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Appraisal of Some Modern Assessment Techniques in Science Education

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Abstract: *Researches into effective science teaching at primary school provide us with two important information; the ideas that science teaching and learning of children should start at school and understanding of a concept is the fundamental of the learning. Recently, the quality of teaching and learning science becomes the question in hand. A lot of researchers agree that objectives of learning science at primary and secondary schools may not be only to prepare students for the secondary stage education, it is also important for the preparation of lifelong learning and understanding of the phenomenon around them. Today, there is a fundamental shift from testing to learning as assessment is perceived as integral part of teaching-learning process. This shift has also brought a shift in traditional ways (tools and techniques) of assessment. Tasks like role plays, crossword puzzle, flow charts, popular science, book review, field trips, class work/homework assignments, group work, survey, project work, worksheets, games, etc. became tools for assessment. This paper discusses role plays, debate and flow charts as tools and techniques, which can be used by teachers in science classroom.*

Keywords*:* assessment, techniques, teachings, learning.

INTRODUCTION

A teacher has to devise various tools and adopt different techniques for assessment depending upon nature of content, type of skills, level of learner, etc. In means, one cannot use similar kind of tool for assessing variety of process skill, for different kind of content and activities. The unit will discuss various tools and techniques, which are being used for assessment in science at secondary level. Assessment in science promotes scientific enquiry when a teacher plans

assessment activities in science, its key focus is that it should promote scientific enquiry. Assessment in science should not be based on rote memory. Mere memorization of facts, principles or theories will not serve the purpose of science teaching-learning. If as a teacher, you plan and use such tools and techniques, which involve problem solving, investigation, active thinking and reasoning, your assessment will promote scientific enquiry. Assessment is linked with cognitive levels of learner in unit 5, we have discussed levels of cognitive learning, which are based on Anderson's taxonomy i.e. remembering, understanding, applying, analyzing, evaluating and creating. When as a science teacher, you are planning your assessment strategy, you should keep in mind that your assessment tool should be linked with every level of cognitive learning. You have to identify, decide and plan that which content is related to what level and what should be appropriate tool or technique for its assessment.

Tools for Scholastic Assessment in Science Under the domain of scholastics assessment, formative and summative assessments are two dimensions.

Formative assessment is used by the teacher in the classroom to monitor the progress of learners and to provide them appropriate support for enhancing their learning. Summative assessment is generally carried out at the end to assess how much learner has learnt. We can say, focus of formative assessment is more on 'assessment for learning' whereas focus of summative assessment is more on 'assessment of learning'. Some of the following tools and techniques have been suggested for scholastic assessment as secondary level in science.

A. Role-play

The Concise Oxford English Dictionary (1978 edition) definition of role-playing is: 'behaving in accordance with specified function'. This is accurate but a working definition of role-play is more difficult to arrive at largely because it is associated with 'dramatic' activity in the minds of teachers, and also because of confusion in the literature arising from its relatedness to play, games and simulation (Jones, 1985). Role-play is a product of 'play', 'games' and 'simulation', and definitions of these are provided in Box 1. In science education role-play may be seen as an interaction between these three components – either in combination or by themselves – and the child who 'performs' the activity, resulting in learning outcomes (Figure 1). It is suggested in this model that there is progressively increasing intellectual rigour involved as you move from play to games to simulations. Again, in this model, all aspects of role-play are derived from 'play'. Since the initiation and design of role-play is driven by the teacher, play takes on an educational function. Some types of role-play use techniques derived from drama, which may be adapted for use in teaching science. Role-play in science, therefore, is a product of the use of drama, games and simulations. Since, properly designed, it involves children in physical and intellectual activity, it has a potential to elucidate scientific concepts.

Why use role-play in science? The theory behind the use of role-play in science teaching and learning – as with 'active', 'experiential' or 'child-centred' learning – is that children are encouraged to be physically and intellectually involved in their lessons to allow them to both

express themselves in a scientific context and develop an understanding of difficult concepts (Taylor, 1987). The key to role-play, and the reason why role-play can help to make science relevant to many children, is that it is based upon 'play'. By the time that children begin to be educated in science, they are already very experienced at play, having had their whole lifetime to practise. This play activity is naturally used by children to develop their knowledge and intelligence (Piaget, 1951). The desire to play, and therefore to learn, is a fundamental part of human psychology and is a potentially powerful resource residing in the children themselves.

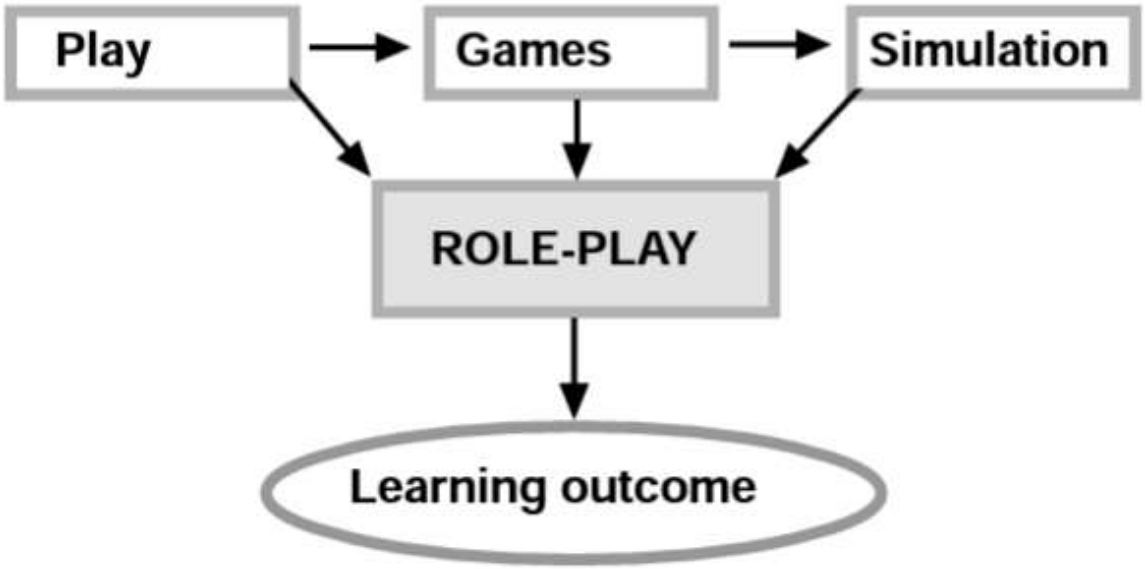

Figure 1 Role-play as the medium of interactive/ experiential learning.

In Kimber, O., Cromley,J.G. and Molnar-Kimber, K.L. 2018.

There are other reasons why role-play may be a valuable educational tool:

■It gives science teachers another option that can be used to link their work with 'the more feeling, creative side of education and as a method of increasing the manipulation of factual material by children' (Watson, 1985), a good example of which would be asking children to describe the water cycle to their peers in the role of television weather presenters.

■It gives children a feeling of 'ownership' of their education (Danby and Upitis, 1988). 'Ownership' refers to the way a child facilitates their own learning by creating their own role-plays through either scripted or improvised work, for example to explain the way the planets orbit the Sun.

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■It can be used effectively to teach about moral or ethical issues arising from the curriculum (Colby, 1987), for example debates about genetically manipulated food production or the arguments for and against the opening of a new quarry in the school's playing field.

■It can help children across the full spectrum of educational needs to 'interpret their place in the world' (Cayton, 1989). Merely explaining to children about their environment in the course of a theory lesson may not be the best method for helping them to gain an understanding of why it is there or how the processes at work in the environment have formed it. Role-plays, such as those describing predator–prey relationships or why day and night occur, give children a chance to experience these events in a physical way, which may be more appropriate to their personal learning style.

■Many role-plays are based upon analogy, which helps children to conceptualise and greatly increases learning (Lawson, 1993) about, for example, kinetic theory, electrical currents and antibody–antigen interactions.

B. Flow Chart

Communicating science to peers and students often involves constructing clear, concise flow diagrams and illustrations as well as writing narratives (Vandenbroucke, von Elm, Altman Gotzsche, Mulrow, Pocock, Poole, Schlesselman, Egger, 2014). Diverse methods for learning, including the use of diagrams of complex biological pathways (O'Hara, Livigni, Theo, Boyer, Angus, Wright, Chen, Raza, Barnett MW, Digard, Smith, Freeman, 2016), help increase the number of active retrieval pathways, lengthen memory, and improve recall efficiency (Congleton & Rajaram, 2012). Diagrams vary in their complexity, which should match the audience's familiarity with the topic. High school, premedical, and medical students who reviewed a brief set of comic strips or a comic chapter book on the anatomy of the digestive system had greater recall of the organs' functions than control students (Kim, Chung, Jang & Chung, 2017).

TABLE 1: Common uses of flowcharts and flow diagrams.

Content and Examples	
Flowcharts	**Flow Diagrams**
1. Linear progression of steps	1. Complex set of inputs, and interactions, in a process or theory
Steps in laboratory procedure	Life cycle of microorganism
Overview of steps in procedure for scientific poster, article, or slide set for presentation	Interaction of key signaling pathways in a process, such as Krebs cycle
Theory of straightforward method with linear input	Theory of complex method
	Theory of how process works

2. Group of steps that are repeated Procedure of polymerase chain reaction (PCR)	2. Comparison of two similar but distinct processes, or comparison of two substances affecting a process Comparison of mitosis and meiosis Comparison of activity of two or more immunotherapy drugs for cancer
3. Relationships between members of group Relationship of levels in multi-tiered organization Family tree for related organisms Family tree of extended family, for disease status	3. An organ, or organelle, shown at different magnifications Simplified illustration of condensation of DNA helix into metaphase chromosome Zooming in or out of an organ with panels showing different magnifications, such as a lung, bronchiole, alveolus, proteins on the surface of cells lining the alveolus.

Both flowcharts and flow diagrams can help students and readers who learn through seeing comprehend the relationships between objects or steps. Some people can remember details from a picture with text for a longer time than details from prose: for example, pictures with text in patient leaflets improve recall, comprehension, and medication adherence by the general public (Katz, Kripalani & Weiss, 2006). Flowcharts and flow diagrams commonly use brief text and graphic elements to give an overview of a multistep process, a theory, or comparisons (Table 1). Although some students have better spatial cognition than others, all students who actively construct diagrams discover how to "follow the arrows" (von Kotzebue, Gerstl & Nerdel, 2015). Students who self-completed diagrams with both text and graphic elements but not diagrams with only graphic elements could transfer inferences to a different scientific field (Cromley, Bergey, Fitzhugh, Newcombe, Wills & Tanaka, 2015).

C. DEBATE as a neglected tool in teaching science

Debate can be used for scholastic as well as co-scholastic assessment. Debate provides an opportunity to children to communicate their view point about any issue with logical arguments. The objective of debate should not be to highlight the negative aspects only or to criticize, but to provide an opportunity of balanced evaluation by highlighting both dimensions of the issue/topic. Debates are a useful tool for development of a collaborative and cooperative learning environment as well as for motivating children to search, collect, arrange, share and discuss new information related to any issue being debated. In Science, you can use debate for various topics like balanced diet and deficiency diseases, wastage and conservation of water, industrial growth vs. pollution, effect of deforestation on wildlife, etc. Debates provide an opportunity for healthy competition among children. Children also learn and sharpen their skills to evaluate the problem/issue with two different sets of opinions. Their higher order thinking skills, communication skills, critical analysis improve through such activities.

Let us explain the steps you can adapt to plan using debate as a learning and assessment tool in your class.

SN	**Indicator of Learning**	**Activity specific Indicator**	**Assessment**
1	Planning for the Debate	• Selection of specific roles in organizing the debate by children • Choosing the sub-theme • Assigning/choosing specific task in a group dealing with a particular sub-theme	Willingness to participate in the organization of the event Selection of relevant subthemes Assigning responsibilities to all members of the group with their consent
2	Organization of facts/ information	• Selection of the source of information • Collection of relevant information from various sources • Logical arrangement of subthemes • Sequencing of the information to be presented	Knowledge of relevant resources Selection and screening of relevant information Decision about sequencing of sub-themes Linking the previous sub-theme and next subtheme
3	Presentation of data	Introduction of the sub-theme • Rationale of discussion • Issues/aspects raised • Logical sequencing in presentation • Supportive data/facts to justify the logic	Relevant background of the subtheme Linkage of issues with subtheme Contextualization of the issue New information, which is not commonly known to all
4	Communication Skill	• Expression of views • Confidence and clarity of thoughts • Acceptance of other's view point • Describing important details	Use of vocabulary and command over language Confidence and logic Considering and countering other's view point during deliberation Including all finer details
5	Linkage with daily life	• Citing examples from their day-to-day lives • Giving solutions from their everyday observations routine • Giving examples on the basis of their life experiences or	Examples from household wastage of water like in kitchen, garden, washing the road, etc. Small initiative to taken care at home Examples from wastage or

		observations	conservation at large scale, if they have observed anywhere
6	Values/ Attitude	• Respect other view points • Cooperating in group dealing with a particular sub-theme • Cooperating in organizing the event • Showing a responsible attitude towards the tasks chosen • Avoiding wastage of material • Showing concern for the issue • Sensitivity towards the issue being debated.	To what extent have other views been considered The degree of cooperation among all children Concentration and effectiveness of task chosen by children in organizing of the event Cooperating with others in group for providing supportive data and encouragement

Strategies to Stimulate Science Students

According to National Academies of Sciences, Engineering, and Medicine (1996), the following are excerpts of strategies for effective learning of science by students.

Develop A Framework of Year-Long and Short-Term Goals for Students.

All teachers know that planning is a critical component of effective teaching. One important aspect of planning is setting goals. In the vision of science education described in the Standards, teachers of science take responsibility for setting yearlong and short-term goals; in doing so, they adapt school and district program goals, as well as state and national goals, to the experiences and interests of their students individually and as a group. Once teachers have devised a framework of goals, plans remain flexible. Decisions are visited and revisited in the light of experience. Teaching for understanding requires responsiveness to students, so activities and strategies are continuously adapted and refined to address topics arising from student inquiries and experiences, as well as school, community, and national events. Teachers also change their plans based on the assessment and analysis of student achievement and the prior knowledge and beliefs students have demonstrated. Thus, an inquiry might be extended because it sparks the interest of students, an activity might be added because a particular concept has not been understood, or more group work might be incorporated into the plan to encourage communication. A challenge to teachers of science is to balance and integrate immediate needs with the intentions of the yearlong framework of goals. During planning, goals are translated into a curriculum of specific topics, units, and sequenced activities that help students make sense of their world and understand the fundamental ideas of science. The content standards, as well as state, district, and school frameworks, provide guides for teachers as they select specific science topics. Some frameworks allow teachers choices in determining topics, sequences, activities, and materials. Others mandate goals, objectives,

content, and materials. In either case, teachers examine the extent to which a curriculum includes inquiry and direct experimentation as methods for developing understanding. In planning and choosing curricula, teachers strive to balance breadth of topics with depth of understanding.

Select Science Content and Adapt and Design Curricula to Meet the Interests, Knowledge, Understanding, Abilities, and Experiences of Students.

In determining the specific science content and activities that make up a curriculum, teachers consider the students who will be learning the science. Whether working with man dated content and activities, selecting from extant activities, or creating original activities, teachers plan to meet the particular interests, knowledge, and skills of their students and build on their questions and ideas. Such decisions rely heavily on a teacher's knowledge of students' cognitive potential, developmental level, physical attributes, affective development, and motivation—and how they learn. Teachers are aware of and understand common naive concepts in science for given grade levels, as well as the cultural and experiential background of students and the effects these have on learning. Teachers also consider their own strengths and interests and take into account available resources in the local environment. For example, in Cleveland, the study of Lake Erie, its pollution, and clean-up is an important part of a science curriculum, as is the study of earthquakes in the Los Angeles area. Teachers can work with local personnel, such as those at science-rich centres (museums, industries, universities, etc.), to plan for the use of exhibits and educational programs that enhance the study of a particular topic.

Select Teaching and Assessment Strategies that Support the Development of Student Understanding and Nurture a community of Science Learners.

Over the years, educators have developed many teaching and learning models relevant to classroom science teaching. Knowing the strengths and weaknesses of these models, teachers examine the relationship between the science content and how that content is to be taught. Teachers of science integrate a sound model of teaching and learning, a practical structure for the sequence of activities, and the content to be learned.

As more complex topics are addressed, students cannot always return to basic phenomena for every conceptual understanding. Nevertheless, teachers can take an inquiry approach as they guide students in acquiring and interpreting information from sources such as libraries, government documents, and computer databases—or as they gather information from experts from industry, the community, and government. Other teaching strategies rely on teachers, texts, and secondary sources—such as video, film, and computer simulations.

Work Together as Colleagues Within and Across Disciplines and Grade Levels.

Individual and collective planning is a cornerstone of science teaching; it is a vehicle for professional support and growth. In the vision of science education described in the Standards, many planning decisions are made by groups of teachers at grade and building levels to construct coherent and articulated programs within and across grades. Schools must provide teachers with

time and access to their colleagues and others who can serve as resources if collaborative planning is to occur.

- Teachers of science guide and facilitate learning. In doing this, teachers
- Focus and support inquiries while interacting with students.
- Orchestrate discourse among students about scientific ideas.
- Challenge students to accept and share responsibility for their own learning.
- Recognize and respond to student diversity and encourage all students to participate fully in science learning.
- Encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.
- Coordinating people, ideas, materials, and the science classroom environment are difficult, continual tasks. This standard focuses on the work that teachers do as they implement the plans of Standard A in the classroom.

Teachers of science constantly make decisions, such as when to change the direction of a discussion, how to engage a particular student, when to let a student pursue a particular interest, and how to use an opportunity to model scientific skills and attitudes. Teachers must struggle with the tension between guiding students toward a set of predetermined goals and allowing students to set and meet their own goals.

Focus and Support Inquiries.

Student inquiry in the science classroom encompasses a range of activities. Some activities provide a basis for observation, data collection, reflection, and analysis of first-hand events and phenomena. Other activities encourage the critical analysis of secondary sources—including media, books, and journals in a library. Although open exploration is useful for students when they encounter new materials and phenomena, teachers need to intervene to focus and challenge the students, or the exploration might not lead to understanding. Premature intervention deprives students of the opportunity to confront problems and find solutions, but intervention that occurs too late risks student frustration. Teachers also must decide when to challenge students to make sense of their experiences: At these points, students should be asked to explain, clarify, and critically examine and assess their work.

Orchestrate Discourse Among Students About Scientific Ideas.

An important stage of inquiry and of student science learning is the oral and written discourse that focuses the attention of students on how they know what they know and how their knowledge connects to larger ideas, other domains, and the world beyond the classroom. Teachers directly support and guide this discourse in two ways: They require students to record their work—teaching the necessary skills as appropriate—and they promote many different forms of communication (for example, spoken, written, pictorial, graphic, mathematical, and electronic).

Using a collaborative group structure, teachers encourage interdependency among group members, assisting students to work together in small groups so that all participate in sharing data and in developing group reports. Teachers also give groups opportunities to make presentations of their work and to engage with their classmates in explaining, clarifying, and justifying what they have learned. The teacher's role in these small and larger group interactions is to listen, encourage broad participation, and judge how to guide discussion—determining ideas to follow, ideas to question, information to provide, and connections to make. In the hands of a skilled teacher, such group work leads students to recognize the expertise that different members of the group bring to each endeavor and the greater value of evidence and argument over personality and style.

Challenge Students to Accept and Share Responsibility for Their Own Learning.

Teachers make it clear that each student must take responsibility for his or her work. The teacher also creates opportunities for students to take responsibility for their own learning, individually and as members of groups. Teachers do so by supporting student ideas and questions and by encouraging students to pursue them. Teachers give individual students active roles in the design and implementation of investigations, in the preparation and presentation of student work to their peers, and in student assessment of their own work.

Recognize And Respond to Student Diversity and Encourage All Students to Participate Fully In Science Learning.

In all aspects of science learning as envisioned by the Standards, skilled teachers recognize the diversity in their classes and organize the classroom so that all students have the opportunity to participate fully.

Encourage And Model the Skills of Scientific Inquiry, As Well As the Curiosity, Openness to New Ideas, And Skepticism That Characterize Science.

Implementing the recommendations above requires a range of actions based on careful assessments of students, knowledge of science, and a repertoire of science-teaching strategies. One aspect of the teacher's role is less tangible: teachers are models for the students they teach. A teacher who engages in inquiry with students models the skills needed for inquiry.

Use Multiple Methods and Systematically Gather Data on Student Understanding and Ability.

During the ordinary operation of a class, information about students' understanding of science is needed almost continuously. Assessment tasks are not afterthoughts to instructional planning but are built into the design of the teaching. Because assessment information is a powerful tool for monitoring the development of student understanding, modifying activities, and promoting student self-reflection, the effective teacher of science carefully selects and uses assessment tasks that are also good learning experiences.

Classroom assessments can take many forms. Teachers observe and listen to students as they work individually and in groups. They interview students and require formal performance tasks,

investigative reports, written reports, pictorial work, models, inventions, and other creative expressions of understanding. They examine portfolios of student work, as well as more traditional paper-and-pencil tests.

CONCLUSION AND RECOMMENDATIONS

The paper explored techniques for enhanced teaching and learning internationally and within Nigeria. It demonstrated that assessment of teaching and learning are core to education delivery. It showed that the concern for assessing of teacher and learner performances cut across countries, educational systems and epochs. However, facts in the paper indicated that much progress has not been made to institutionalize these exercises in the Nigerian school system. A few instances of the exercises exist but they have been insufficient to reveal reliable and comprehensive information that can help policy formulation. Overall, teaching and learning assessments are part of the very critical issues in teacher quality and education delivery which must be kept at the front burner all the time.

In this light, it is suggested that government and other stakeholders take techniques for teaching science seriously. It is hoped that the implementation of the blueprint will become manifest soon. On the bases of the facts discussed in the paper, the following measures are recommended:

i. The government should implement the new national blueprint for assessment of learning in the basic and secondary schools in Nigeria.

ii. The national blueprint should at all times promote compatibility of national with international teaching and learning assessment models.

iii. Stakeholders should support the implementation of the teacher assessment framework provided by the Teachers Registration Council of Nigeria, titled Professional Standards for Nigeria Teachers.

iv. Stakeholders in Nigeria should comply with the national teacher and learner assessment blueprints to ensure that the findings of their assessments could be integrated in the national data management systems and reported internationally.

v. There should be a national forum on teaching and learning assessment driven by the Federal Ministry of Education to promote exchange of best practices.

vi. Stakeholders should seriously consider synergy in order to pull resources and expertise together to carry out more effectively the assessment of teaching and learning in Nigeria.

vii. It is also important to put the outcome of teaching and learning assessments into good use. For instance, it should be recognized that students' academic achievement is largely related to teacher quality and commitment. In this case, a reward scheme may be put in place to recognize teachers whose students achieve excellent results.

Similarly, teachers with poor-performing students need not be punished. Rather the students' poor results indicate a need for training or retraining of the teachers. It may also indicate a need for the supply of lacking instructional materials and/or general improvement in the school environment.

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