The Development and Use of Mathematical Games in Schools

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Abstract.
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.   Therefore, the focus of this paper is to discuss the format for the development of Mathematical Games and how to utilize Mathematical Games in Mathematics classrooms. The paper recommends that all Mathematics teachers should embrace the use of Mathematical Games in the classroom in order to improve the performance of students in the subject.
Keywords: Mathematical Games, Attitude towards Mathematics, Academic Achievement in Mathematics.

1. Introduction

The teaching and learning of Mathematics at all levels 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).   Teaching has been has been described as being ineffective (Oyedeji 1992).   The difficulties to students and the poor teaching usually come to light through the poor performances of students.   Students are seen to perform poorly in both internal and external examinations. For instance, in 1996 over, 52.9% of Nigerian students failed Mathematics in Senior Secondary School Examination (WAEC 1996). Also in Nigeria, in the years 2008, 2009, 2010 and 2011 the percentage pass with credit and above were 23.0%, 31.0%, 24.94%   and 38.98% respectively (Kurumeh & Imoko 2008; Moseri & Smart 2010; Iyi   2011).

Thus, every concerned educationist is seeking ways out of this problem of the poor performances in Mathematics.   One way is the improvement of the teaching process by introducing teaching aids.   One of such teaching aids is the Mathematical Game.

Mathematical Games have been used to teach Mathematics and science in many countries.   This is as a result of the usefulness of games in the educational process.   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 a pupil useful to himself and more wide awake."   Games can facilitate the mathematical environment as they release boredom, tension and establish a friendly atmosphere which allows for growth of skills and knowledge. (Obioma 1992).

2. 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

(Oldfield 1991).

3. 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:

a. Many Secondary School Mathematics teachers have not been exposed to Mathematical Games
b. Many teacher are not aware of the reasons for playing Mathematical Games
c. Many teachers do not know the guidelines for preparing Mathematical Games
d. Many teachers do not know the guidelines for evaluating the usefulness of Mathematical Games
e. Most Secondary School Students do not play Mathematical Games
f. There is no period for playing mathematical games in virtually all Secondary Schools
g. 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.

4. Materials for Making Games

Most Games are made from simple and inexpensive materials.   The sophistication or complexity of a game does not depend on the expensive materials that are used to make the games-but on the skills involved in the game situation.

Materials may include, cards, cardboard, marking pencil, wax pencils.   Printed cards with numbers and bottle tops and pebbles can also be used.   Cuisenaire rods are also useful.   This is not an exhausted list. In fact the nature and purpose of the Game will determine the materials to be used.

5. Suggested Format for Developing Mathematical Games

To develop a Mathematical Game the following format can be used (National Mathematical Centre 2002)

i.   **Title:**   You can choose a name or title for the game.   The title should be clear, unambiguous and meaningful. The title could be related to the topic being covered by the game. For example the title "Trigoratio" shows that the game is on trigonometry

ii.   **Class Level:** Indicate the class level that the game is suitable for. The   game   being designed should he suitable and appropriate for a particular class level.   This has implication on the depth of the topic to be covered by the game

iii   **Topic/Content:**   A game should cover at least one Mathematics topic or content.   Some games can be designed to cover a variety of topics. One must consider this while designing any game

iv   **Objectives:** Every game must have objectives.   The objectives of the game should be stated in behavioural, clear and unambiguous manner and must be related to the topic/content.

v   **Materials:** There is need to list the materials for the game.   The materials must be easy to obtain or fabricated from the local environment. Materials also include a sketch or diagram for the game.

vi.   **Plan: A p**lan is the outlay of the game.   This must be described clearly.   The plan should include how the game is made or arranged, the number of players, judges, scoring procedures etc.

vii   **Procedure:**   Provide detailed and clear instructions on how the game is to be started, methods of play, penalties and how the winner is to emerge. You need to state the tasks involved.   The rules and scoring instructions should be well explained as guide on how a winner is to emerge.

viii   **Strategies:**   Strategies involve tricks on how to outwit an opponent. In strategies there is need to include ways of bringing fun to the game.   There is need to state the strategies for winning or

preventing losing a game.   This strategy should imply some sense of competition, humour and value.

ix   **Follow-up Activities:**   This involves activities that the students can engage in to further master the topic covered by the game. The follow-up activities may be mathematical tasks or problems or simply future exercises.

This format has been adopted in the preparation of the Mathematical Games below as an illustration.

A. **Title**: Algebraic Substitution Attack
B. **Class Level:** Senior Secondary One
C. **Contents:** Basic Arithmetic Operations, Powers, Directed Numbers, Algebraic Substitution
D. **Objectives**: The Game will enable students master algebraic substitution involving powers and roots
E.   **Materials**: Game board, X and Y value board, thirty two game tokens(Game seeds) of two colours
F. **Plan:** The Game board is designed as an A by B Matrix of algebraic expressions. Below is the X and Y values board. Two tokens of two colours are used as marker tokens and the remaining ones are used to form shapes on the game board. The game should be played by two players at a time and there should be a judge to certify the correctness of the answers supplied by players. Each player is expected to spend maximum of thirty minutes in on a question
G. **Procedure**: Each player should have fifteen tokens (game seeds) of the same colour. The player to start the game is balloted. First, Player A starts by placing a token on any of the expressions on the game board. Then Player B is expected to place the maker tokens on any of X and Y values on the X and Y value Board. Then player A is expected to evaluate the chosen expression with the two values of X and Y chosen by Player B. If player A gets it right, he leaves his token on that algebraic expression. For instance, if Player chooses 2(X+Y) and Player chooses X=5 and Y = -3, then Player is expected to provided the answer as 4. If he is wrong, he removes it from the algebraic expression cell and Player B evaluates the expression as bonus. If he gets right, he places his token in that cell.

Then Player B places his token on any algebraic expression while player A selects any two values of X and Y for Player B to use to evaluate his chosen algebraic expression. If he is right he leaves his game token in that cell. But if he is wrong he will remove it and Player evaluates the expression as bonus. The game continues in turns until a winner emerges.

A winner is determined by the first Player to form a rectangle or square or a straight line (vertically, horizontally or diagonally) with at least four of his game tokens on the Game board without enclosing his opponent's Game tokens.

H. **Strategies**: To outwit your opponent, a player   tries to block his opponent any time he is trying to form a shape by choosing an expression in the cell that not prevent him from forming a shape. This blockage brings fun in the game.
I. **Follow Up Activities** : The teacher can give more problems on the topic for students to solve as assignment

2X+Y	4X-2Y	2(X-Y)	3(2X +Y)	XY
3XY – 4Y	Y-2X	7XY +Y	-3X +4Y	-4Y +5X
-4Y+ 3X	6Y – 4X	-7X – 2Y	-(3X-4Y)	-7X +6Y
X^2 -3Y	$(2X-Y)^3$	XY^2	X^2 + Y^2	X^2 - Y^2
$(X+Y)^{-2}$	$(X+Y)^{-1}$	X^0 +2Y	$(XY)^{-1}$	$3X^2$ -4Y
$-(2X +Y)^3$	$X^{-1} – Y^{-1}$	$X^{-2} Y$	$(4X-2Y)^3$	X^3 $-(2Y)^2$

<div align="center">**Game Board**</div>

X	-3	-2	-1	0	1	2	3	4	5

Y	-5	-4	-2	-1	2	4	5	7	8

<div align="center">**X   and Y   Values Board**</div>

6.   Choosing Mathematical Games

The choice of a Mathematical Game for use in the classroom will depend on such factors as the class level, the nature of the children, the topic of interest, the environment of the school. Most lessons involving practice can be converted into a learning game by choosing teams, taking turns, solving problems and keeping score.   A 'Play' will usually involve solving a problem or making an association.   This is very important considering for making a Mathematical Game.

7.   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: The Game must be of need to the class and the students must be seen to benefit from the Game. The basic criteria are that the game makes a maximum contribution to the learning of topics that may not be well attained by any other techniques.   The Game must involve important mathematical skills and concepts.

-Use the game at the proper time: Games should not be used anyhow and should be used when the skills/concepts are being taught. For example, you cannot make students to play a game on probability when they are studying Geometry in class.

-Active participation by all: The Game must allow for active participation on everybody all students in class. Therefore, enough game materials should be provided for all the students in the class to participate in the game. For instance, although one person is working a problem at a time, the other team members must be responsible for its solution too.

-Minimization of informality and excitement: Games generate a lot of fun and excitement in the class. This is good but the informality and over excitement if not well controlled may serve as distractions.   This must be controlled in the classroom.

-Something must be learnt from the game: Games are not just entertainments alone as something must be learnt. All activities must be geared towards ensuring that something is learnt from the Game. The follow-up activities such as discussions, readings or tests will emphasize the responsibility of learning something.

8.   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:

(a)   Making practice period more pleasant and successful. Games situation can reduce tension and boredom considerably, thereby adding colour to the study of mathematics

(b)   Enriching the Mathematics vocabulary. The vocabulary of Mathematics is peculiar and unique. Games can provide avenues for learning, internalizing and enriching the vocabulary.

(c)   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.

(d)   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.

(e)   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.

(f)   Generation of interest and excitement about learning Mathematics.   This is one of the main objectives of mathematical games. Once students generate interest in and are excited about learning Mathematics, half of the problem would have been solved.   Once students lose interest in Mathematics then it becomes strange to them.

(g)   Improvement of study habits.   As each player is actively involved, study habits are improved. Co-player can also help poorer pupils.

(h)   Developing positive attitudes toward Mathematics. The informality and excitement of games can lead to the development of positive attitudes.   Pupils will tend to like activities that excite them.

(i)   All in all Mathematical Games are activities which normally develop sense of competitiveness, bring satisfaction and pleasure to the students. They may also help to improve creative use of mathematical and meaningful learning related to social needs.

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

9. Conclusion

The importance of Mathematical Games in schools cannot be over emphasized. Unfortunately, many Mathematics teachers are yet to embrace the use of Mathematical Games in schools. Therefore, teachers are encouraged to use the strategies explained in this paper to produce Mathematical Games and arrange for their students to play relevant games in the Mathematics classroom. This will, perhaps, help to solve the dismal poor performances of students in Mathematics. Mathematical Games have been found to improve the attitude and academic performance of students in Mathematics.

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