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Mathematical games development, effects and application on teaching and learning of mathematics. A case study of some selected schools in Ondo west local government area Ondo state, Nigeria

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ABSTRACT

The study investigated the effect and application of mathematical games on teaching and learning of mathematics in primary and secondary schools. A total number of ninety (90) students were involved in the study. An existing game, ADEMMAK Arithmetic game which was developed by the author was used and applied to teach conceptual topics in Mathematics for the selected students. Two null hypothesis provided focus for this study. The works of different authors were reviewed. Self-Assessment Questionnaire was used

for data collection and was validated and the reliability was tested. The collected data were analysed using t-test. From the findings, it was discovered that there is significant difference in the academic performance of students using game approach and that Mathematical games enhanced the achievement in mathematics in primary and secondary schools than the conventional teaching approach, irrespective of the student's sex and age. Mathematical games enhanced the teaching and learning of mathematics in primary, junior and senior secondary schools irrespective of their sex. Some recommendations were given, among which include: mathematical games should be adopted in class as teaching aid by mathematics teachers, organization of training for mathematical teachers on the use of some mathematical games, curriculum planners should incorporate the use of mathematical game in restructuring mathematics in the country and ADEMMAK Arithmetic game should be encouraged for teaching basic arithmetic operations, most especially at the early child numeracy stage.

Keywords: ADEMMAK Arithmetic Game, Mathematics, Teaching.

1. INTRODUCTION

Mathematics without doubt remains very important to all disciplines and fields of human work and study (Odili, 2006). It has continued to play significant role in the development of both the individuals and nations. According to Abakpa and Iji (2011), teaching and learning of mathematics consistently generate interest among scholars over the years. Mathematics is an intellectually stimulating subject that affects every talent of human activities such as politics, economic, science and technology (Umoru and Ubom, 2013). It is the model by which scientific concepts are understood and bedrock for understanding and applying technologies.

Despite the benefits of Mathematics to our day to day activities and as an agent of nation's development and wealth creation (Umoru, 2013), the teaching and learning of Mathematics at all level of the educational system can be described to be in a dismal state. Just as students find it difficult to understand (Amazigo, 2000), teachers find difficulties in teaching many topics (Oyedeji, 1992). The difficulty to students and the poor quality in teaching come to manifestation in the poor performance of students. Students are seen to perform poorly in both internal and external examination. For instance, in 1996 over 52.9% of Nigerian students failed Mathematics in Senior Secondary School examination (WAEC, 1996). Also in Nigeria, in the year 2008, 2009, 2010 and 2011 the percentage pass with credit and above were 23.0%, 31.0%, 29.9% and 38.98% respectively (Kurumeh and Imoko, 2008, Mosari and smark, 2010, Iyi 2011).

Thus, every concerned Mathematician is seeking ways to improve the performances of students in Mathematics. One of the ways is that improvement in teaching process through the introduction of teaching aids. One of such teaching aid is the Mathematical Games.

Nevertheless, Mathematics is often hated, feared and misunderstood by students and adults, one source of this problem might be in the nature of Mathematics which involves computation and manipulation of members. To this end, if Mathematics is well understood by the students and adults, these will be sound development of science and technology, sound economy and better well-being to all citizens of that community (Owojori, 2010).

As quoted by Obioma (1992), Plato said "Amusement and pleasure ought to be combined with instruction to make the subject more interesting. These things make pupils useful to themselves and more wide awaken".

Statement of the Problem

In the 21st century, we have a modern society with rapid technological growth and technology comes with Mathematics. Over the years, Mathematics has become one of the most important and compulsory subject in school curriculum. Based on result of (Sijil, 2013), there are reduction of achievement in Mathematics while all other subjects increased. This is due to the method adopted by the teachers and the interest of the students towards the subject "Mathematics itself". Therefore, there is need for more stimulation as an approach to the teaching of Mathematics so as to improve students' academic performance.

The incessant failure in Mathematics courses in institutions of higher learning has really caused a lot of damages to our technological growth and development. According to Abakpa and Agbo-Egwu (2008), Nigerian students are competing for the last position and not the best in Mathematics in School Certificate Examination among the eleven English Speaking West African Countries. Students' performance in Senior Secondary School Examination administered by both WAEC and NECO continues to deteriorate from year to year in both science and social sciences.

Based on the above backdrops, this study is designed to determine the effects and application of Mathematical Games on teaching and learning of Mathematics. That is. This study intends to check how the introduction of Mathematical Games help in motivating students to learning. This is with a view of revealing the obstacles and menace affecting the effective use of

Mathematical Games in teaching Mathematics in our Senior Secondary Schools and also enhancing and influencing the teaching, learning and good students' performance in Mathematics.

Significance of the Study

The significance of the study lays in the fact that the study will ascertain whether the use of mathematical games in teaching mathematics in schools can improve the academic performance of the students. If the use of mathematical games in teaching mathematics in schools can help in improving the students' performance, thus, teachers can apply these mathematical games as their teaching aid and will benefit all students. Also, with the use of mathematical games as teaching aid, this will help the students improve in their thinking skills and also help them understand the lesson easily.

Games and Mathematics are related because each has rules which involves experiences, drills, and practical application. This study therefore exploits how games can enhance students' interest in mathematics.

Furthermore, this study aims at facilitating the mathematical environment through the adoption of mathematical games as it releases boredom, tension and establishes a friendly atmosphere which allows for growth of skills and knowledge of the students.

Also, the study aim at improving students' learning outcomes through their active participation and interaction.

Research Hypothesis

1. There is no significant difference in the performance of students taught Mathematics using games approach.
2. There is no significant difference in the performance of students taught using game approach on the basis of their academic level.

Defining a Game

Definitions from the field of non-computer game-based learning include that of Ellington and colleagues (1982), who define a game as necessarily containing rules and overt competition, either between other players or against the game system. This limitation to overt competition appears to be somewhat restrictive, however, particularly when considering co-operative learning games, and Klabbers (1999) uses a wider definition including competition or challenge and describes games as "an activity or sport involving skill, knowledge or chance, in which you follow fixed rules and try to win against an opponent to solve a puzzle." (Klabbers, 1999, p 18). Greenblat (1987) defines games as simulations that work wholly or partly on the basis of players' decisions, which have roles, goals, activities, constraints and consequences.

Definitions from commercial game designers have a different perspective.

Crawford (1984) argues that the elements that define a game are representation (a closed formal system with explicit rules that represents a subjective, fantastic, subset of reality), interaction (social or personal), conflict or challenge, and provision of a safe environment, i.e. one where consequences do not hold in reality. Oxland (2004) says that games need rules and boundaries, feedback, an interface to the game world, context sensitivity (or immersion), goals, quests and challenges, a game environment and balance (or playability). Koster (2005) provides a much less formal definition, saying that games are puzzles to solve, they are exercises for our brains and that it is the act of solving these puzzles that makes games fun. It is hardly surprising that there is more focus on playability and fun in the definitions created by game designers in the entertainment industry, and it is important not to lose these elements of what makes games engaging when considering how games could be used for learning. This is not an easy task, as Virvou and colleagues (2004) highlight, saying that "educational software games aim at serving two distinct aims, which are often conflicting each other: education and entertainment" (p 692).

More recent definitions by researchers in the field of computer game-based learning have more in common with those of non-computer-based games researchers. Dempsey and colleagues (2002) define a game as an activity involving players (one or more), with goals, constraints, payoffs and consequences, which is rule-guided, artificial in some respects and has an element of competition, while Prensky (2001) describes six structural elements of games; namely rules, goals, outcomes and feedback, competition or challenge, interaction, and representation or story.

The Development and Use of Mathematical Games

Mathematical games are form of puzzles, magic tricks, or any mathematical activities that provide amusement, brings joy, break resistance or negative attitude to learning by reducing tension, flushing boredom and providing environment for learners to develop interest and acquire skills and competencies. According to Benard and Awogbemi (2012), both the teachers and students experience difficulties in the teaching and learning of Mathematics in Schools. Educational Game is one of the strategies that have been found

to enhance the attitude and academic achievement of students in many subjects including Mathematics. But many Mathematics teachers lack the knowledge of the role of Mathematical Games, how to make and play Mathematical Games in classrooms. Hence, Mathematical Games are not played in many schools in most parts the world.

Nature of Mathematical Games

Educational Games have been defined as "an enjoyable social activity with goals, rules, and educational objectives" (Steven & Cary 1994). Mathematical Games are educational games. An important aspect of educational games is enjoyment. Without enjoyment, games may resemble tedious workbook activities rather than play (Steven & Cary 1994). Adequate information and strategies should be put in place to make games enjoyable. Mathematical Games are not quiz and should not be treated as such. If they are not made enjoyable to the players it could be frustrating and players may dislike the game thereby defeating the aims and objectives of the game.

Mathematical Games may be used to introduce concepts as a prelude to explicit teaching or practice skills or consolidate a concept after explicit teaching. Educational Games do lead to improved learning (Dennis & Stewart 1999). Some Researchers have evaluated the effectiveness of Mathematical Games and giving reasons for the use of Games. Among them are the powerful motivation, excitement, involvement and positive attitudes that teachers using games in their mathematics lessons frequently report. The needs for good motivation, involvement, and the development of positive attitudes in learning have long been recognized as being essential and necessary. Games are also valuable for encouraging social skill, for stimulating mathematical discussion, helping the development of mathematical understanding, for developing strategies for learning new concepts, reinforcing skills and concepts as an aid to symbolization and logic (Oldfield 1991). Obioma (1992) stated that the roles of Mathematical Games in the classroom are making practice periods more pleasant and successful, enrichment of vocabulary, introduction of new ideas, allowing for individual differences, improvement of study habits, developing positive attitudes towards Mathematics. As a result of these immense benefits, Mathematical Games have been recommended for inclusion in the curriculum.

The Use of Mathematical Games in Nigerian Schools

Despite these significant roles of Mathematical Games, not much seem to be done on the use of Mathematical Games as a teaching aid in Nigerian Secondary Schools. Many Schools and teachers seem to be ignorant about the utilization of Mathematical Games. Research has shown that in Nigeria:

1. Many Secondary School Mathematics teachers have not been exposed to Mathematical Games
2. Many teachers are not aware of the reasons for playing Mathematical Games
3. Many teachers do not know the guidelines for preparing Mathematical Games
4. Many teachers do not know the guidelines for evaluating the usefulness of Mathematical Games
5. Most Secondary School Students do not play Mathematical Games
6. There is no period for playing mathematical games in virtually all Secondary Schools
7. Many teachers were not exposed to Mathematical Games in their certificate or degree training courses (Azuka 2001).

It is clear from the research that Nigerian Secondary Schools are not utilizing the benefits of Mathematical Games. This could partly lead to low interest and achievement of students in Mathematics as evidenced by the results of our examinations in Mathematics. In Nigeria, the National Mathematical Centre has developed over ninety Mathematical Games for the Primary and Secondary School levels and teachers are being trained on how to make and play the Games in schools. As Resource Persons on Mathematical Games in training workshops in Nigeria, the authors have observed that in the training sessions, teachers exhibit high fun, enjoyment and pleasure while playing the games. In fact, teachers have described the Mathematical Games as veritable tools for the teaching of Mathematics in schools as it enables students to develop positive attitude towards Mathematics. Also many empirical studies such as Alamina and Olubumi (2007) have indicated positive effect of games on academic achievement and attitude of students towards Mathematics in schools. Alamina and Olubunmi (2007) investigated the effects of Mathematical Games on students' attitude in Mathematics in Secondary Schools in Port Harcourt. The results showed that the attitude of students towards Mathematics improved after the use of games in teaching Mathematics for both males and females. Mathematical Games leads to positive attitude and positive attitude leads to better academic performance.

ADEMMAK Arithmetic Game

The ADEMMAK arithmetic game was coined after the name of the person that developed it, ADENEGAN Kehinde Emmanuel in 2011. The game received international recognition as it was listed for oral presentation at the 2011 Methodological Aspect of Teaching Mathematics, (MATM) Faculty of Education, University of Kragujevac. Serbia. The game is an essential tool for teaching basic and

conceptual topics relating to the cardinal arithmetic/mathematical operations. The game is particularly used for this project for the teaching-learning process. (*For detail of the game, see appendix*).

How to Use Mathematical Games

In preparing to use any game, the teacher should consider how it can be used to achieve its objective in the classroom. This is similar to a research situation where data analysis plan is usually considered in advance before the actual data collection. The following factors should therefore be considered in using Mathematical Games:

- Needs of the class
- Use the game at the proper time
- Active participation by all
- Minimization of informality and excitement
- Something must be learnt from the game

The Role of Mathematical Games

Many other authors have written on the role of Mathematical Games. Obioma and Ukeje (1992) and National Mathematical Centre (2002) highlight the role of mathematical games as follows:

1. Making practice period more pleasant and successful. Games situation can reduce tension and boredom considerably, thereby adding colour to the study of mathematics.
2. Enriching the Mathematics vocabulary. The vocabulary of Mathematics is peculiar and unique. Games can provide avenues for learning, internalizing and enriching the vocabulary.
3. Introducing new ideas. New ideas and concepts can be introduced through Games. This can be facilitated, if the games are arranged in such a way as to precede the learning of the concepts.
4. Allowing for individual differences. The power of Games is that they can be planned to suit or meet the needs of individual differences. Providing for remedial work, reinforcement work or accelerated tasks can be brought about through some special game.
5. Review of variety of mathematical skills or to reinforce specific ones. Through good Mathematical Game students are aided to review variety of skills and to reinforce them.

Thus, in general, Mathematical Games are assessed for their mathematical skills, motivational potency and competitive strategy.

2. RESEARCH DESIGN AND METHODOLOGY

The detailed description of the methods used in this study is presented in this chapter under the following headings:

- Research design
- Population
- Sampling and Sampling procedures
- Research instrument
- Validation and Reliability of the instrument
- Administration procedure of the instrument
- Data analysis

Research Design

This study is a sample survey of mathematics teaching strategies used for some selected students from two secondary schools and a primary school in Ondo town in order to determine the relationship that exists between mathematical games and students academic performance in mathematics.

Population

The population of this study includes all students in Ondo West Local Government area of Ondo State. A total number of 90 mathematics students took part in the research.

Sample and Sampling Procedure

A random sampling technique was used to select two secondary schools and a primary school from Ondo West Local Government area in order to facilitate detail findings. The schools are:

1. Ondo Boys High School
2. St Louis Girls
3. St John Bosco Primary School

The researcher considered the proximity of the student to her location so as to facilitate adequate findings. Forty students were picked from each secondary schools and ten from the primary school using a simple random sampling. A total number of ninety school students from the said schools were used for the study.

Research Instruments

The instrument for data collection is questionnaire which was titled Student Self-Assessment Questionnaire (SSAQ). It was divided into three sections: Section A, Section B and Section C. The section A was designed to find out information about the students' interest in Mathematics, interest in Mathematical Games and students' academic performance. Section B was designed to get information on Mathematical games that each of the students has played before. Section C was designed to get information about the students' appraisal of the games they have played. The questionnaire consists a two point response type of Yes and No.

Validation and Reliability of the Instrument

The validation of the instruments was ensured through the critical evaluation of the questionnaire by the researcher's supervisor.

Administration Procedure of the Instrument

The first step taken by the researcher in administering the research instrument was visiting the school concerned to inform the principals with what he wants to do. Having gotten the approval, the researcher printed ninety (90) questionnaire and administered forty (40) each in both the senior and junior secondary school and ten (10) in primary school. The filled questionnaire were collected from the students immediately and ensured that none was left or tampered with.

3. DATA ANALYSIS

The results from the questionnaire administered to the students collected were arranged and analysed using t-test. The analysis helped in evaluating the effect of Mathematical Games on students' academic performance in Mathematics.

Research Hypothesis 1: There is no significant difference in the performance of students taught Mathematics using game approach.

Table 1 t-test comparison of the performance of students taught using game approach

	N	Mean	Standard deviation	Df	t-cal	t-table	Decision at 0.05
Students taught	10	61.3	429.21	18	3.518	2.101	Significant
Using game approach	10	28.7					Significant

The table 1 above shows that the t-calculated value at 0.05 alpha level (3.518) for the students is greater than the t-table (2.101), hence the null hypothesis is rejected while the alternative hypothesis is accepted, thus there is a significant difference in the performance of students taught using game approach.

Research Hypothesis 2: there is no significant difference in the performance of students taught mathematics using game approach on the basis of academic level.

Table 2 t-test comparison difference between the performance of students on the basis of academic level.

	N	Mean	Standard deviation	Df	t-cal	t-table	Decision at 0.05
Primary	10	7.50 4.50	9.20	18	2,205	2.10	Significant

Junior Secondary	10	9.10 2.90	11.09	18	4.163	2.10	Significant
Senior Secondary	10	8.20 3.80	10.96	18	3.235	2.10	Significant

The table 2 above shows that t-calculated value (2.025), (4.163) and (3.235) for primary, junior secondary and senior secondary schools respectively are greater than the t-table value (2.10) at alpha level 0.05, hence the null hypothesis is rejected while the alternative hypothesis is accepted, thus, there is a significant difference in the performance of students taught mathematics using game approach on the basis of academic level. The table also shows that the Junior secondary school student had a mean value of (9.10) and (2.90) which is the greatest of the three academic level. This reveals that the junior secondary school students created more interest to mathematics when exposed to mathematical game.

4. DISCUSSION OF FINDING

The major finding in the research work has shown that mathematical games environment influence the teaching and the learning of mathematics. The result of hypothesis one revealed that a significant change in the academic performance was found to exist among the mathematics students taught using game approach. The result gave credence to what was earlier found by (Dennis and Stewart 1999) that educational games do lead to improved learning. The result also had support to what was found by Obioma (1992) that roles of mathematical games in the classroom include improvement of study habit and developing positive attitude towards mathematics.

The result of hypothesis 2 showed that mathematical game can be used in teaching and learning in all academic level. The result gave support to what was found by Alamina and Olubunmi (2007) that mathematical game improves the attitude and performance of students after they have being taught mathematics using games. The result also gave credence to Kambori and colleagues (2006) finding that the use of games motivate young and adult learners to improve their basic literacy skills.

5. CONCLUSION

On the basis of the results obtained in the investigation into the effect and application of mathematical games on teaching and learning of mathematics, the following conclusions were drawn:

1. Game is most effective in improving students' performance in mathematics
2. Mathematical game is most effective in enhancing students' interest in mathematics
3. Mathematical games can be used in teaching and learning in all academic level regardless of the students' age.

Hence, Mathematical games have been found to improve the interest and academic performance in mathematics.

Recommendations

From the findings of this study, the following recommendations are given for the benefit of further researchers, educationist, governmental and non-governmental organisations.

1. Mathematics teachers should be trained on the use of mathematical games during the teaching of mathematics in order to relate mathematics to real life.
2. Mathematics teachers should be trained on the use of mathematical games and during their training process, the educators should ensure that the teachers grasp the concept of mathematical games.
3. Seminar, conferences and workshops on the use of mathematical games should be organised for serving teachers, educators, textbook writers and curriculum developers.
4. The curriculum should be reconstructed to reflect the basic concept of mathematical games as it pertains to teaching and learning of mathematics.
5. Mathematical games should be introduced to schools in Nigeria in order change students' bad motive about mathematics, to improve the academic performance of students of all level and to make teaching and learning of mathematics interesting to both the students and teachers.
6. ADEMMAK Arithmetic game should be encouraged for teaching basic arithmetic operations, most especially at the early child numeracy stage.

APPENDIX 1: ADEMMAK ARITHMETIC GAME

1 +	**2** -	**3** +	**4** +	**5** - →**14**	**6** ×	**7** -	**8** +	**9** + **R**	**10** -
11 -	**12** +	**13** ×	**14** - →**35**	**15** **( )** **L**	**16** ×	**17** **( )**	**18** + →**99**	**19** -	**20** + **W**
21 +	**22** -	**23** +	**24** -	**25** -	**26** ×→ **30**	**27** +	**28** - **R**	**29** +	**30** × **L**
31 + →**40**	**32** ×	**33** **( )**	**34** +	**35** - **R**	**36** ×	**37** - →**47**	**38** **( )**	**39** ×	**40** +
41 -	**42** + **37**←	**43** ×	**44** **( )**	**45** + **W**	**46** ×	**47** +	**48** + →**79**	**49** -	**50** + **18**←
51 × **L**	**52** -	**53** × →**67**	**54** +	**55** -	**56** +	**57** × →**66**	**58** **( )**	**59** -	**60** × **R**
61 - **31**←	**62** +	**63** +	**64** -	**65** + **W**	**66** ×	**67** +	**68** - **L**	**69** ×	**70** -
71 **( )**	**72** +	**73** -	**74** ×	**75** **( )** **25**←	**76** ×	**77** +	**78** +	**79** - **L** -	**80** **( )** **74**←
81 ×	**82** -	**83** + **W**	**84** -	**85** + → **90**	**86** ×	**87** ×	**88** +	**89** +	**90** - **79**←
91 -	**92** +	**93** -	**94** - **83**←	**95** +	**96** ×	**97** **( )**	**98** -	**99** - **R**	 **Winner**

KEY: L- Loose a Turn, **R**- Restart, **( )** - Empty your score and **W**- Win a Turn.

How to Play the Game

The game can be played in two ways as desired by the players which are described below as Game 1 and Game 2

Game 1

a. Reshuffle the 20 numbered cards and pick any two, take note of their numbers and return.
b. Add the numbers on the picked cards (or simply find its additive value on the addition table) and locate its placement value on the game board by placing your choice button.
c. Any sign (arithmetic operation) found in the box of the placement value on the game board should be used on the two numbered cards picked in (i) and traced out on the respective operation table, but with '**( )**', your score is lost for that round/turn.
d. Record the score obtained in (iii) on the score sheet/score board.
e. Steps (i)-(iv) will be taken successively by all players involved.

f. The first player and other players take turns again and follow the steps above by starting and moving their buttons from their last position on the placement value on the game board.
g. If the last round of any player exceeds the game board, then addition should be used for the two card numbers and consequently recorded.
h. Finally, the scores on the score sheet should be added and the player with the highest score automatically emerges as the winner and presumably "wins" the car in the last box.

Game 1 Score Sheet Outlook

Rounds	Player 1	Player 2	.	.	.	Player *n*
1	S_1					S_1
2	S_2					S_2
.	.					.
.	.					.
.	.					.
N	S_n	,	.	.	.	S_n
TOTAL						

Where TOTAL = $\sum_{i=1}^{n} S_i$ and S_i means score obtained at any i^{th} round/turn.

Game 2

a. Reshuffle the 20 numbered cards and pick any one, take note of the number and return.
b. Locate its placement value on the game board by placing your choice button on the respective space on the game board as in a(ii) above.
c. Any letter or sign found below the arithmetic operation in (ii) should be adhered to. (See the KEY above and if nothing is found under the operation, then stay in the space till your next round or turn. Obviously, → means 'move forward to' while ← means 'moves backward to'.)
d. Steps (i)-(iii) will be taken successively by all players involved.
e. The first player and other players take turns again and follow the steps above by starting and moving their buttons from their last position on the placement value on the game board.
f. A winner automatically emerges if he /she is the first to get to the car box or exceeds it.

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