# ACTIVE LEARNING TECHNIQUES IN SCIENCE AND MATHEMATICS CLASSROOM: THE ROLE OF THE TEACHER

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Abstract

Most of the time, in a typical classroom setting, students are involved only passively in learning. Research shows that such passive involvement generally leads to a limited retention of knowledge by students. This paper therefore focuses on the need for active learning in the Mathematics and Science classroom; the techniques for active learning and the role of the teacher in facilitating learning. Some of the suggested techniques include the use of open-ended questions, concept maps, co-operative learning or small group learning, use of mathematical games and practical works. The paper concludes that active learning techniques if employed in our mathematics and science lessons; would bring about higher students' achievement and retention in mathematics.

## Introduction

In the traditional approach to teaching Science and Mathematics, most class time is spent with the teacher teaching and the students watch and listening. The students work individually on assignment and co-operation is discouraged. Research shows that such passive involvement generally leads to a limited retention of knowledge by students (Pennick and Bonnsteffer, 1993).

However, research also indicates that by re-organizing or adapting the ways they present material to students, teachers can create an environment in which knowledge retention in Mathematics and Science is significantly increased. One of the best methods is to implement so-called active learning.

Active learning according to Jeffrey (2005), is the process of involving students in the learning process through reading, writing, acting, moving, problem-solving, discussing, brainstorming, explaining, debating, answering questions formulating questions, hypothesizing, etc. This means that instead of simply receiving information verbally and visually, students are receiving and participating and doing.

Many students have linked the use of active learning Lo increased motivation in the classroom, improved student retention, increased concentration, better student -faculty interaction, enriched understanding of content, better feedback and more supportive learning communities (Smith, 2005). By designing active strategies that engage each student's learning skills, a teacher becomes a guide by the side rather than a sage on the stage.

The purpose of this paper therefore, is to provide practicing mathematics and science teachers with active learning techniques that can be used in their classrooms to help students learn mathematics and Science concepts meaningfully. Specifically, participating teachers will have the opportunity to explore these strategies through hands-on-minds-on activities. By so doing, they will discover how teachers can teach less and student learn more.

## The Role of Students and Teacher in Facilitating Learning in Mathematics and Science Classroom

### The Role of the Students

Effectiveness in teaching means having and achieving specific goals for students. Achieving any particular goal requires action, often specific to that goal. With our well-considered goals in mind and with reference to logic, the literature, and experience we may predict which action or behaviour (the students' role) might result. Regardless of the source of support for a goal, the outcome is the same; if the student plays his role, follows his action, exhibits her behaviour; with time they will tend to move toward the desired goals. If we want students to be able to apply knowledge, then routine and regular opportunities for applying knowledge must be present in their learning environment.

Pennick and Bonnstetter (1993) envisioned the anticipated role of the students in the classroom as being derived primarily from the expected goals or outcomes (Figure 1).

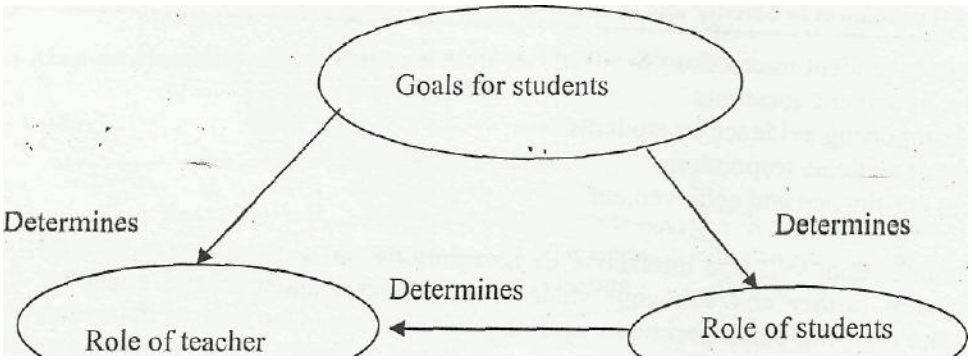



Figure 1

Students are therefore actively learning when they are: participating, writing, thinking and concluding, talking and listening, asking questions, contributing, arguing, brainstorming, working in groups and being physically active.

**The Role of the Teacher**

The teacher sets the tone of the classroom. Through actions and responses, teachers stimulate what their students do in the classroom. Thus, as you can see in Figure 1, just as the students" roles are derived from goals we have for them, the teachers' role flows from the desired students' roles. In the same way, the teacher's role guides the student's role. The teacher's role is to provide materials and learning opportunities conducive to enhancing not just the single goal in mind but the entire goal set. Thus, teacher's role simultaneously must enhance any particular goal while not endangering other goals. This balancing act also involves using research to plan, describe and explain which specific teacher behaviours and roles to use in the classroom.

The teacher's role in facilitating learning therefore, involves: guiding, demonstrating, directing, creating conducive environment, motivating, writing, asking questions and stimulating.

**Incorporating Active Learning Techniques in** Science **and Mathematics Classroom**

Implementing active based learning in Mathematics and Science teaching can Be as simple as the teacher stopping his/her lectures for a few minutes to ask students' questions about the content he/she is teaching, breaking out into small discussion groups and/or engaging students in interactive demonstration. The following are a few simple techniques that can be used in mathematics and science classroom.

(A) Ask students specific open-ended questions structured to provide curiosity: relate concepts to the real world; illustrate meaning or trigger discussion and/or debate. Questions raise new ideas and suggestions, stimulating students' thought and action while revealing a particular strand of problem-solving logic. When asking question, the teacher should follow a logical questioning strategy (history, relationships, application, speculation and explanation) to decide on the sequence and types of questions to ask students (Pennick, Crow and Bonnstetter, 1996). This question strategy shows students how the teacher goes about asking questions to resolve problem, revealing the teacher's own, experienced, problem-solving logic and strategies.

After asking questions, the teacher should think about using Wait-Time 1 (pause after asking a question) and Wait-time II (pause after a student's response). When teachers ask students questions, they typically wait less than one second for a student's response.

Further, after a student stops speaking; the teacher reacts or responds with another question in less than one second.

Research (Rowe, 1986), demonstrates that there are many positive effects of Wait Time.

These include increased;

length of student responses

incidence of speculative thinking

Student-to-student interaction number
of student questions use of supporting
evidence by students number of students
responding
student confidence and achievement

(B) Show rather than tell: Use interactive demonstrations and simulations to illustrate concepts. Take this one step further and ask your students to predict behaviour and construct their own hypotheses before carrying out experiments or doing calculations. One way of doing this is to show students a photograph, map or diagrams and ask them to make their own observations and
interpretation (Me Connel, Steer and Owens, 2003). This method may be used when the actual object or situation is not available or far removed from the classroom setting.

(C) . Incorporate active learning exercises such as concepts and Venn diagrams into your teaching. Concepts are short multiple-choice tests that faculty intersperse .in their teaching to assess whether students are learning. Venn diagrams add a visual (graphical) touch when comparing and
constructing characteristics (mathematical sets) and demonstrating relationship between phenomena (hurricanes vs. tornadoes; igneous vs sedimentary vs. metamorphic rocks, vertebrates vs.
invertebrates).

Venn diagrams can be used in illustrating or getting solutions to problems involving sets. This may be done by shading and indicating on the diagram the number of elements each region is representing.

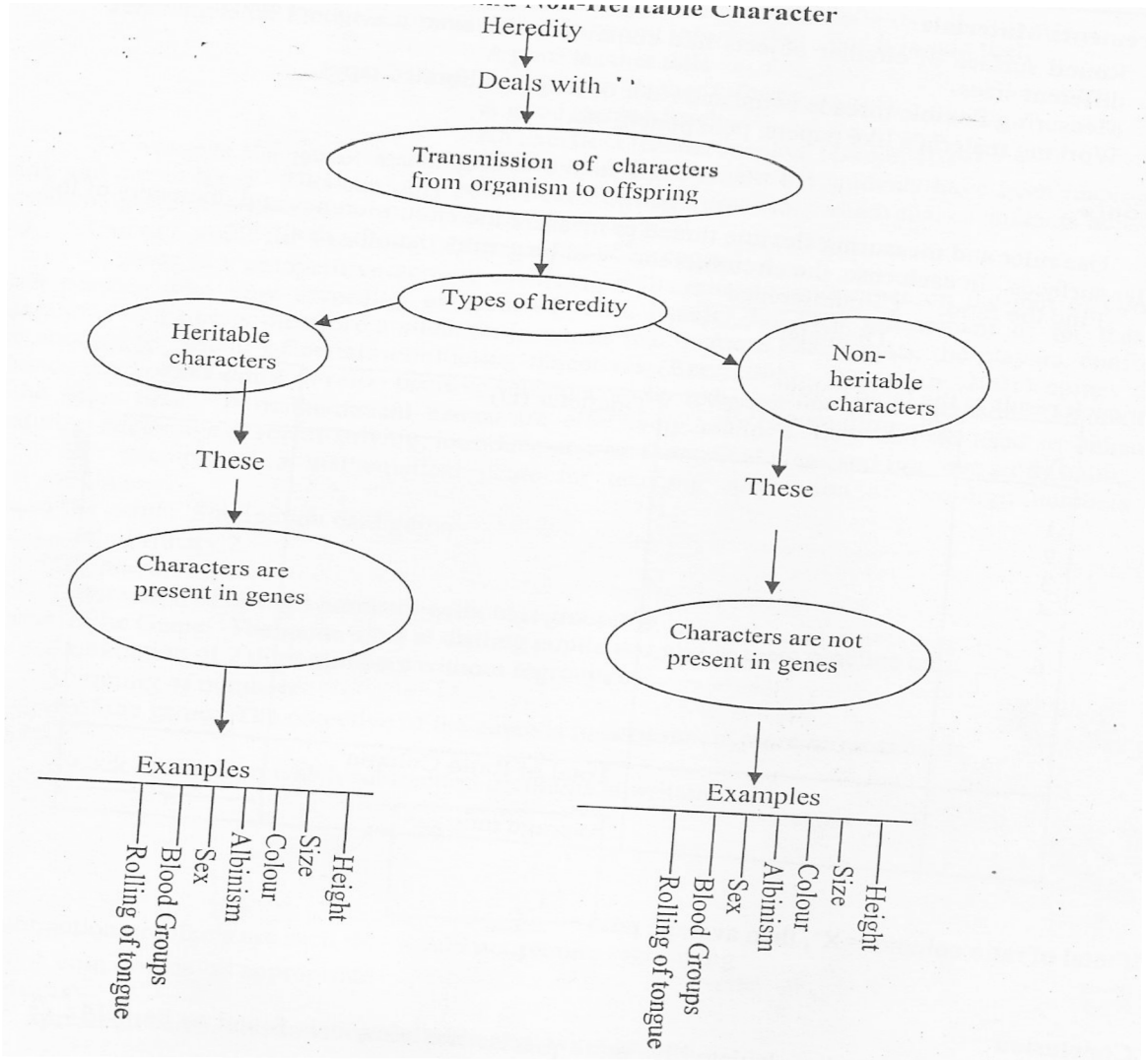
(D) Use concept maps to establish and demonstrate how concepts are related to
(i) one another
(ii) the real world and
(iii) other concepts in related mathematics and scientific disciplines. A concept
map is a schematic device for representing a set of concept meanings embedded in a framework of propositions.

According to Horton et al (1993), concept mappings which has become a viable
educational medium can help teachers become more effective, serve as a heuristic for curriculum development and promote meaningful learning.

Example of concept maps for teaching difficult concepts in genetics is illustrated as follows:

Figure 2

Concept Map on Heredity, Heritable Non-heritable Character




Concept mapping as activity based strategy enhances meaningful understanding of scientific concepts. It provides a schematic summary of what has been learned and promotes meaningful learning as opposed to rote learning (Novak, 1990).

(E) Use cooperative learning or small group learning. In cooperative learning, students work in teams on problems and projects under conditions that assure both positive inter-dependence and individual accountability.

In teaching mathematics and science, the students can be divided into smaller groups in which each group will be assigned to carry out a certain project in mathematics or science. Cooperative learning establishes community, better student faculty interaction and a more supportive and caring learning environment,

**Example:** Practical Verification of the mathematical Ratio of Pie concept

**Aim:** Measurement of the diameter and circumference of six different circular objects and the determination of the relationship of the diameter to the circumference.

**Requirements/Materials**

(1) Round surface of circular objects like containers and even a stagnant water tank or well of different sizes.
(2) Measuring flexible threads twine and ruler or length calibrated tapes.
(3) Working materials like papers, pen, pencil, etc.

**Procedure**

Use ruler and measuring flexible thread to measure the circumference and diameters of the circular surfaces. In each case, the circumference will be greater than the diameter. Find the ratio:

$$\frac{\text{Circumference}}{\text{Diameter}}$$

Enter each result in the table below.

| No | Circumference (C) | Diameter (D) | Ratio C/D |
|---|---|---|---|
| 1<br><br>2<br>3<br>4<br>5<br>6 | | | |
| | | Total of Ratio Column | |

If total of ratio column ~ *X'*, then average ratio = $\frac{X}{6}$

**Conclusion**

When this ratio is calculated by more precise methods, it is found to be 3.142 (3 decimal places).

Therefore, for every circle

$$\frac{\text{Circumference}}{\text{Diameter}} = 3.142$$

This ratio we denote by the Greek letter (pi) ie $\pi = 3.142$ = constant.

These activities would make the students active in the classroom and also understand the topic. (F) Use **Appropriate Practical Work**

Direct engagement of learners in activities or practical work that are sometimes involved in the teaching of some concepts should be encouraged by the teacher. The importance of engaging learners in practical activities could be affirmed by the old Chinese proverb, which says:

I hear and I forget
I see and I remember
I do and I understand.

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This means that until a child praclicalizes a concept or participates in the learning process, lie cannot understand the concept.

Teaching is far more than transmitting facts and information. For it is said that,

A poor teacher tells An average teacher informs A good teacher teaches An excellent teacher inspires (Ukcje, 1979)

To evaluate the job of leaching is to evaluate the extent the students have been inspired to think and create ideas. This can only be achieved through practical, which makes students active in the teaching-learning process. (G) Use **of Games for Teaching Mathematical Concepts**

A game is a competitive activity involving skills, chance, endurance on the part of two or more persons who play according to a set of rules, usually for their amusement or for that of spectators. A game is therefore a situation in which two or more participants, the players, confront one another in pursuit of certain conflicting objectives (Eze, 2005), Agwagah (2001) opines that "Games can help students develop positive self-concept by reducing fear of mathematics and anxiety at the same time. If mathematical games arc effectively planned, they can be used to enhance creativity, encourage problem-solving, introduce new mathematical ideas and improve study habit.

An example of a mathematical game for teaching subtraction of two-digit numbers is illustrated below.

Title of the game: Subtraction card game

Class Level: Primary 2 Number of players; 2 to 4

Topic: Subtraction of 2- digit numbers without regrouping.

Purpose of the Game: The game aims at drilling pupils and giving them practice on. (i) Subtraction of 2 digit numbers without regrouping. (ii) Counting of numbers

Objective of the game: The objective of the game is to accumulate more or most cards.

Materials:

(a) A deck of cards on which subtraction problems is written. E.g.


The subtraction problems are such that would not require regrouping

(b) A coin or dice, as appropriate

**Procedures**

(i) Spread all cards, facedown on the table or playing ground.

(iii) Players take turns to reverse cards face up. When a card is reversed, the player must find the difference of the two numbers on the card, by subtracting the number on the lower right end from the number on the upper left end of the card. The answer given by the players is then cross-checked by the teacher or arbiter. Play proceeds in this manner until all cards are reversed.

(iv) Rules (I) If a player gives the correct difference, he retains the card. But if he gives an incorrect difference, the card must be turned face down and the next player takes a turn. Once a card is touched, it must be reversed, otherwise the player loses his turn. : The player with more or most cards wins the game.

(2) Winner

**Recommendations and Conclusion**

Students understand mathematics and science concepts and have higher retention when they actively participate in the lesson. Teachers should move away from the "telling method" and select

strategies promoting active learning in the classroom. Active learning strategies if employed in our mathematics and science lesson would bring about higher achievement of students in mathematics and science. Mathematics and science teachers should also be encouraged to be creative, innovative and inspiring in their teaching through regular attendance of conferences, seminars and workshops to
• enrich their methodology in handling difficult concepts in mathematics and science.

Finally, teachers on their own part should not only be knowledgeable in the subject matter but should be able to use their initiative to utilize all natural and improvised materials available in their surrounding for the teaching of mathematics and science. They must set good goals mat are linked to real life situation and plan practical way of achieving the goals by employing the best strategies capable of eliciting the best response that is, making students active participants during the lesson and. after.

**References**


Agwagah, U. N. V. (2001). *Mathematical Games for Primary Schools;* Nsukka: Mike Social Press.

Eze, J. E. (2005). The Effect of Mathematics Games on Primary School Pupils Achievement in mathematics. *Multidisciplinary Journal of Research Development.*, 6(1), Pp. 112— 116.

Horton, P. B; Moenney, A. A; Woods, A. L. (1993). An Investigation of the Effectiveness of Concept Mapping as an Instructional Tool. *Science Education.* 17(1), John Wiley and Sons Pp. 95 - 111.

Jeffery, J. M. (2005). Active and Cooperative Learning. Http:// WWW - cs. Canisiuss.edu/-mcconnel/, active-learning.html.

Me Connell, D. A; Steer, D. N. and Owens, K.D (2003). Assessment and Active Learning Strategies for Introductory Geology Courses. *Journal of Geoscience Education.* 51(2). Pp. 2205-217.

Novak, J. D. (1990). Concept Mapping Tool for Science Education. *Journal of Research in Science Teaching.* 27(10), Pp. 937-949.

Pennick, J. E and Bonnstetter, R. J. (1993). Classroom climate and instruction. New Goals.Demand
New Approaches. *Journal of Science Education and Technology* 2(2), Pp. 389 - 395.

Pennick, J. E; Crow, L. W. and Bonnstetter, R. J. (1996). Questions are the Answer. *The Science Teacher.* 63(1), Pp. 27 -29.

Rowe, M. B. (1986). Wait Time: Slowing Down May be a Way of Speeding Up. *Journal of Teacher Education. 3,7(1).* Pp. 43 - 50.

Smith, K. A; Sheppared, S. D. and Johnson, R. T. (2005). Pedagogues of Engagement: Classroom-Based Practice. *Journal of Engineering Education.* 94(1), Pp. 87— 101.

Ukeji, B. O. (1979). Means of Evaluating Job of Teaching. A Paper Presented at the Annual Conference of Boards and Commissions Responsible for Recruitment, Promotion and Discipline of Teachers held at Awka between 22$^{nd}$ - 24$^{th}$ November.