fourth claim of the null hypothesis. Hence, high achievers of the experimental group and low achievers of the control group could be treated as equal on variable of previous achievement in mathematics. The empirical evidence proved that the high achievers of the experimental group had mean score of 74.20 and low achievers of control group were 69.40. Comparing their mean difference, it depicted that both was not statistically significant i.e. 1.13 > 0.05.

Having analyzed the students' previous achievement in mathematics, with independent t test which all proved that the null hypotheses should not be rejected; which set another platform for further analysis on the variables of among the means of conditions, within conditions and interactions within the groups. This calls for further statistical analysis with two - way analysis of variance (ANOVA). Because of the independent groups, the significance value of the t - test is 0.05 depicting that the variances for the both experimental and control groups are not the same. Further critical analysis proved that all performances of the experimental group were statistically significantly better than that of the control group on post-test. The difference between the two means was statistically significant at 0.05 levels (Tables 3, 5, 7, & 9).

Thus, all the null hypotheses stated should be rejected at 0.05 level in favour of the experimental group. These findings supported in line early studies that computer based educational games have seven requirements for an effective learning environment [36]. These requirements are fulfilled by computer based educational games and satisfying them better than most other learning modalities [40]. Moreover, to attest the variance of treatments (i.e. teaching strategies used), groups and interaction levels, further analysis was conducted using two – way analysis of variance (ANOVA) which produced the output in Table 8.

H_{o5}: There is no statistically significant difference between the attitudes of experimental group towards computer based educational game as instructional strategy and attitudes of the control group towards traditional teaching approach.

Table 9. *ANOVA (2 × 2) Comparison of Mean Scores on Previous Achievement of Experimental Group and Control Group.*

Source of Variance	N	Degree of freedom	Sum of squares	Mean square variation	F
Among the means of conditions	4	3	419.48	139.8	*1.38
Within conditions		36	3647.50	101.32	
Total		39	406.98	104.28	

*Not significant
F at 0.05 = 2.84

It is evident from Table 9 that the difference between mean scores of experimental group and control group on the variable of previous achievement was not statistically significant; thus 1.38 < 2.84. Hence, both the groups on the variable of attitudes could be treated equal on the basis of having exhibited common behaviour towards teaching and learning setting. The analysis of variance (ANOVA) compares the variance (variability in scores) between the different groups (believed to be due to the independent variable), with the variability within each of the groups (believed to be due to chance). An F ratio was calculated which represents the behaviour variance between the groups, divided by the behaviour variance within the groups indicating not statistically significant in this case. Meaning we should refuse to reject the null hypothesis.

Both the experimental and control groups were compared on the variable of previous achievements. The results obtained from the statistical analysis showed that no statistically significant difference existed between the two groups (Tables 2, 4, 6, 8 & 10). Hence, all hypotheses stated must refuse to be rejected in any circumstances and both groups could be treated as equal. Further analysis was conducted on the post –test scores. The results are presented in Table 10.

Table 10. *ANOVA (2 × 2) Comparison of mean scores on post –test of experimental group and control group.*

Source of variance	N	Degree of freedom	Sum of squares	Mean square variation	F
Treatment	2	1	409.60	409.60	20.89*
Achievement levels	4	3	360.00	360.00	18.37**
Interaction	4	3	2323.20	2323.20	118.53***
Within cells		60	705.60	19.60	

* Significant
**Significant
***Significant
Fat 0.05 level = 4.13

Table 10 reflects that the F – value (i.e. 20.89 > 4.13) obtained in the case of “treatment” as the source of variation was statistically significant at 0.05 level. Meaning there is a major behaviour difference exhibited between experimental group and control group in favour of the experimental group. Besides, the interaction effect between treatments and achievement levels of the students at 0.05 level portrayed the F values of both groups and interaction among the students as 18.37 > 4.13 and 118.53 > 4.13 respectively as statistically significant. Again, this indicates that there are healthy discussions, socialization, team work, critical reasoning and serious learning among the students within the experimental group than that of the control group.

These results are in corroboration with a study that students develop expert behaviors such as pattern recognition, problem-solving, qualitative thinking, and principled decision-making as their individual expertise with computer based educational games as their practice increases [41]. Furthermore, the results justify argument that since computer based educational games contain such features as text, picture, sound, video, animation, graphic, and so on, the multi-situations in which these features are used develop and facilitate learning and save it from traditionalism [5].

In addition, there is empirical evidence which corroborate with the findings that positive effect of computer based educational games improve the metacognitive levels of students’ [38]. The overall results of the study indicated that computer based educational games, as an instructional strategy improved students’ achievement in the subject of mathematics at senior high school level with higher achievement gains by the experimental group. The results of the study were in line with those of previous researches carried out in other cultures. However, individual variations were found regarding the impact of computer based educational games on experimental group as evidenced by the significance of interaction effects.

5. Conclusions and Recommendations

The application of computer based educational game in teaching geometry in core mathematics was found to be more effective than the traditional teaching approach which call for its adaptation and wide use in our classrooms. Though computer based educational games as instructional strategy was found to be equally effective for both low and high achievers of the experimental group yet high achievers benefited more from computer based educational game.

Positive feedback has been obtained from the heuristic evaluation through the use of computer based educational games. This is indicating that, computer based educational games should be designed in consistent with the Piagetian process of equilibration, behaviorism views, constructivist view, cognitive schemas, human information axioms, teachers concern and the designers' opinions; these elements encourage learners to resolve conflict, meet varied learning styles, address individual differences and enhance identity development with reference to academic achievement and assessment techniques incorporated.

Since no software was available in Ghanaian language for the teaching of mathematics, the experiment was conducted in an English medium. It is recommended that, the Department of Information Technology Programme of Center for Continuing Education of the University of Cape Coast should institute educational software cell for the development of educational software in English and Ghanaian languages for different subject areas in the basic and pre-school stages. In such case, the students from rural areas can also benefit from computer technology and our culture will be harmonized as well.

It is also recommended that, in as much as computer based educational geometry games activities help to foster students' confidence, team work and interaction about their capacity to understand geometry, teachers of different subject areas, especially from rural schools should be be trained in the use of information communication technology and computers in the classrooms.

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