Depictions of Philosophy and History of Science in Curriculum and Texts in Secondary Schools in Nigeria

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Abstract

This paper examined how history and philosophy of science are depicted in both curriculum and texts in schools in Nigeria. Data were collected using checklist, participant observation and interviews. Results show that materials in the philosophy and history of science indirectly foster the belief that scientists are infallible. Ttextbooks played a dominant role in the way science was taught. The teachers simply followed the textbooks. Although, experiments and demonstrations were mentioned during classroom teaching, actual laboratory experiments were reduced to a minimum and more time was spent memorizing the fundamental concepts, laws and theories in the textbooks. It was suggested that history and philosophy of science be taught informally through science clubs.

Introduction

Science Educators have often stated their interest in urging teachers and students to pay more attention to the philosophy and history of science. This is often regarded as a source of information which will help improve science teachers understanding of the nature of science and how scientists do their work. The philosophy and history of science should enable students to gain an insight into both the principles of science and an appreciation of the values of the scientific enterprise, which has characterized the great scientific advances of the past. (Clark 1969; Stimson, 1969). While these basic propositions have been widely accepted by scholars, there are some fundamental issues in dealing with the philosophy and history of science. For example, *What do teachers need to know about the philosophy and history of science? How should the philosophy and history of science be taught to students in schools?* Baddeley (1980) has argued persuasively that the philosophy and history of science should be taught to students not by separate studies in the philosophy and history of science, but through "normal" day-to-day science teaching or as he aptly puts it "through the normal syllabus work by using carefully selected experimental situations" (Baddeley, 1980 p. 75). However, Mathew (1994) has pointed out whenever science is taught, some philosophy of science is transmitted. This line of reasoning was recently developed by Kichawen, Swain and Monk (2004) who argued that a philosophy of science is conveyed to the students through the choice of activities and the points of emphasis on what is rendered problematic by the science teacher (e.g. science content, concepts, laws and theories, some practical activities and applications). 'Of course, this does not mean that the students learn a philosophy of science acceptable to philosophers or are able to articulate an understanding of a philosophy of science themselves'. However, it does provide a basis for examining both ***students*** and ***teacher's*** own views on the philosophies of science.

By and large, attention must also be paid to science textbooks used in classroom teaching and laboratory work. The curriculum in schools is defined not only by courses of study but also by textbooks used in the suggested programs of teaching (Apple 1998). Examining science textbooks, laboratory guides and other written materials one could obtain valuable information about how science is taught in different countries. This indicates the important role textbooks play in the teaching of science. Of course there are significant differences in the way science has been taught in different countries at different times, but nevertheless, a common pattern can be found in the way textbooks portray the philosophy and history of science. The impact of textbooks on the social relations of the classroom is also immense. Michael Apple's analysis of *'The culture and commerce of the Textbook'* indicates for example "75 percent of the time, primary and secondary students are in classrooms and 90 percent of their time on homework is spent with text materials" (Apple, 1998). While textbooks dominate the curricula at the primary and secondary and even University levels, very little attention has been paid by science educators to how much use is made of philosophy and history of science materials in the school curriculum and texts.

The purpose of this paper therefore is to examine how the philosophy and history of science are depicted in both curriculum and texts in secondary schools in Nigeria. In addition, the paper will examine the nature of science curriculum, the textbooks commonly used and how science is taught when using these texts.

Changing Perspectives in Philosophy and History of Science

WHAT PHILOSOPHY OF SCIENCE AND HOW MUCH?

Much has been written about the philosophy of science and what ideas-about-science should be taught in school science. (Collins et al, 2001; Bybee, 1993) Driver et al 1996, Miller 1996). While these analyses use a range of terminologies (e.g methods or processes of science, products of science, nature of science, status of science, socio-scientific issues) a common feature is the identification of knowledge about the development and use of scientific knowledge, or what Ryder (2002) calls *"knowledge about science"*. Such knowledge can be distinguished from the concepts laws and theories that constitute *"Knowledge in Science"*. (Ryder, 2002). Ryder argues that a weakness of existing school science curricula is the presentation of the concepts, laws and theories and relations of science (knowledge in science) without any reference to the ways in which these ideas were developed (knowledge about science).

KNOWLEDGE ABOUT SCIENCE" VS. "KNOWLEDGE IN SCIENCE"

"Knowledge about Science" itself can be characterized in terms of the epistemology and the sociology of science' (Ryder, 2002, p639). Epistemology examines the ways in which knowledge claims in science are developed and justified while the sociology of science studies the interactions among scientists and the means by which science professionals interact with those outside science. In using this distinction, it is recognized that these issues need to be elaborated in specific science contexts, and that they are interrelated.

Nott and Wellington, (1993) have provided the following list of continuum about science which suggests some interesting dimensions to the knowledge about science that extends our thinking on how we should look at science. These include:

1) Revlativism vs positivism – truth as being relative or absolute.

2) Inductivism vs deductivism – generalizing from observations to general laws versus forming hypotheses and testing observable consequences.

3) *Contextualism vs decontextualism – science interdependent with or independent of cultural context.*

4) *Process vs product – science characterized mainly by processes or by facts, concepts, laws and theories.*

5) *Instrumentalism vs realism – science as providing ideas, which work versus a world independent of scientists' perceptions.*

Our work as teachers is not only influenced by the way we think about these ideas but also by our own ideas about the "Knowledge about science' and 'knowledge in science' Jenkins (1997) identifies several significant features of knowledge about science that define the role it plays in citizenship. This includes how one views the risks involved, how it affects other aspects of our lives, how we make sense of the information and which social group we belong to. Devereux (2000) suggests that we need to understand science as a human endeavour. Science involves us in making moral and ethical judgments about different research, its methodology and outcomes. In order to be able to do this, it is important to develop the public understanding of science and a scientifically, literate citizenry. Scientific literacy involves the acquisition of basic knowledge of science that are so important in our roles as citizen, workers and family members.

HOW SCIENTIFIC KNOWLEDGE IS GENERATED

Science is not only a way of knowing, it is also a way of doing, and each shapes the other. The following are some notions expressed about how scientific knowledge is generated.

1) Empiricism: One view about science is that for knowledge to be termed scientific, it must be derived empirically. Empiricism refers to the view that all true and lasting knowledge is gained through experience. i.e. all our scientific knowledge and the concepts we use, are derived only from direct 'sense-experience'. However in science, the situation is far removed from the naïve empiricist account. In many situations, our observations and experiences do not give rise to knowledge and conceptual structures – they are determined by them. Thus, the concepts or conceptual frameworks come first. Without some kind of appropriate conceptual frame work observations cannot take place at all. A large part of science education must be concerned with initiation into ideas and concepts which are brought to bear upon observations. Students are educated into 'what to look for'. As Driver aptly puts it, science teachers initiate pupils into wearing 'their own brand of spectacles' (Driver, 1975, p. 8). Thus, empiricists' account is the exact opposite of the way in which much of our everyday and scientific knowledge is acquired. We need concepts in order to classify our experiences and even to see things in a different way. In other words, concepts often precede observations. Observations are determined by hypothesis. Thus, a scientists hypothesis, and existing theories, point clearly to which observations or experiments he should carry out. Of course, science is more than just observations and experiments. Scientists formulate theories, which are intended to explain experimental results and to make it possible to accurately predict future observations. But how do we get from observation to theory? And how are theories used in science?

2) *Inductivism:* The process by which we move from a series of observations to a hypothesis or generalization is known as 'Induction'. This was seen by Francis Bacon as the key element in the scientific process. We see numerous white swans and conclude that 'All swans are white'. We observe many instances of metals expanding and conclude that 'All metals expand when heated.' This jump, from the particular to the general, is called induction. The philosophy of science which asserts that induction is an essential part of

scientific method is known as ‘Inductivism’. It is this outdated philosophy of science which seems to underlie certain curriculum projects in Africa concerned with showing pupils how to think and work in ways characteristic of a successful practitioner of science. In some guided discovery experiments pupils are invited to use the process of induction. They are presented with the phenomena, they carry out an experiment, and are then asked to form a hypothesis. It is assumed that inductivism enables the pupils to enter into the ‘sprit of science’ and copy the processes used by practicing scientists. Unfortunately, this view of science and the scientist is no longer accepted or tenable.

3) *Hypothetico-Deductivisim:* Carl Hempel (1966) gave an account of how scientists operate which is very well known and which was widely accepted until quite recently. According to Hempel scientists operate on a *hypothetico-deductive* method. What this means is that firstly scientists are supposed to begin by making and recording observations in whatever field they happen to be investigating; secondly they formulate a hypothetical covering law; and thirdly, this hypothetical law is then used as a premise in a deductive argument which could be used to explain or to predict natural phenomena.(Hempel, 1966). Let us take a simple example:

Step one: Set up a battery and some wires and try to send electric currents through various objects made of silver, iron, copper, brass and other metals. Observe and record that all the objects conduct electricity’.

Step two: Formulate a hypothetical law: “all metals conduct electricity’.

Step three: Use this law as a premise in a deduction, for example: All metals conduct electricity. Mercury is a metal. Therefore the mercury fillings in teeth will conduct electricity.

Figure 1, below gives an illustration of “Empiricism, Inductivism and ‘Hypothetico-Deductivism’.

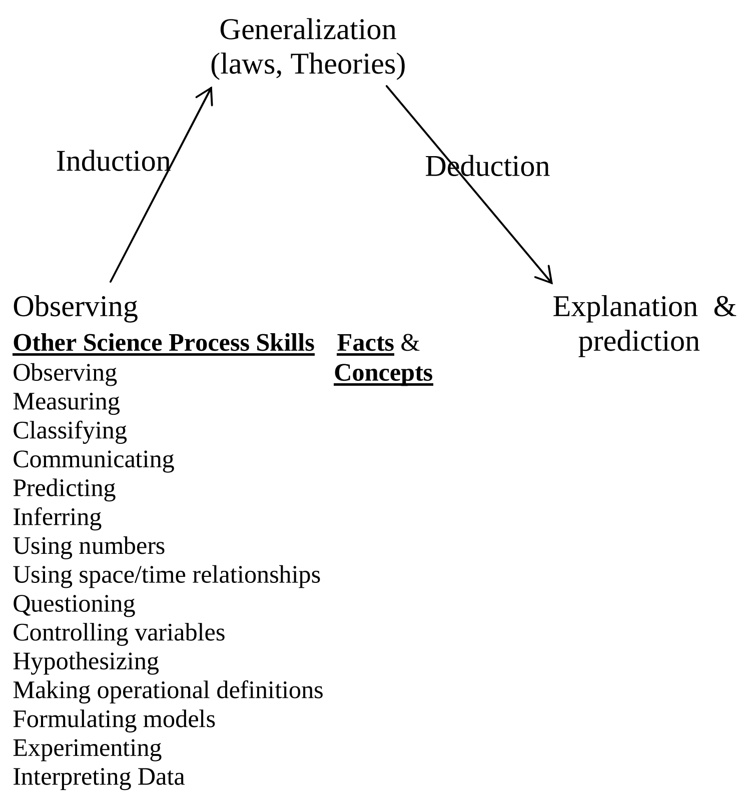

Fig 1 – Illustration of Empiricism, Inductivism, and Hypothetico-Deductivism

4) *Falsificationism*: Karl Popper (1972) is perhaps the most famous philosopher of science in this century. His account of scientific reasoning may aptly be called '*falsificationsm'*. According to Popper scientists formulate 'highly falsifiable' theories, which they then test. In a way scientists can be said to spend much of their time trying to show that their own theories are false. When all the scientist's theories have been shown to be false except one, then he or she can conclude, at least for the time being, that one unfalsifiable theory is the correct one. But no theory is safe for all time. Every theory is ultimately only a hypothesis, and hence permanently opens to the possibility of being falsified. The Popperian view in part makes use of *hypothetico-deductivism* (Monk and Dillon, 2000). This is because the method involves making hypotheses and then making logical deductions from the combination of hypothesis and empirical results. Popper's view can be summarized approximately as follows:

a) A problem is perceived (usually as a rebuff to an existing theory)
b) A solution, the hypothesis is proposed
c) Testable propositions from the hypothesis are deduced
d) Attempted falsifications by, among other things, observations and experiments are carried out.
e) A preference is established between competing theories.

The question that needs to be asked is 'How is Popper's falsificationsm to be applied in science classrooms? There is no generally accepted view on how this is to be done.
On one hand, Monk and Dillion (2000) explain thus:

> *"Where can we see Popperian falsificationism in the science classroom? We would suggest that generally one cannot. We think students of science are hardly ever engaged in trying to disprove some theory or casual mechanism. Instead, they are more usually asked to carry out carefully controlled experiments, which provide rhetorical support for the scientific view being advanced by their science teacher. The social locations of the production and reproduction of scientific knowledge are different – research institute or school – and their social dynamics are different. If Popperian falsificationism were to operate in science classrooms, then teachers would need to organize students' activities so that they could make their own conjectures, devise their own tests, and then take part in mini-conferences where ideas were critically evaluated. The student's reports on their investigations would need to be refereed by their peers before publication. Perhaps constructivism, as a viewpoint on learning, offers the opportunity for science teachers to re-conceptualize their teaching along these lines" (Monk and Dillion, 2000 p. 76).*

On the other hand, Wallis (1980) suggests that in order to investigate Poppers falsificationism the following questions can be used at the classroom level:

i) Are the pupils observant? That is to say, do they see what there is to see, or do they rely on being told what to see?
ii) Do they select from their observations those, which have a bearing on the problem before them?
iii) Do they look for patterns in what they observe and are they able to relate the current observations to others they have made earlier?
iv) Do they seek to explain these patterns? If they can offer more than one explanation, do they attempt to rank them in order of plausibility?

v) *Can they devise, or contribute to the devising of, experiment, which will put to test the explanations they suggest for the patterns of observations? Are they prepared to reconsider an explanation in the light of new evidence? (Wallis, 1980)*

For school use these criteria could be transformed into a seven-stage algorithm, under the following headings:

1	*Making observation*	*5*	*Ranking hypotheses*
2	*Making relevant observations*	*6*	*Testing hypotheses*
3	*Relating observations*	*7*	*Dealing with contradictory evidence*
4	*Offering hypotheses*		

While these issues are still being debated the concern of scientists and philosophers of science and educators is not whether science teachers and their students are being sufficiently exposed to knowledge in science in the form of concepts, laws and theories, but whether they conceptualize an identifiable philosophy of science. The empirical sciences as Carl Hempel has noted, seeks to explore, to describe, to explain and to predict the occurrences in the world we live in'. (Hempel 1966, p1) This involves: "the <u>processes</u> by which scientific knowledge is gathered, analyzed, synthesize and disseminated, the <u>products</u> (i.e <u>concepts</u>, <u>laws</u> and <u>theories</u>) by which regularities in natural phenomena are <u>described</u>, <u>explained</u> and <u>predicted</u>, and upon which the meanings of scientific content depend; and the written and unwritten <u>ethical</u> and <u>conventional systems</u> guiding the scientific community in its methodological inquiry".

Thus, in teaching philosophy of science in schools, the knowledge about science and knowledge in science all need attention:

1) Processes by which scientific knowledge evolves i.e (induction, deduction, observation measuring classifying, communicating, predicting inferring, using space/time relationships, questioning , controlling variables, hypothesizing, making operational definitions, formulating models, experimenting and interpreting data.
2) Scientific knowledge in the form of <u>concepts</u>, <u>laws</u> and <u>theories</u>; and
3) The social and ethical aspects of science. (Ogunniyi and Pella 1980)

What History of Science and How Much?

Thomas Russell in his classic paper '*What History of Science, How Much and Why?*' has argued that the question 'What history?' arises because the common textbook accounts of the history and methods of science are not suggested by the actual historical records of science'. Thus, although the characterization of methods of science is an ongoing topic of discussion among historians and philosophers of science, their interpretations, bear little resemblance to textbooks, names and date references emphasizing the discovery of particular scientific facts and laws.' Thomas Kuhn is well known for suggesting that the historical record of scientific advances cannot be accounted for with a simple view of cumulative progression in scientific knowledge, but rather is better modelled with discontinuous changes in viewpoints, ideas, models and theories. Donnelly's article on "*The Work of Popper and Kuhn on the Nature of Science*" outlines the main features of Kuhn's account of the progress of science (*<u>pre-science</u>, the emergence of the <u>paradigm</u>, <u>normal science</u> as the exploration of the paradigm, <u>crisis</u>, <u>revolution</u>,* etc.). Kuhn's observation of scientists and investigations into the history of science led him to distinguish two different varieties of scientific enterprise, **normal** science and **revolutionary science**. Normal science does not construct new theories, nor does it test the adequacy of older ones. Normal science simply assumes that current theories are true. It proceeds by determining 'known facts' or 'true facts' with more precision, by investigating unexplained happenings with the aim of fitting them into current theory and by resolving small theoretical ambiguities. From time to time, a scientific revolution takes place. Such revolutions occur only when existing theories turn out to be very unsatisfactory indeed. For a while a number of different theories (and a number of different scientists) might compete, until one comes to be preferred to the others. The triumph of a theory will be due to a variety of factors: its capacity for explaining recalcitrant facts, its usefulness in solving problems and making accurate predictions, and last but not least the clout and prestige of the scientists who invented it and support it.

This view of scientific knowledge and activity, which has emerged, can help teachers understand knowledge about science. The facts, concepts and theories, which make up scientific knowledge are not permanent nor beyond dispute. They are much more like a report on progress so far, which future investigators will modify and even, may be, contradict. Any scientific theory is, to put it simply, the best explanation which scientists have produced up to the present. Theories are provisional; they are used until something is observed which contradicts them or which they cannot explain. When that happens to an important and influential theory, something rather like a scientific revolution occurs: old theories are discarded and new ones are invented, tested, discussed, negotiated, refined and eventually accepted, or rejected, by the scientific community. Today, the strength of science is thought to lie in its openness to criticism and correction. Science is regarded as a powerful and influential activity precisely because the truth of scientific knowledge cannot be taken for granted and because it is always open to question.

Assessment Criteria for Depicting the Philosophy and History of Science in Curriculum and Texts

When taken together, the philosophy and history of science specified and described above could be converted into a checklist consisting of six features; students' activities, teaching strategies, learning strategies, scientific method, scientific knowledge and history of science. These features can be used as Assessment Criteria for depicting the philosophy and history of science in curriculum and texts

TABLE 1

A Checklist For Depicting The Philosophy & History Of Science In Curriculum And Texts.

A	**PHILOSOPHY OF SCIENCE**
	1 Students Activities
	What experimental activities are students required to carry out?
	i Students are required to obtain perfect results.
	ii Students are required to accommodate errors due to experimental inaccuracy.
	iii Students are required to repeat experiments due to unknown factors.
	iv Students are required to accommodate disagreements
	v Students are required to construct theories.

2 Teaching Strategies

What teaching strategies are emphasized?

- *i* *Experiments are used to give operational content to theoretical concepts.*
- *ii* *Experimental are results used to teach the logic of induction and deduction.*
- *iii* *Experimental are results used to show a pattern, which may be an induction of a law or an evidence gained to support it.*
- *iv* *Theories are used to explain or predict important chemical/physical/biological phenomena.*
- *v* *Experiments are done to provide evidence for theories.*

3 Learning Strategies

What learning strategies are emphasized ?

- *i* *Note taking from the board*
- *ii* *Open-ended investigation*
- *iii* *Students describe their experiences*
- *iv* *Data collection to determine empirical relationships*
- *v* *Practical work developed out of theory, which in turn is developed from observation*

4 Scientific Method

Are experiments and theory used to teach the nature of scientific method?

5 Scientific knowledge

What status is given to scientific knowledge?

- *i* *Scientific knowledge consists of concepts, laws and theories of observable behaviour of natural phenomena*
- *ii* *Scientific knowledge consists of concepts, laws and theories that incorporate unobservables*
- *iii* *Demonstration and laboratory experiments about natural phenomena are regarded as 'true'*

B. HISTORY OF SCIENCE

How much use is made of history of science?

- *i* *Historical facts are duly presented.*
- *ii* *Current concepts, laws and theories are set out as if these were the final truth.*
- *iii* *Older theories are duly described.*
- *iv* *Rejected theories and laws are duly described.*
- *v* *They foster the belief that it is impossible for scientific theories to be falsified.*
- *vi* *They foster belief that scientists are infallible.*
- *vii* *Discrepancies exist between the historical record and the historical content included in texts.*

Research Questions

The following research questions were addressed

1) What is the nature of the science curriculum in Nigerian Secondary Schools?
2) What textbooks are commonly used in the various sciences (chemistry, physics and biology)?
3) How much philosophical and historical materials are contained in these texts?
4) How is science taught when using these textbooks? Do students ask questions; discuss issues involving philosophy and history of science?
5) What lessons do we learn for policy and practice?

Methodology

1) SELECTING THE SCHOOLS

The selection of the schools in which to conduct this research was considered to be a crucial step in the study. Therefore, it was intended that this step be approached as systematically as possible. The search for the schools was based on a number of criteria which were identified for the purpose of this study and which seemed compatible with the nature of the questions asked. These criteria included:

i) that the schools must have had biology, chemistry, physics in their curriculum for at least ten years. It is important in this study that the science programme should not be in its first year of operation in order to gain a stable and accurate perspective of the actual operation of science teaching.

ii) That the schools be well staffed; and the teachers who would participate in this study must have had in-service training at the University of Benin and taught philosophy and history of science

The choice was narrowed to two schools in which the study could be carried out successfully. The Federal Government College Benin City (FGGC) and the University Preparatory Secondary School (UPSS).

2) COLLECTION OF DATA

In the study, participant observation and interviewing were the methods for data collection. Borg R. Walter and Gall, (1979) described participant as “a role in which the observer is known to all and is present in the system as an observer participating by his presence, but at the same time usually allowed to do what observers do rather than expected to perform as others perform”. One of the unique aspects of employing the participant-observer technique is that although the researcher finds little opportunity for becoming a full-fledged participant, the opportunity for observing and recording are limited only by the endurance of the observer. Interviewing was also used as a supplementary method for gathering the data necessary in this study. Adding interview data to recorded observation further improves the validity of the findings (Kaplan, 19734). The procedure for recording data from daily classroom observation was the same at each school. Special attention was paid to the utterances and actions of teachers and pupils during science lessons as well as situations and incidents, which were especially telling. Two lessons were observed for each teacher in the three science subjects: chemistry, physics and biology.

Science Curriculum in Nigerian Schools

The early 1960s and 1970s saw massive science education reform activities in both developed and developing countries aimed at a more functional interpretation of science education for pupils at all levels of education. The predominant reform strategy focused attention on the nature of the science curriculum, and many science teaching projects were initiated with the aim of re-evaluating the contents of science teaching programmes and the way they are taught at both primary and secondary schools. (Ivowi, 1990)

Nigeria was one of the many African countries that also embarked on the science curriculum reform process, along with the rest of the world in 1970s. The first organized science curriculum project for Nigerian Secondary Schools is the Basic Science for Nigerian Secondary Schools (BSNSS) project in 1962 through the collaborative efforts of the staff of the science department of the comprehensive High School, Aiyetoro, Ogun State and specialists in science education of the Harvard University, USA. However, the first nationwide secondary school science curriculum in Nigeria occurred through the formation of the science Development Committees in 1968, nurtured by a cooperative effort between the Science Teachers Association of Nigeria (STAN) and the erstwhile comparative Education Study and Adaptation Centre (CESAC). The products of these committees led eventually to two science curriculum projects: The STAN Nigerian Integrated Science, Project (NISP) and the CESAC's Nigerian Secondary Schools Science Project (NSSSP) in Biology, Chemistry and Physics. While STAN syllabuses in Biology, Chemistry and Physics were well-used and had textbooks written on them between 1970 however, the more popular was the NSSSP. (Ivowi, 1990).

THE NIGERIAN SECONDARY SCHOOL SCIENCE PROJECT (NSSSP

In August 1969 CESAC organized a science curriculum Development conference at the University of Ibadan with the aim of preparing some Nigerians with the skills necessary for designing and producing instructional materials in secondary school biology, chemistry and physics. Following this conference was a writing workshop held at the Comprehensive High School Aiyetoro in 1970. (Ivowi, 1990). The NSSSP had an examination syllabus in each of biology, chemistry and physics together with students' texts and teacher's guides. The project followed the curriculum development processes of syllabus preparation, writing of instructional materials, assessment at a critique conference, organization of teacher training courses, trial testing and feedback leading to a revision of texts and final production of materials for public use (Ivowi, 1990). The NSSSP materials, in Biology, Physics and Chemistry, were used in selected trial secondary schools that had the facilities required to implement them throughout Nigeria in 1970s at senior school level (from Forms III to V). Other non-trial schools used the standard science curriculum produced by the WAEC. The NSSSP materials shared quite similar rationale found in most of the post-sputnik science curricula then characteristic of science curricular reform particularly in developing countries. (Ivowi, 1990). With the introduction of the ***National Policy on Education*** (FGN, 1984), the Nigerian government discarded the WAEC curriculum now considered obsolete to contemporary developmental needs, and introduced a new science curriculum at Senior Secondary Schools across the nation in 1985 which so closely resembled the old NSSSP materials these latter materials were actually adopted for use throughout the Senior Secondary Schools of Nigeria as a new science curriculum. The adoption saves the trouble of developing a whole new curriculum; especially as the NSSSP materials had been on trial for over a decade at the time they were adopted on a national basis. (Ivowi, 1990)

RATIONALE FOR THE COURSE CONTENT

The major concepts underlying the topics in the SSS science curriculum contents are clearly stated in the syllabuses. For physics, motion and energy are predominant; in chemistry, structure, energy and periodic classification are relevant; while nutrition, energy production, cell behaviour and ecology suffice for biology. (Ivowi, 1990). In all the cases, relevance of the subjects to society in terms of application is stressed, selection of topics in each case has been carefully done to avoid irrelevance and to ensure adherence to the dictates of concepts. A general treatment based on a unifying concept and elaborate applications is adopted throughout. To avoid authoritarian atmosphere around each subject, the syllabus is less detailed and rigid. Apart from the syllabus content, the curricula advocated a new approach. The new approach called for active students' participation through experimentation and discussion. Through appropriate strategies, the contents were attainable in terms of their teachability and studyability. The guided-discovery method of teaching, was adopted. The recommended textbooks addressed concepts very well. A fine combination of the presentation of concepts, application and student-activities made the curricula well represented in the textbooks in three key subjects: chemistry, physics and biology.

SUPPORTING SERVICES

The NSSSC was started with graduate teachers who studied science (Biology, Chemistry or Physics) with no professional teaching experience. Therefore, there was a need for in-service training since the content and approach were different from the traditional science courses that were previously taught in secondary schools. The Federal Ministry of Education and Faculties and Institutes of Education in Nigerian universities are the agencies, which implement in-service educational policies in Nigeria. In order to ensure success, two major undertakings were embarked upon in the mid – 1980's. The first was a massive in-service training of science teachers through the annual long vacation science courses and the master trainers courses organized at the different centers in the country. It was intended that the master trainers would organize similar training courses at the state and local government level to produce a multiplying effect. The philosophy objectives, and content of the curricula, as well as improvisation featured in most of these courses.

Analysis of Philosophical and Historical Materials Contained in Textbooks Commonly Used in Schools

CHEMISTRY

General Features of the Chemistry Curriculum

The objectives of the chemistry curriculum are to:

1) *Facilitate a transition in the use of scientific concepts and techniques acquired in integrated science to chemistry.*
2) *Provide the students with basic knowledge in chemical concepts and principles through efficient selection of content and sequencing.*
3) *Show chemistry in its inter-relationships with other subjects*
4) *Show chemistry and its link with industry, everyday life, benefits and hazards.*
5) *Provide a course, which is complete for students not proceeding to higher education while it is at the same time a reasonably adequate foundation for post-secondary chemistry course.*

TEXTS

Some of the widely used texts in chemistry include:

1) Bajah S.T., Teibo B.O. Onwu G. and Obikwere A. (2002) **Senior Secondary Chemistry** (Textbook 1, 2, 3) Longman Nigeria Plc., Ikeja, Nigeria.
2) Ababio, Osei Yaw (2000) **New School Chemistry** (Senior Secondary Science series; New Edition) Africana – Fep Publishers Limited, Onitsha, Nigeria.
3) Vowa, C.A., Nwokeogu M.O., Ibole, P.M. and Adunse J.O. (2001) **Round-Up Chemistry** (For Senior Secondary Certificate, University Matriculation and PCE Examinations), Longman Nigeria Plc., Ikeja Nigeria.
4) Uche I.O., Adenuga I.J. and Iwuagwu, S.L. (2003) **Count-Down to WASSCE/SSCE, NECO, JME Chemistry** Evans Brothers (Nigeria Publishers) Limited.

Bajah et al's (2002) **Senior Secondary Chemistry** Textbook 1, 2, 3 Longman Nigeria Plc., adopts a more historical flavour to the study of chemistry. The approach adopted in these texts is spiral and conceptual in nature with three manors – periodicity, energy and structure – as core. Furthermore, an experimental approach with guided discovery was adopted in conformity with WAEC's expressed desire that practical work should be a basis of teaching the course. The tune adopted in the texts is set at the introduction.

> *"Chemistry is a branch of science which deals with the study of the structure and composition of matter"*
>
> *"Two developments marked the beginning of chemistry as a science. The first development was the discovery and explanation of the true nature of combustion in 1744 by a French Chemist, Antoine Lavoisier. The second was the discovery of oxygen in 1744 by an English Chemist, Joseph Priestly".*

Eight chapters in these series (Books 1, 2, 3) are with some history of (chemistry) science. Topics and concepts in which History of science were presented in texts were as follows:

TABLE 2

Topics and Concepts in which History of Science were Presented in Chemistry Texts

S/N	***Topics***	***Concepts***	***History of Science Presented in Chemistry Text***
1	Separation Techniques	Column Chromatography	Russian botanist, Michael Tswett first used chromatography in 1906 to separate the constituents of the greenish colouration of a leaf.
2	Particulate nature of matter	Nature of matter	Different ideas about the nature of matter as put forward by Greek philosophers: Anaxagoras, Leucippus, and Democritus
		The concept of atoms and molecules	Greek philosophers: Anaxagoras, Leucippus, and Democritus
		Dalton's atomic theory	Historical work of John Dalton, (1766 – 1844)

		Constituents of the atom	Historical work of Henri Becquerel (18996) J.J. Thomjpson (1897) R.A. Milikan and Harvey Fletcher (1913) Lord Rutherford (1896) and Geiger and Marsden
		Atomic Number	Rutherford's experiments and historical work of British physicist Henry Moseley (1914)
3	Symbols, formulae and equations	-	Historical work of Swedish scientist Berzelius and Dalton
4	Gaseous state and gas laws	The kinetic theory (Brownian movement)	Observations of Scottish botanist Robert Brown (1827)
		Boyles law	Historical work of Robert Boyle (1662)
		Charles laws	Historical work of French Physicist Jacques Charles (1787)
		Diffusion of Gases	Work of Thomas Graham (1833)
		Avogadro's laws	Work of Italian professor Amedo Avogadro (1811) and opposition of Avogadro's contemporaries
5	Chemical periodicity	Historical development of the periodic table	Initial attempt by Lavoisier (1787) and subsequent work by john Dalton (1807) Berzelius (1828) and Dobereiner (1827)
6	Electro chemistry	Faraday's laws of electolysis	Work of Michael Faraday (1791 – 1867)
7	Orbitals and electronic structure of the atom	Electronic structure of the atom	Historical work of John Dalton (1808); Rutherford (1911)
		The nature of light	Work of Scottish physicist James Clerk Maxwell (1864); and the work of Germany physicist Max Planck
		Rutherford's model of the atom	Work of Neils Bohr (1913)
8	Nuclear chemistry	Evidence of the atomic nucleus	Work of Crookes (1886); Goldstein and J.J. Thompson (1899)
		Rutherford classic experiment	Work of professor Rutherford (1911)
		Radioactivity	Work of Rutherford; a Discovery X-ray by Withelm Rontgen (1875) Discovery of radioactivity by Henri Becquerel (1896)

PHYSICS

General Features of the Physics Curriculum

The aims of Physics curriculum were listed as:

1. *To provide basic –literacy in Physics for functional living in the society*

2. *To acquire basic concepts and principles of Physics as a preparation for further studies.*
3. *To acquire essential scientific skills and attitudes as a preparation for the technological application of physics.*
4. *To stimulate and enhance creativity. (NERDC 1985 p.ii).*

In order to achieve the aims of the Physics curriculum at the Senior Secondary School level, the guided-discovery method of teaching has been recommended. Teachers are strongly encouraged to employ the student-activity based and inquiry oriented mode of teaching… Ample opportunity for laboratory activities and discussion has therefore been provided in every unity of the course. To stimulate creativity and develop kills in students, opportunity is also provided for the construction of workable devices in appropriate unit of the content (NERDC 1985 p.ii).

Textbooks Commonly Used

1. Ndupu, BNL, Okeke PN and Ladipo, OA (1987) **Senior Secondary Physics** Books 1, 2 & 3 Longman, Nigeria Plc, Lagos.
2. Okeke , Okeke PN and Ladipo, OA (1989) **Fundamental of Physics for Senior Secondary Schools** Longman, Nigeria Plc, Lagos.
3. Anyakoha M.W. (2000) **New School Physics for Senior Secondary Schools (SS1 – SS3)** Africana Fep Publishers Ltd.

Most of the physics texts did not pay attention to the history of science. M. Anyakola M.W. (2000) ***New Physics for Senior Secondary Schools (SS1 – SS3)*** Africana fep Publishers Limited mentioned aspects of the history of science in only three topics; models of the atom, radioactivity and energy quantization.

TABLE 3

Topics and Concepts in Which History of Science were Presented – Physics Texts

S/N	***Topics***	***Concepts***	***History Of Science Presented In Physics Texts***
1	Models Of The Atom	Various Models Of The Atom	Work of John Dalton (1766 – 1844), Willian Crookes (1895), Henry Becquerel (1895), J.J Thompson ( ), Ernest Rutherford, Niels Bohr (1913)
2	Nucleus, Radioactivity Nuclear Reactions	Radioactivity	Work Of British Physicist Ernest Rutherford; Marie Curie And Pierre Curie
		Nuclear Energy	Enrico Ferml (1934)
3	Energy Quantization	Atomic Energy	Work Of Max Planck 1902

BIOLOGY

General features of the Biology Curriculum

Textbooks Commonly Used

1. Idodo – Umeh (1996) **College Biology** Idodo-Umeh Publishers Ltd., Benin City. Nigeria.
2. Sarojini T. Ramlingan (1992) **Modern Biology for Senior Secondary Science Series** (New Edition), Africana Fep Publishers Ltd. Onitsha, Nigeria.

3. Eluwa, MC, Soyibo K.O. Famembola E.A and Ohazurike N.C. (1991) **Countdown to WASSCE/SSCE NECO, JME Biology** Evans Brothers (Nigeria Publishers) Ltd. Ibadan.
4. Stone R.H., Cozens A. B. and NDU F. O. C. (2001) **New Biology for Senior Secondary Schools,** Longman Nigeria, Lagos.

None of the above texts had any materials in the History of Science.

How Science Was Taught Using These Textbooks

Because a major concern of the NSSSC is to improve the quality of science teaching, we examined the translation of the NSSSC into actual classroom setting.

CLASSROOM OBSERVATIONS:

Chemistry: Teacher 'BZ' teaches Atoms and Molecules to Senior Secondary Class1

LESSON

As an introduction Mrs. BZ asked the students to give the names of four different elements. (Many of the students raised their hands and gave spontaneous responses (air, gold, hydrogen e.t.c.)

A chart showing the structure of an atom, and pieces of different materials was displayed on the blackboard.

She then explains to the students that the idea of atom was first initiated by ancient Greeks. Greek philosophers like Thales described the smallest invisible particles as atoms. The actual existence of atoms was established in the 19^{th} century by English chemist John Dalton who used his theory to describe the nature of the atom. (Teacher goes on to explain atoms, molecules and ions (following the textbook definitions, students take notes written on the board).

Atom: is the smallest particle of an element, which can take part in a chemical reaction. It is the smallest part of an element that can ever exist and still possess the chemical properties of that element.

The teacher asks the students to pick out pieces of paper and split it to as far as they could. He referred to the smallest indivisible element (piece of paper) as atom.

Molecules: Some atoms cannot exist alone. They join up with others to form a molecule. A molecule is the smallest particle of a substance that can normally exist alone and still retain the chemical properties of that substances, be it an element or a compound. The number of atoms in each molecule of an element is called the atomicity of the element. Most gaseous compounds are diatomic i.e contains two atoms e.g. 0_2 Cl_2 e.t.c. Some are polyatomic i.e contains more than two atoms e.g. P_3 e.t.c.

Ions: Some substances are made up of charged particles. These are called ions. When positively charged, its called CATIONS and negatively charged its called ANIONS. An ionic substance must be electrically neutral i.e containing same number of positive and negative charge. An ion therefore can be seen as any atom or group of atoms, which possess an electric charge.

Teacher reminds the students that Dalton used his theory to describe the nature of atom and give the summary as follows: (in form of notes on the blackboard)

1) All elements are made up of small, indivisible particles called atoms.
2) Atoms can neither be created nor destroyed.
3) Atoms of the same elements are alike in every aspect, and differ from atoms of al other elements.
4) When atoms combine with other atoms, they do so in simple ratios.
5) All chemical changes result from the combination or the separation of atoms.

Teacher explains that although Dalton's theory has undergone modifications, the principal aspects as still useful. Teacher writes and explains the notes on the chalkboard (following the textbook descriptions and explanations).

Atomic Structure: From Dalton's description, atom is made up of small *invisible* particles. In 1911, Rutherford's discovery and other development broadens the idea on the nature of atom. This reveals that atom is made up of number of particles. The most important are PROTON, NEUTRON and ELECTRON. *Proton:* This is a positively charged particle found in the nucleus of an atom. It has a mass of 1. *Electron:* Is a negatively charged particle revolving round the nucleus. It has a negligible mass. *Neutron:* Has no charge found at the middle of the atom. Has a mass of 1.

Evaluation: The teacher ask the students to state Daltons Atomic theory; and asks students to draw and label the structure of Na, Li, Argon, 0_2

PHYSICS

Teacher 'AZ' teaches The Concept of Motion, to Senior Secondary Class1

Lesson: Teacher AZ begins the lesson by defining motion, explains the concept of motion; and types of motion.

THE CONCEPTS OF MOTION

When we take a look at our surroundings, we observe that the earth is never still. The wind blows, the rain falls. Even when we sit still, we are actually moving. Remember we are on earth, and the earth it self is always rotating on its axis, revolving in its path round the sun. as a matter of fact, nothing on earth can be at absolute rest. Motion itself is the change of position of a body and it depends on time.

There are four basic types of motion namely: Oscillatory, Rotational, Random and Translational motions. *(Teacher writes notes on the blackboard for studies to copy.)*

1. *Oscillatory Motion:* When an object repeats into movements within a fixed point, we say the object is oscillating. Oscillatory motion can also be said to be a to and fro movement about a fixed point. Examples include the motion of pendulum and the motion of a balance wheel of a writs watch.

2. *Rotational/Circular Motion:* This is a motion that describes a circle or it is a motion in a circle about a center of axis. Examples include the motion of a rotating fan, motion of the earth round the sun,

3. *Random Motion:* This is a disorderly motion with no pattern: it is a zig-zag motion. Example includes, the motion of a butterfly in flight, and the motion of gaseous molecules.

4. *Translational/Rectivlinear Motion:* This is a motion in which, every part of an object moves in the same direction. Also, when a body moves from a point A along the line AB to another point B, we say that the body has translated from A to B, and the motion performed is known as translational motion. Your motion from the school gate to class is an example of translational motion.

Period 2 Topic: Relative motion; causes of motion and types of force

The students listen attentively to teacher's explanations, and take notes questions. Teacher begins the lesson by explaining the concept of relative motion using everyday examples.

Relative Motion: It is a fact of everyday experience that object on the earth appear to be in a continuous state of motion, considered in relation to the motion of another pedestrians move relative to buildings, vehicles move in various direction in the street. The actual motion of quite most objects is quite complicated. Relative motion is motion considered in relation to another.

Causes of Motion: When the leaves of a tree moves this is usually due to the wind. If one keeps an item outdoor one expects it to remain there, unless it is pushed or pulled. According to Sir Isaac Newton, an English scientist, in his first law of motion, a body will continue in it state of rest or uniform motion in a straight line, unless it is acted in by a force. Hence, the cause of motion is force.

Force is that which changes a body state of rest or of uniform motion in a straight line; the unit of force is Newton.

Types of Force: There are two types of forces contact force and force field.

Contact Force: This is the force, which acts between two surfaces in contact. It includes tension forces in strings and wires, pushing and pulling, frictional forces and reaction forces.
Fig. (i) below shows a block of weight W, counter-balanced by the reaction of force R of the table, while the pulling force is opposed by the frictional force acting between the table surface and the block.

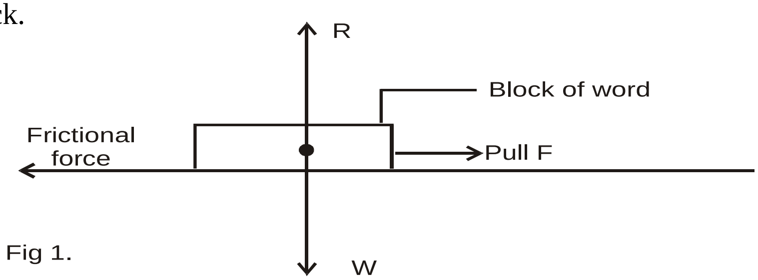

Fig 1.

Force Field: This is the space in which a force is experience. This type of force does not require contact with the body on which it acts. Examples of force field include: gravitational, electrostatic and magnetic forces.

Conclusion: At the end of the lesson, students were asked to read an assigned text.

BIOLOGY

Teacher 'ZZ' teaches the Basic Ecological Concepts to SS1

Lesson:
Objectives: At the end of the lesson students are expected to be able to:

1. Name components of any ecosystem
2. Measure or estimate sizes of some ecosystem

The teacher begins by explaining that the part of the world where life exists is called the biosphere. It is very extensive area; therefore, it has to be divided into smaller units for the purpose of effective studies.

The ecosystem is the unit of study of the biosphere. It is extremely variable in size (being perhaps as small as a rotten log, a puddle, a pond; or as large as an area of the savanna forest; a big river, e.g. Ogun, Kaduna, Imo, Cross or lagoon).

Each ecosystem is characterized by a well-defined soil vegetation, animals and climate. The energy absorbed from the sunlight by the green plant flows through the ecosystem. This energy is made available to other organisms that are not capable of producing their own food. Thus there is a 'nutritional chain' consisting of a series of organisms where one serves as food for the next.

An ecosystem constitutes a complex of elements, which in natural conditions, possesses a certain balance. Man is the most important animal in the ecosystem because of his cultural evolution. As man becomes integrated into the environment, he transforms it through science and technology. Man thus possesses a reasonable control over the structure and functioning of the ecosystem.

The functioning of an ecosystem involves a series of cycles, e.g. water cycle and mineral cycles period, i.e., nitrogen, carbon cycles, etc., linked with solar radiations. Man, like other animals, is a consumer of energy. He is thus integrated into the energy cycle and becomes a consumption factor. Human population increase is a very important factor in the ecosystem. The components of the ecosystem are abiotic (non-living) eg water, soil, air, rotten log etc and Biotic (living) eg plants animals. The sizes of an ecosystem vary and the changes in an ecosystem may depend on the size.

The teacher takes students out to observe the following items:

1. a rotten log
2. a puddle and a pond
3. a stream and a river
4. a bush

Teacher asks students to complete the chart showing some properties of ecosystems.

Name of ecosystem	Names of living things		Name of non-living things
	Plants	Animals	
Rotten log	Toadstool	Centipedes	Log

The teacher explains to students how ecosystems are studied. Direct measurements of area and depth may be necessary in the case of Microsystems. Tape measures, and a weight tied to a string may be useful for measuring depth. Insect nets may be useful for collecting some living things either on land or in ponds and streams for identification. Hand lenses may be used to identify some small organisms. Jars, containers and preservatives like alcohol or formaldehyde (methanol) may be found useful.

EVALUATION
At the end of the lesson, teacher asks the students.

1. To look for examples of the ecosystem studied in class
2. To suggest factors that can change them eg the effect of drought on puddle and ponds, decay on rotten log and bush etc
3. To relate the size of the ecosystem to the changing effects of the factors

.

Observations and Findings

The following observations were based on the day-to-day classroom lessons and interviews with teachers and students in the two schools studied.

HOW SCIENCE WAS TAUGHT USING THE TEXTBOOKS

The textbooks played a dominant role in the way science was taught. The teachers simply followed the textbooks. Note taking from the board was the major teaching strategy used by teachers. From interviews with teachers, the main aim of teaching science was to help the students learn what is written in the textbooks. They saw the main aim of their teaching as giving students a good understanding of the major concepts in each subject matter in the textbook. When teachers were asked why they adopted the traditional pattern of teaching they responded that students did better in their examinations when the textbook was strictly followed during classroom teaching. While experiments and demonstrations were mentioned during classroom teaching, actual laboratory experiments were reduced to a minimum and more time was spent memorizing the fundamental concepts and laws presented in the textbooks. The conscientious teachers went through all details of the textbook in the class doing his/her best to help students understand difficult concepts and in periodically, teachers carried out the demonstration and experiments described in the textbooks. Furthermore, the students solved theoretical problems and in chemistry and physics and did experiments in the laboratory. The experiments were aimed mainly at verifying physical laws or measuring characteristic properties of matter.

The students were expected to study at home what they had previously done in the classroom, and usually the teacher spent part of the next lesson in confirming that they had understood what they had read.

PHILOSOPHY AND HISTORICAL MATERIALS IN TEXT

The textbooks commonly used in the NSSSP were well-written but simplified. They suppress many historical facts, particularly those that are deemed to 'confuse the issue'. They set out current theories as if these were the final truth. And one way or another they always enhance the myth that science is constantly progressing and constantly overcoming the weaknesses and failure of earlier generations.

Science textbooks never revealed the fact that older theories (Dalton's Atomic Theory) often contradict current views. Instead they incorrectly describe these earlier theories as simpler and more specialized versions of modern ones. For example, during chemistry lessons, accepted older theories (Dalton's Atomic Theory) were said to be consistent with current theories even when this is not the case. Thus, they directly foster the belief that it is impossible for a scientific theory to be false, and indirectly foster the belief that true scientists are pretty well infallible.

Suggestions for Policy and Practice

The following suggestions were made in the light of the above observations:

First, the NSSSP has no teacher texts. In teaching the philosophy and history of science in secondary schools, there should be teacher texts, specially written for teachers. Teacher texts could offer helpful suggestions on the method of presentation, experimental activities to be taught, and the philosophy and history of science depicted in the topics. The teacher should study them. In addition to such teacher texts, there should also be other helpful sources of information. The teacher should at least posses some of these in his personal library or else should see that they are procured for the school library.

Secondly, the philosophy and history of science should be integrated into the overall secondary school science project. Thus, the philosophy and history of science should not just be confined to physics, chemistry and biology but all of these well integrated with the philosophy and history of science. The teacher education programmes in the teacher training colleges must prepare teachers to be able to teach philosophy and history of science in an integrated form effectively.

Thirdly, apart from the formal teaching of the philosophy and history of science, there is also the informal approach. One immediate value of this approach is that it takes science out of the classroom. One way of getting about this is via the school science clubs, whose activities could include lectures. Film shows, excursions, science, fairs and science competitions. This will make the philosophy and history of science fun and part of the ordinary life of the school. It also allows for the widest active participation of the students population who study science and may never become scientists.

Conclusion: Lessons from the Project

There are a number of lessons that can be learnt from NSSSP. The first is that there is no curriculum that is "teacher proof". Thus the teacher is the key to effective teaching the philosophy and history of science. The curriculum designers, and textbook writers can conceive and produce science instructional materials, which should enable learners to achieve almost any goals. However, when placed in the hands of teachers, the materials all too frequently get used in ways and towards achieving objectives other than those, which the designers in tended. Since the introduction of new science programmes undoubtedly will be accomplished by sets of instructional materials, it is important to anticipate those problems that teachers may have in using the materials, in the spirit of and to end for which they are conceived and developed.

Secondly, textbooks are a vital part of any curriculum. In the meantime, the textbooks for the NSSSP still need to be re-written to reflect the philosophy and history of science. But this is not the only problem. The evaluation and modification of the materials, the assembly and distribution of apparatus, the involvement of colleges of education and the salaries and in-service training of teachers are all essential elements of the whole programme. Attention must be paid to all of them if a really significant breakthrough is to be achieved in the teaching of philosophy and history of science in the secondary school. Nevertheless, the enthusiastic reception of the secondary project and the interest displayed in the NSSSP leads us to believe that a useful start has been made.

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