ANALYSIS OF SCIENCE PROCESS SKILLS IN WEST AFRICAN SENIOR SECONDARY SCHOOL CERTIFICATE PHYSICS PRACTICAL EXAMINATIONS IN NIGERIA

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Abstract. This study analyzes the science process skills in West African senior secondary school certificate physics practical examinations in Nigeria for a period of 10 years (1998-2007). Ex-post facto design was adopted for the study. The 5 prominent science process skills identified out of the 15 used in the study are: manipulating (17%), calculating (14%), recording (14%), observing (12%) and communicating (11%). The results also show high percentage rate of basic (lower order) science process skills (63%) as compared to the integrated (higher order) science process skills (37%). The results also indicate that the number of basic process skills is significantly higher than the integrated process skills in the West African senior secondary school certificate physics practical examinations in Nigeria. It is recommended that the examination bodies in Nigeria should include more integrated science process skills into the senior secondary school physics practical examinations so as to enable the students to be prone to creativity, problem solv-

ing, reflective thinking, originality and invention which are vital ingredients for science and technological development of any nation.

Keywords: physics, senior secondary school, science process skills, Nigeria

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Introduction

The shift from the teacher-centred method of teaching science to child-centred activity based method which encourages and develops in the child the spirit of inquiry; an attempt to make students fully aware as well as understand the ways scientists work; and also the equipping and preparing students for their possible careers in science and technology led to the development of process skills (Akinbobola, 2006). It is worth noting that for science teaching to be meaningful and relevant, it must adequately reflect the nature of science. That is, it must not only be process-oriented, but it should also emphasize the products of science. It should also promote affective reaction to science and stress the attitudes such as honesty, open and critical mindedness, curiosity, suspended judgment and humility which characterize scientists and the scientific enterprise (Akinbobola & Ado, 2007).

Science process skills have been described as mental and physical abilities and competencies which serve as tools needed for the effective study of science and technology as well as problem solving, individual and societal development (Nwosu & Okeke, 1995). The American Association for the Advancement of Science (AAAS) classified the science process skills into fifteen (Bybee et al., 1989). These are: observing, measuring, classifying, communicating, predicting, inferring, using number, using space/time relationship, questioning, controlling variables, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data. According to Ango (1992), science process skills can be classified into two categories as basic and integrated process skills. The basic (simpler) process skills provide a

foundation for learning the integrated (more complex) skills. Basic science processes are vital for science learning and concept formation at the primary and junior secondary school levels. More difficult and integrated science process skills are more appropriate at the secondary and tertiary school levels for the formation of models, experimenting and inferencing. Hence both basic and integrated science process skills are relevant and appropriate at the senior secondary schools level in Nigeria.

According to Bybee et al. (1989) and Ango (1992), the basic science process skills comprised of observing, measuring, classifying, communicating, inferring, using number, using space/time relationship and questioning while integrated science process skills are controlling and manipulating variable, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data.

Physics practical skills are science process skills. They are taught as part and parcel of the physics curriculum. Science process skills are cognitive and psychomotor skills employed in problem solving. They are the skills which sciences use in problem-identification, objective inquiry, data gathering, transformation, interpretation and communication. Science process skills can be acquired and developed through training such as are involved in science practical activities. They are the aspect of science learning which is retained after cognitive knowledge has been forgotten. Using science process skills is an important indicator of transfer of knowledge which is necessary for problem-solving and functional living.

The skills on the graph practical work cannot be completed without creativity. Practical work is not just putting the apparatus together when seen, but it needs planning, designing a problem, creating a new approach and procedure and also putting familiar things together in the new arrangement. This implies that the knowledge of creativity exhibited by candidates in any practical class helps them to manipulate some practical equipment.

According to Giddings & Fraser (1988), achieving the objectives of science practical work depend a lot on the mode of assessment of laboratory work adopted by the teachers and examination bodies. According to them, the mode of assessment directly influences teachers' teaching methods, students' learning styles and attitudes towards practical activities.

The West African Examinations Council (WAEC) makes use of practical test/examination to assess students' acquisition of various physics practical skills. In these tests, students are required to carry out certain physics practical activities following some given instructions. The scores of the students obtained through the marking of their practical works indirectly indicate the levels of physics practical process skills they could demonstrate during the practical examination. This mode of assessment is also adopted by physics teachers who prepare the students for Senior Secondary School Certificate Examination (SSSCE). This mode of assessment influences the teaching methods adopted by teachers. Also, students' learning style is influenced in such a way that they always try to find certain correct responses or answers irrespective of the procedures adopted.

The process approach method of teaching science is meant to foster inquiry and manipulative skills in students and discourage rote learning. This method embraces other methods of science teaching and is mainly activity based, superior to those in which the students are not actively involved in learning process (Akinbobola, 2008). This reason has made the West African Examinations Council (WAEC) and bodies that conduct Senior Secondary School Certificate Examination (SSSCE) to stipulate that practical work should form the basis of teaching. During examination, the practical work is also assessed separately. Currently, physics being one of the physical science taught in senior secondary schools is taught both in theory and practical. In both internal and external examinations, practical physics is assessed separately as an integral part of the subject.

The problem

The basic science process skills are useful in science and non-science situation while the integrated skills are the working behavior of the scientists and technologists. Thus, both basic and integrated science process skills are relevant and appropriate for all science subjects, in particular Physics at the senior secondary schools level in Nigeria. Hence, there is need to find out the level of acquisition of the science process skills and also to identify the science process skills inherent in the West African Senior Secondary School Certificate (WASSSC) Physics practical examination in Nigeria and classify them to various hierarchical levels. Therefore, will the relative percentage of integrated process skills included in the West African Senior Secondary School Certificate (WASSSC) Physics practical examinations be adequate to meet the quest for national development *vis-a vis* scientific technology growth and self reliance in Nigeria?

Purpose of the study

The purpose of this study is to determine the science process skills included in the West African Senior Secondary School Certificate (WASSSC) Physics practical examinations in Nigeria for a period of 10 years. The study is design to achieve the following objectives: (1) to investigate the science process skills included in the West African senior secondary school certificate physics practical examinations in Nigeria; (2) to compare the basic and integrated process skills included in the West African senior secondary school certificate physics practical examinations in Nigeria for a period of 10 years

Research questions

The study sought to provide answers to the following questions: i) what are the prominent science process skills in the West African senior secondary school certificate physics practical examinations in Nigeria; ii) what

are the percentages of basic and integrated process skills included in the West African senior secondary school certificate physics practical examination in Nigeria.

Research hypothesis

There is no significant difference between the number of basic and integrated process skills included in the West African senior secondary school certificate physics practical examinations in Nigeria.

Method

The entire May/June WASSSCE Physics practical examination questions from 1997 to 2006 were studied to identify the science process skills required from the students. All the basic and integrated process skills in the questions were identified. The design adopted for the study was an ex-post facto design. The instrument used for the study was the West African Senior Secondary School Certificate Physics Practical Questions (WASSSCPPQ) across the years 1998 to 2007. The WASSSCPPQ had already been validated and the reliability had been conducted and obtained by the West African Examinations Council (WAEC). The researchers collected the entire alternative A of the WASSSCPPQ and identified all the basic and integrated process skills for each year. Due to the nature of the physics practical questions in Nigeria, the researchers identified 15 science process skills and classified them into basic and integrated process skills. The basic science process skills comprised of observing, measuring, comparing, contrasting, drawing calculating, recording and communicating while integrated process skills comprised of experimenting, investigating, formulating models, deducing, graphing, interpreting and manipulating. The data collected were analyzed using simple percentages and t-test.

Results and discussion

Research question 1

What are the prominent science process skills in the West African senior secondary school certificate physics practical examinations in Nigeria? The analysis is as shown in Tables 1 and 2

Table 1. Basic (lower) science process skills in the West African senior secondary school certificate physics practical examinations in Nigeria across the years (1998-2007)

YEAR	Basic (Lower Order) Science Process Skills								
	O	M	C	CO	D	CA	R	COM	TOTAL
1998	5	3	1	0	1	4	5	4	23/5
1999	6	3	0	1	2	3	3	6	24/5
2000	5	2	0	2	0	7	6	4	26/5
2001	6	2	0	0	0	7	5	5	25/5
2002	3	3	0	0	1	3	7	5	22/4
2003	5	1	1	1	3	7	8	5	31/6
2004	8	7	0	0	0	7	11	8	41/8
2005	7	2	0	0	5	13	6	5	38/8
2006	8	3	0	0	5	8	9	7	40/8
2007	7	5	0	0	4	12	8	8	44/9
Total	60/12	31/6	2/0	4/1	21/4	71/14	68/14	57/1	314/63

* Second figures are in percentages

O = Observing, M = Measuring, C = Comparing,
CO = Contrasting, D = Drawing, CA = Calculating,
R = Recording, COM= Communicating

Out of the 500 science process skills identified within the period of 10 years (1998 – 2007) in the West African senior secondary school certificate physics practical examinations in Nigeria as shown in Table 1 and 2, the prominent science process skills are manipulating with a total frequency of 86(17.20%), calculating with a frequency of 71 (14.20%), recording with a frequency of 68 (13.60%), observing with a frequency of 60(12.00%) and communicating with frequency of 57(11.40%). This implies that out of the 15 science process skills used in this study, manipulating skill is the only prominent skills from the integrated (higher order) process skills while calculating,

recording, observing and communicating skills are basic (lower order) science process skills. The implication is that only 5 out of 15 science process skills are prominent within the period of 10 years (1998-2007) in the West African senior secondary school certificate physics practical examinations in Nigeria.

Table 2. Integrated (Higher) process skills in the West African Senior Secondary School certificate physics practical examinations in Nigeria across the years (1998-2007)

YEAR	Integrated (Higher Order) Process Skills							
	M	E	G	D	I	F.M	IN	TOTAL
1998	9	2	3	6	1	0	2	23/5
1999	10	1	3	1	6	1	0	22/4
2000	5	0	3	3	0	0	0	11/2
2001	6	3	3	3	1	0	1	17/3
2002	10	1	3	3	0	0	0	17/3
2003	10	0	3	3	0	1	0	17/3
2004	7	2	3	3	0	0	0	15/3
2005	8	4	3	3	0	0	1	19/4
2006	11	5	3	5	0	0	1	25/5
2007	10	5	3	2	0	0	0	20/4
Total	86/17	23/5	30/6	32/6	8/2	2/0	5/1	186/37

*Second figures are in percentages
M= Manipulating, E = Experimenting, G = Graphing,
D = Deducing, I = Investigating,
F.M = Formulating models, IN = Interpreting

Research question 2

What are the percentages of the basic and integrated science process skills included in the West African senior secondary school certificate physics practical examinations in Nigeria? The analysis is as shown in Table 3.

Table 3. Summary of the basic (lower order) and integrated (higher order) science process skills in the West African senior secondary school certificate physics examinations in Nigeria across the years (1998-2007)

S/N	Basic Process Skills	F(%)	S/N	Integrated Process Skills	F(%)
1.	Observing	60(12%)	1.	Manipulating	86(17%)
2.	Measuring	31(6%)	2.	Experimenting	23(5%)
3.	Comparing	2 (0%)	3.	Graphing	30(6%)
4.	Contrasting	4(1%)	4	Deducing	32(6%)
5	Drawing	21(4%)	5.	Investigating	8(2%)
6	Calculating	71(14%)	6	Formulating Mod-els	2(0%)
7	Recording	68(14%)	7	Interpreting	5(1%)
8	Communicating	57(11%)			
	Total	314(63%)		Total	186(37%)

F= Frequency

The analysis in Table 3 shows that, among the basic (lower order) science process skills identified in this study, calculating was rated highest with the frequency of 71 (14%), seconded by recording with the frequency of 68(14%), followed by observing with the frequency of 60 (12%) and closely followed by communicating with the frequency of 57(11%). Other basic science process skills are rated low. These include drawing with the frequency of 21(4%), contrasting with the frequency of 4(1%), and comparing with a frequency of 2(0%).

The analysis in Table 3 also shows that, among the integrated (higher order) science process skills identified in this study, manipulating was rated highest with the frequency of 86 (17%), seconded by deducing with the frequency of 32 (6%), followed by graphing with the frequency of 30(6%) and experimenting with the frequency of 23(5%). Other integrated science process skills are rated very low. These include investigating with the frequency of 8(2%), interpreting with the frequency of 5(1.00%) and formulating models with the frequency of 2(0%).

From the results presented in Table 3 above, it was observed that there was a high requirement made of the basic science process skills than the integrated science process skills in the West African senior secondary school certificate physics examinations in Nigeria across the years (1998-2007). This is indicated by high percentage rate of the basic science process skills (63%) as compared to the integrated science process skills (37%).

The results presented in Tables 1 and 2 also indicated that there are more science process skills in the last five years (2003-2007) than the first five years (1998-2002). That is, there is a gradual departure from the general pattern observed in the first five years to a pattern where more emphasis is placed on laboratory work or experimenting and critical thinking. This is in line with the national policy on education (FME, 2004), which aims at consolidating the science process skills knowledge gained in the primary schools and junior secondary schools levels.

Similarly, there was steady emphasis in the requirement of the skill of communicating in the last five years (2003-2007). This is in line with the new approach to science teaching and learning which emphasis on communicating science rather then listening to talks and taking down notes (Akinbobola, 2008). Another obvious pattern is the increased emphasis on the skills of manipulating, drawing, calculating and recording in the last five years (2003-2007). This might be due to the fact that in Nigeria, emphasis has been shifted from the teacher-centered approaches to child-centered approaches of learning such as problem-solving, discovery and inquiry methods (Akinbobola, 2006) and to involve the learner in hand-on-activities in order to acquire appropriate skills, abilities and competencies both mental and physical as equipment for the individual to solve life problems and contribute to the development and growth of the society (Akinbobola & Ado, 2007).

Also, it is from the manipulation of apparatus, materials and equipment during practical that lead to drawing, calculation and give the result that is recorded and hence deduced to give the final result required.

However, in the areas of the process skills of comparing, contrasting, investigating, formulating models and interpreting, there are scanty representations in questions in the years under review particularly in the last five years (2003-2007).

Research hypothesis

There is no significant difference between the number of basic and integrated science process skills included in the West African senior secondary school certificate physics practical examination in Nigeria.The analysis is as shown in Table 4.

Table 4. t-test analysis of the basic and integrated process skills included in the WASSSC physics practical examinations

Process Skills	N	<x>	S.D	DF	t-cal	t-critical	Decision at P<.05
Basic	80	3.93	3.23	148	2.58	1.96	*
Integrated	70	2.67	3.01				

*= Significant at P<.05 alpha level

The analysis in Table 4 shows that the calculated t-value of 2.58 is greater than the critical t-value of 1.96 at .05 level of significance. Hence, the hypothesis which stated that there is no significant difference between the number of basic and integrated process skills included in the West African senior secondary school certificate physics practical examinations in Nigeria is rejected. The table also shows that the number of basic process skills is more than the integrated process skills in the West African senior secondary school certificate physics practical examinations in Nigeria across the years (1998-2007) under review.

This is in line with the findings of Nwosu (1994) that there is very low level of development of skills of inferring, predicting and formulation of models among year one senior secondary biology students. The result is also in line with the findings of Okebukola (1985) that students were given few opportunities to acquire the process skills and such few opportunities were often for the acquisition of the basic skills rather than the integrated science skills. This might be due to the fact that basic process skills can be easily learnt, and readily transferred to new situations unlike integrated process skills abilities that need to be practiced over a period of time and cannot be learned via a 2-week unit in which science content is typically taught in Nigeria. These abilities are closely related to the formal thinking described by Piaget (Tomera, 1974). Tomera (1974) further explains that one way to decide whether someone is concrete or formal is to ask that person to design an experiment to solve a problem. Chiapetta (1976) observes that most early adolescents and many young adults have not yet reached their full formal reasoning capacity. It is worth nothing that many of our senior secondary school students fall within this age bracket. This might be one of the reasons for the West African Examinations Council to set most of their questions on basic science process skills.

Conclusion

The five (5) prominent science process skills identified out of fifteen (15) used in this study are manipulating (17%), calculating (14%), recording (14%), observing (12%) and communicating (11%) in the West African senior secondary school certificate physics practical examinations in Nigeria within the period of 10 years (1998-2007). Out of this, only manipulating skill is the integrated (higher order) science process skill. The result also indicated high percentage rate of basic (lower order) science process skills (63%) as compared to the integrated (higher order) science process skills (37%). The results

also indicated that the number of basic process skills is significantly higher than the integrated process skills in the West African senior secondary school certificate physics practical examinations in Nigeria across the years (1998-2007).

Implications

The significance of the science process skills has led to the expansion of the goal of science education to include an understanding by, and development in the students of these process skills. The basic (lower order) science process skills are useful in science and non-science situation while the integrated (higher order) science process skills are the working behavior of the scientists and technologists. The integrated (higher order) science process skills are important since they are more needed for self reliance, development and problem solving than the basic skills.

Adequate fulfillment of our goals and aspirations of individuals for relevant and functional education demand a reasonable and higher level of acquisition of science process skills since integrated process skills are the bedrock of science and technology. In the light of the findings, it becomes apparent that students' acquisition of high level skills such as investigating, formulating models and interpreting was very low. That is, not much is seen in the higher order skills or the integrated science process skills, which has much to do with reflective thinking, creativity and problem solving. Hence, there is need to increase the number of integrated process skills in the West African senior secondary school certificate physics practical examinations in Nigeria.

Recommendations

In the light of the findings, the following recommendations are made: (1) Examination bodies in Nigeria, especially West African Examinations Council (WAEC) and National Examinations Council (NECO) should include

more integrated (higher order) science process skills into the senior secondary school physics practical examinations so as to enable the students to be prone to creativity, problem solving, reflective thinking, originality and invention which are vital ingredients for science and technological development of any nation. (2) Physics students at secondary schools level should be given the opportunity to handle and manipulate materials, tools and equipment in the laboratories; test their ideas experimentally; collect, compare, and interpret data; formulate models and draw conclusion. (3) Seminars, workshops and conferences should be organized to re-orientate the physics teachers and to instill the awareness to the public on the use and application of science process skills in the nation's growth and development. (4) The present physics curriculum should be reviewed to ensure greater involvement of integrated (higher order) process skills at the senior secondary school level. (5) Guided discovery/inquiry method should be used by the physics teachers to improve students' levels of science process skills acquisition. (6) Governments (Federal, State and Local) should equip laboratories and physics teachers and students should utilize the facilities in such a way that could lead to the development of both basic and integrated science process skills.

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