EJPCE Eurasian Journal of Physics and Chemistry Education

Eurasian J. Phys. Chem. Educ., 3(2):75-83, 2011

journal homepage: http://www.eurasianjournals.com/index.php/ejpce

Evaluation of the Nigerian Physics Curriculum Contents and Physics Textbooks towards the Attainment of the Goals of the History and Philosophy of Science

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Received: 04 March 2010 – Revised: 14 February 2011 – Accepted: 11 March 2011

Abstract

This qualitative study examined the Nigerian Physics Curriculum contents and some purposively selected physics textbooks to ascertain the attainment of the goals of the History and Philosophy of Science (HPS). Content analysis of both the National Physics Curriculum and selected Physics textbooks was carried out. Only 17.4% of the topics in the curriculum contained issues concerned with HPS key among which is the models of the atom. Only one textbook out of five reviewed dealt measurably well with the HPS topics as contained in the curriculum. The students and teachers most preferred physics textbook has almost nothing in it to justify its attainment of HPS goals, while the rest of the physics textbooks dealt with HPS matters implicitly. The implication of these results is discussed.

Keywords: Physics Curriculum; Physics Textbooks; History and Philosophy of Science; Nature of Science; Science/Physics Instruction

Introduction

All over the world, efforts are being made not only to increase enrolment of students in science and improve performance, but also to find ways of providing scientific literacy and the teaching of the attitudes and skills of scientists to even non-science students (Shahn, 1988; Duschi, 1990; Roach & Wandersee, 1993; Khisfe & Lederman, 2006). This is because of the obvious gains that will accrue to a society which has been made to appreciate science as a basic element of the human culture. Some snags have however been observed towards the attainment of these lofty ideals. The first problem is that there are a few projects and curriculum materials geared towards achieving these propositions within the classroom instruction (Ray, 1991; Bybee, Powell, Ellis, Parisi & Singleton, 1991). Another major obstacle is that the science teachers themselves do not understand the nature of science (NOS) and so may not be able to teach what they neither have nor understand (Roach & Wandersee, 1993; Lederman, Wade & Bell, 1998). Furthermore, it has been observed by some experts that the present science textbooks have either misrepresented or only reported selected

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ISSN: 1306-3049,

intellectual products of science but failed to reveal the stories of quest for knowledge in the natural sciences as well as the historical trails of such inquiry (McComoas, Clough & Almazora, 1998; Akerson & Volrich, 2006). This view is supported by Rutherford (2005) who stated that science is a grand human adventure but one may not discern this from reading science textbooks. Rutherford believes that 'every science discipline has stories to tell, ideas to explore and understand, advances and disappointments to confront, applications to astound or worry about, mysteries solved and new mysteries created'. This is not what we see in our science textbooks. The result is over simplification and what Schwab & Brandwein (1962) call "rhetoric conclusion" in science. A glaring consequence here is that knowledge construction in science is hampered because some vital procedure and information necessary for doing so are totally lacking.

It is against this backdrop that some experts (Rutherford, 2005; Khisfe & Lederman, 2006) have suggested that not only should we teach science knowledge; but also how science works using appropriate tools. They contend that we must emphasize the kind of insight, imaginative processes and intuition used by such scientists like Galileo and Einstein to make breakthrough in science as well as make students aware of the cultural and political temperaments of their time. This will make students in turn to appreciate science as an integral part of society and heighten their interest thereby. Thus a 'holistic' approach to science education which incorporates systematically the 'History and Philosophy of Science' (HPS) into the curriculum, classroom instruction and science textbooks is presumed to produce far greater positive impacts on learners and society at large as well as reflect the true nature of science (Mathews, 1994; Allchin, 1995; Monk & Ogborn, 1997; Rutherford, 2005). Experts such as Justi & Gilbert (2000) further believe that if students understand how scientific knowledge is developed and how historical, philosophical and technological contexts influence its development, they will acquire a more comprehensive view of science and consequently become more engaged in learning science.

There is no agreement among experts on the definition of nature of science (NOS). For instance, Khisfe & Lederman (2006) and Roach & Wandersee (1995) have defined NOS in a manner that emphasizes the nature of the individual disciplines within science contending that these have somewhat different strategies for solving varied domain specific problems. The idea is for us to treat the HPS of Physics, Chemistry, and Biology as individual subjects in agreement with non integrative conception (Durkee, 1974, Lederman & Abd-El-Khalick, 1998). Furthermore, Lederman (1992) views NOS from epistemological perspective as a way of knowing or the values and beliefs inherent in the development of scientific knowledge. However, the National Science Teachers Association (NSTA, 2000) articulated views on NOS and recommended that science knowledge should go along with its methods, explanations and generalizations which should form the core of science instruction vis-a-vis science curriculum.

There is therefore a substantial mass of reason for the inclusion and teaching of the nature of science through HPS either in the individual or integrated forms of the subjects in our educational programmes. But the critical question is how can this be achieved? A few strategies have been suggested and used elsewhere for instructional framework. These are based upon stories of scientists and of historical events in science. They include among others:

Strategy I: Replication of classical experiments. This strategy is said to be particularly common in physics (Seroglon, Koumaras & Tselfes, 1998; Lawrenz & Kipris, 1990).

Strategy II: Using examples from history to illustrate the role of theories as a basis for explanations and exploration (Rudolph & Stewart, 1998; Scharmann & Harris, 1992).

Strategy III: Use of historical vignettes which attempt to provoke students into critically re-examining their ideas about the nature of scientific knowledge (Roach & Wandersee, 1995; Chan, 1999; 2005).

Strategy IV: Use of historical models and modeling (Justi & Gilbert, 2000).

Strategy V: Use of explicit/implicit approaches which envisage that NOS should be cognitive learning outcome planned for explicitly or anticipated automatically from studying science (Abd-El-Khalid & Lederman, 2000; Khisfe & Abd-El-Khalick, 2002; Parker et al, 2008).

The basis for these suggested strategies is an inclusion of NOS and HPS contents in the curriculum that will not necessarily jeopardize the teacher's desire to cover more content given the limited time available for instruction (Chan, 2005).

Justi & Gilbert (2000) had gone a step further to enumerate some six reasons for the inclusion of 'models and modeling' as one way of integrating HPS in science curriculum as follows:

- models are suitable basis for HPS in science education;
- historical models can be characterized;
- school curricular do not refer clearly to historical models;
- textbooks do not make use of appropriate models;
- a finite number of models exist; and
- hybrid models are used in teaching.

It is therefore the opinion of these researchers that time is ripe for Nigerian Science educators to make frantic efforts towards a systematic inclusion of the nature of science (through HPS) into our secondary school science curriculum and instruction. To do otherwise will make our science education endeavors irrelevant in the scheme of things. The secondary school is suggested as a starting point because it reflects a very partisan and nationalistic framework for developing the mind of our children (Brown, Lindsay & Brush, 1972). This study is significant in line with the current reform efforts of the Nigerian government in the educational sector. The opportunity would serve to correct/review content areas of the National curriculum found to be at variance with current trends and practices in Science education in other parts of the world. Against this background, it is being proposed that a critical examination of the present physics curriculum contents (FME, 1985) be carried out to determine how much of HPS content is present, so as to compare and contrast this with what is available in physics textbooks used for instructional purposes in our secondary schools. This will reveal the plans put in place and the steps being taken by authors towards the attainment of the HPS goals in physics at the secondary education level.

Statement of the Problem

Curriculum is a document which states clearly the knowledge, skills, activities and instructional materials as well as expected learning outcomes in a subject. Textbooks are veritable instructional materials necessary for implementation of curriculum. Nigeria's educational system is currently undergoing reform which should include her curriculum last reviewed 25 years ago. This study therefore evaluated the Nigerian national physics curriculum with respect to its contents on NOS and HPS; and related this to what is found in physics textbooks. This was done with the aim to discover whether they are adequate to enable physics teachers implement them through classroom instruction.

Research Questions

In view of the above background to the problem, the following research questions are raised:

(1) What are the specifications (topics, concepts, content, and activities) of HPS in the Nigerian physics curriculum and their adequacy?
(2) What is the most frequently specified and used strategy of HPS in the Nigerian physics curriculum and textbooks?
(3) What is the average number/percentage of HPS related topics/contents in the curriculum?
(4) In what context(s) are the HPS related content used in the textbooks?
(5) Is the use of the HPS in Nigerian physics textbooks adequate?

Methodology

The study adopted the qualitative and content analysis research designs. The major documents reviewed include the:

i) National curriculum for Senior Secondary School for physics (FME, 1985)
ii) Purposively selected physics textbooks.

A total of five physics textbooks which met the following criteria were selected and reviewed:

- recommended by the exam bodies like WAEC, NECO and NABTEB;
- written to address topics outlined in the curriculum; and
- written for the purpose of classroom instruction and not examination preparatory question and answer textbook.

Table 1. Table of HPS related content contained in the national physics curriculum

S/N	Curriculum topic identified	Page Number	Hps content/activity specified	Types of Strategy specified/ inferred
1	Particle nature of matter	112	Use models to illustrate the 3 states of matter	I
2	Waveform– Mathematical and Graphical Representation	126	Draw graphical representations of transverse and longitudinal waves.	IV
3	Light waves	128	Demonstrate mechanical analogue of polarization and use of Polaroid	IV
4	Molecular Theory of matter	133	Use models to establish the fundamental assumptions of molecular theory of matter	IV
5	Magnetic field	137	Describe the working principles of a bell and a telephone earpieces	Not clearly stated
6	Energy quantization	141	Describe X-ray Production	Hybrid experiment IV
7	Energy quantization	141	Discuss Frank-Hertz experiment	Not clearly stated
8	Models of the atom- Thompson, Rutherford, Bohr, electron cloud model. Limitation of various models.	140	i) Discuss the historical events that led to the modern concept of the atom ii) Discuss the scattering experiment and its analogue	I & IV

Two types of data-quantitative and qualitative were obtained in two parts. In the first part, the numbers of topics outlined in the curriculum were determined using simple frequency counts. The qualitative data here involved listing of the topics which were HPS related. These were later counted to determine the number of NOS/HPS related topics specified. The second part of data was obtained from the five physics textbooks selected. The books were reviewed to determine which HPS content related topics were treated and the strategies (as already discussed in strategies I to V) adopted in so doing. The contexts in which they are used were equally examined. Tables 1 and 2 respectively show data obtained from the curriculum and textbooks reviewed.

Table 2: Table of Physics Textbooks Reviewed

Textbook	Title of textbook	name (s) of author	Publisher & year	Evidence of use of model and hps found
A	Senior secondary Physics	Okeke, P.N. & Anyakoha, M.W.	Macmillan Educational PLC (1994)	Not adequate only in waves the mechanical analogue of polarization
B	Principles of Physics (Nigerian Edition)	Nelkon, M.	Heinemann Educational (Nig) Plc (1986).	Consistently used implicit classical experiments replicated and historical accounts. Did not use models
C	Nigerian Secondary Schools Science Project (Physics) Book 1, 2 & 3	CESAC	Heinemann Educational (Nig) PLC (1980).	Used models and narrated historical antecedents culminating into each model in quanta.
D	Senior Secondary Physics Book 1, 2 & 3	Ndupu, B.N.L., Okeke P.N. & Ladipo, O.A.	Longman Nigeria Plc, (2000)	Used multiple models sparingly and inexplicitly. No historical accounts were given.
E	STAN Physics for Senior Secondary Schools	STAN	Heinemann Educational (Nig) Plc (1993).	Gives only an inexplicit description of models of the atom and no historical accounts were given.

Results

A total of 46 topics were outlined in the curriculum. Only 8 topics (17.4%) were identified as having a leaning towards HPS. Of this number, about 6 topics (75%) of HPS related topics specified in the curriculum have clear statements about activities and strategies to be adopted to achieve the HPS content. The rest 2 topics (25%) were unclear in statement of what a curriculum implementer must do to achieve the HPS goals.

Further results from textbooks analyzed indicate that one out of the five books (20%) reviewed could be said to have systematically made use of HPS on some of the major topics specified in the curriculum which have contents geared towards the nature of science through HPS. The rest four (80%) of the physics textbooks discussed very few HPS issues and quite implicitly in a way that the goals cannot be attained.

Discussion

The results of this study showed that there is evidence of HPS related topics in the Nigerian Physics curriculum geared towards the nature of science. However, these efforts are considered inadequate and lop-sided as they do not touch on some of the fundamental concepts in physics. What was found is however good starting point for implementing NOS/HPS in the Nigerian senior secondary school classroom physics instruction? The study equally showed that the most frequently specified strategy inferred from the curriculum is the historical model as proposed by Justi & Gilbert, (2000) and were devoid of strategies suggested by Scharmann, Smith, James & Jensen (2005); Khisfe & Lederman (2006); Akerson & Volrich (2006). This was stated in very clear terms for the concept of quanta. There was evidence that most of the textbooks A, B, C, D and E described one type of model or another but failed to explain the meaning, use and importance of model probably because the curriculum itself failed to specify these too.

Textbook A did not give any historical account of past events in science nor was there a mention of the word model. However, it made use of the idea of modeling in describing polarization of waves as shown on page 58 of the textbook. This has serious implication for this study granted that this seems to be the most preferred physics textbooks in most Nigerian Senior Secondary schools. It leaves most students who rely on this textbook for their study of physics with no knowledge of HPS.

In textbook B, no mention of the word model was recorded. However, there are instances showing the use of history to illustrate the role of theories and replication of classical experiments in hybrid forms. This approach was consistent in the book as a bit of historical background was given at the beginning of most chapters though the necessary instructional implications were not necessarily made.

Textbook C (Book 3) devoted pages 39-58 to the topic of models of the atom. Here, a good historical account of the atom was given in addition to a narration of the historical antecedents culminating into the various models of the atom discussed in the textbook. According to Justi & Gilbert (2000), HPS regards this as very important as it helps students to understand the process of evolution of science, its laws, theories and truth; and to know that the limitations observed at one time or the other occur as more facts emerge from most recent observations and experiments as the tools and instruments of study of science are made better. The textbook also embedded the greatest slice of historical account into various chapters on different topics in order to buttress the point of the nature of science. In spite of the fact, this was often done in a subtle and sometimes unclear manner. Examples of these can be seen in Book 1, chapter 6, page 31 and Book 2, chapter 5, page 93.

Textbook D used modeling approach, for example in Book 2, pages 141 to 149, to describe the concepts of wave and mechanical analogue of polarization. In its treatment of some models of the atom, no attempt was made to explain why one model is given up for the other. This approach was found to be a common feature throughout the book. For example, in describing the kinetic/molecular theory (page 235), no attempt was made by the book to explain the basis for the assumptions made in elucidating the theory. It equally gave only an abridge account of the models of the atom. These approaches are considered inimical to the ideals of the inclusion of HPS in the physics curriculum.

Textbook E, like textbooks A, C and D described some models of the atoms but this was equally abridged. However, an implicit use of analogical and historical model approach is found on pages 195 and 207 of the book.

Conclusion

From the foregoing account, it can be concluded that there is evidence of efforts made towards the inclusion and attainment of HPS content in the Nigerian physics curriculum without very clear specification of how to achieve these goals. Also, the most frequently adopted strategy in physics textbooks is the historical model and analogue strategy (Strategy IV), though textbooks B, D, and E have used this in very unclear ways. Textbook C contained the greatest amount of NOS/HPS content for instructional purposes.

In addition, the percentage of HPS topics specified in the curriculum and treated in physics textbooks is considered grossly inadequate. Both the use of the HPS contents and context of their use are inadequate. Therefore, it is suggested that a systematic programme built around historical model, analogue strategy, classical experiments and Vignettes be developed and implemented for the attainment of the aims and goals of HPS in elucidating the nature of science starting from our secondary schools. The starting point of this suggestion is the curriculum and textbooks of physics and other science subjects such as chemistry and biology.

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