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ENGINEERING RESEARCH AND INNOVATION IN SCIENCE EDUCATION: IMPLICATION ON THE ACQUISITION OF SCIENCE PROCESS SKILLS FOR SUSTAINABLE NATIONAL DEVELOPMENT

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ABSTRACT
This study investigated the implication of engineering research and innovation in Science Education on the acquisition of science process skills for sustainable National Development. The study was carried out in Anambra State of Nigeria. The population comprised of all the science teachers in all the secondary schools in Anambra State. A sample of 120 science teachers obtained during a science teacher's capacity workshop was used. The sample was obtained using purposive sampling techniques. Structured questionnaire was used for data collection. The questionnaire was based on four point rating scale. The instrument was pilot tested and the reliability of the instrument was determined using Pearson's product moment co-relation and a reliability of 0.8 was obtained. Analysis of the data was done using mean ($\bar{x}$) and x^2 for hypothesis at 0.05 level of significance. The result of the study showed that engineering research findings has significant relationship on the acquisition of science process skills. It was therefore recommended that government should sponsor science teachers to conferences and workshops and again experienced science teachers should mentor the inexperienced ones for greater acquisition of science process skills.

INTRODUCTION
Engineering according to New International Webster's Comprehensive Dictionary of English Language is the art of designing, building or using engines and public works or the like. The art is now subdivided into numerous branches dealing chiefly with the application of scientific knowledge for the purpose useful to man. Engineering is the application of science to the needs of humanity. It is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience and practice is applied with judgment to develop way to use economically the materials or force of nature for the benefit of mankind. Research on the other hand is a systematic and objective search for the new knowledge of study and the application of such knowledge to the solution of a novel problem. (Akuezulo, 1993 in Chukwuneke, (2008).Innovation on the other hand, means the introduction of something new, a new idea, method or device. Innovation is the key to transforming scientific knowledge and technological know-how into useful products, services and employment.

The concept of science has been variously defined by different authorities. Here science is defined as a dynamic process of seeking for knowledge about nature through systematic observation and experimentation. (Anaekwe, Nzelum,

Olisakwe and Okpala 2010). The definition portrays the two arms of science namely: science as a process and science as a product. Any definition that fails to harmonize these two is deficient. The process dimension of science is seen to be the primary consideration and gives rise to the product. The process dimension of science is generally treated under science process skill. Science process skills refer to those tools, tactics or techniques and process which are utilized in the study of science (Anaekwe, 2010). They are equally important in the manufacturing of new products. This explains why the Federal Government of Nigeria adequately emphasized the learner's acquisition of these skills at all levels of the education system particularly at the foundation level (FRN, 2004; Ezeuchi, 1993, FRN, 1986).

The mastery of science process skills adds innovation in research in science education because once the skills are mastered; they can now be transferred among the content units forming the basis for further research in science Education. The scientistis systematic in his ways when studying the world around him, his activities are not haphazard. The ways used by scientists in studying the world around him are known as the process of the scientist. These processes are what Brandwain and his colleagues in their book titled concepts of science as seen in (Anaekwe 2015)referred to as methods of intelligent. Their view is informed by the fact that the processes of the scientists are intelligent ways of finding out how the world works. They further stated that it is not enough to know the process of science, but to study science; you need to know what scientists have found out as well as their ways.

A scientist is always probing his environment. In his probe, he begins with one of the scientist's ways of knowing which investigation is. Investigation involves experimentation and observation; scientific concepts are learned using the processes of science. The science process skills are the basic strategies of science. They are immutable and unlike the facts of science can stand the test of time. The process skills are a universal language of science. According to Russel (1991), scientific processes are culture-free, a genuine international language of science, one which would remain relevant at all times everywhere. In support of this view Baez (1979) in Russell (1991) had this to say: it is more important that students acquire the frame of mind associated with discovery and enquiring than it is for them to memorize facts whose value may be transitory. The science process skills are important tools in the hand of a scientist. They are necessary in designing experiments to test ideas or hypothesis and predictions. These processes fulfill the major objectives including laboratory exercise in science enterprise by presenting science as a way of investigating and a way of thinking. The science process skills arose from the research findings of the American Association for the Advancement of Science (AAAS). The association had sought to investigate

the activities or what scientists actually do. The association identified thirteen skills which they classified into basic and integrated skills. The basic skills include observing, classifying, using space/time relations, using numbers, measuring, inferring and predicting. The integrated skills include, defining operationally, formulating model, controlling variables, interpreting data, hypothesizing and experimenting (Aniodo, 2001). A brief explanation of each of these process skills are given hereunder.

BASIC SCIENCE PROCESS SKILLS

Observation: This makes use of all the senses- seeing, hearing, touching, testing and smelling, to gather information from the environment.

Classification: Classification entails using the observed differences or similarities to sort, group or order things according to recognizable patterns.

Using Space/Time Relations: This process skill has been describe as visualizing and manipulating objects and dealing with shapes, time, distance and speed. Here the scientists count, measure, draw graphs, work out equations and so on.

Using Number: This entails an introduction to the use of different forms – Arabic, Romans, positive or negative integers, fractions, indices, percentages etc.

Measurement: This implies using measuring devices eg clock, thermometer, weighing balance etc which has standard units to describe properties of objects like time, temperature, mass respectively.

Inferring: This entails drawing conclusions based on observations, making sense out of a whole gaunt of observed phenomenon.

Predicting: This involves forecasting or using one rule or more rules to determine the outcome of an event or series of event without observing the outcome of the event or series of events.

INTEGRATED SKILLS

Defining Operationally: This refers to providing tentative definitions of the phenomena without complete or exact knowledge of what is happening eg. Pressure may be defined as force per unit area; mathematically, it can be expressed as:

$$\text{Pressure} = \frac{\text{force}}{\text{Area}}$$

Formulating Models: In this case, physical or mental models are prepared and utilized in explaining observed phenomena as well as making predictions. Such models could be charts, pictures, diagrams, prototype etc.

Controlling Variables: This refers to the ability to identify, observe, manipulate and control factors in an experiment.

Interpreting Data: This entails providing answers to questions or hypothesis under investigation. Explanations, inferences or hypothesis can be drawn based

on available data which may be presented in form of graphs, tables, charts or diagrams.

Hypothesizing: This involves the ability to make wise and tentative guess which is subject to further scientific testing. It is a sensible guess. It is a hiatus. A casual hypothesis is one which can be tested in order to find out whether it will be supported or not.

Experimenting: In experimenting, the scientist makes a hypothesis from observations that are of interest to him. He then goes on to device a way to test this hypothesis. He does this by designing situations to find out the effect of some variables (independent) on the other variable (dependent). At the end of an experiment, a scientist interprets and presents his results in a meaningful manner to guide future research work.

The contemporary world is becoming highly research based and increasingly dependent on science and technology for economic growth and national sustainability. The general goal of science is to prepare the individual to cultivate inquiring, knowing and rational mind for learning science processes and principles that will be applied to research in technologically advancing world. This goal gives relevance to science education and encourages the application of researchers that will help individuals acquire and build science process skills that will enable them make decision for their lifelong careers and for sustainable development of our nation. Current emphasis is on using science education to improve lives and nations. The National policy on education (FGN, 2014) emphasize that teaching and learning of science should lead to acquisition of science processes and principles that aims at providing knowledge, skills, capacity for self- reliance and intellectual development. This represents the desired direction for science education and should influence the nature of textbooks, and curriculum both at national and local levels and teaching practices over the next decade and beyond (Osisioma, 2012). When research is engineered, teachers can communicate ideas, add value and improve their problem-solving skills and their students can now learn meaningfully leading to all-round development of our nation.

Research findings, therefore need to be engineered to give science education curriculum meaning, quality and relevance. Despite the improvement that research finding and its application bring to our education in particular and our nation in general, most science educators resist changes because they are not equipped with the skills of educational research and how to apply them, (Etiubon, and Okopide, 2015). Teachers are unable to make use of research finding because they lack the time needed to fully prepare and research materials for teaching. For instance, most teachers lack clear direction on what and how to teach because they feel lazy going through journals where researches are documented to update their notes. Some who have the opportunity to attend conferences where research

finding are used for presentation within and outside the country hardly involve their peers in knowledge-sharing as they are busy with over loaded academic schedules that they forgot that they attended a conference of that nature (Abimbade, 2001). This militates against proper acquisition of science process skills among students and sustainable development of our nation.

In spite of the crucial role, research findings and its application play, most science educators have little or no knowledge of current research findings and how it could be applied to improve classroom instruction and students achievement leading to sustainable national development. These teaches lack confidence in themselves as they have little understanding of how to select and modify concepts using research findings to enable learners gain broader perspective of science instruction for sustainable national development. This hampers students' scientific knowledge and inhibits the acquisition of science process skills. (Okoye, 2002) and (Akpan, 2013) found that there are scanty research reports on the performance of science education programme and schools lack the necessary resources to carry out experimental work in science education programme. Engineering research in science education will improve teachers' knowledge and therefore improve students' level of acquisition of science process skills. National Research Council, (NRC, 2009) found that the background knowledge of teachers on research findings utilization is very poor, resulting in the lack of spread of information on research finding. This may hinder teachers and students acquisition of science process skills and sustainable development of this nation. At the instance of this, the current study goes to investigate the level of acquisition of science process skills through engineering research by science education.

PURPOSE OF THE STUDY

The study goes to investigate the extent of engineering research findings and acquisition of science process skills in science education among secondary school science educators, specifically.

The study goes to investigate the following:

1. Whether new research findings are made available to secondary school science teachers.
2. Whether recent research findings are applied in the area of teaching and learning.
3. The extent to which science process skills are acquired by both teachers and students.

Research Question:

1. To what extent do teachers engineer research findings to improve teaching and learning in science education.

2. What is the level of acquisition of science process skills by science teachers
3. To what extent do teachers use innovative strategies in teaching for acquisition of science process skills?

Hypothesis: (Ho)

A statistically significant number of the respondents will indicate that engineering research findings has no significant relationship on the acquisition of science process skills.

Research Procedure

The study was a survey research design. The study was conducted in Anambra State of Nigeria. The population of the study comprised of all the science teachers in all the secondary schools in Anambra State. A sample of 120 science teachers of (Biology, Chemistry, Physics and Basic Science) obtained during a science teachers capacity workshop was used. The sample of the study was obtained using simple purposive sampling techniques. A structured questionnaire was used for data collection. The questionnaire was based on 4 point rating scale as follows:

Attributes	Points
Strongly Agree	4 points
Strongly disagree	2 points
Total Attributes= 4	**Total point= 10 points**

The questionnaire was validated by two experts from Science Education and one from measurement and evaluation. The instrument was pilot tested and the reliability of the instrument was determined using Pearson's product moment co-relation and a reliability coefficient of 0.8 was obtained. Copies of the rating scale were all administered, filled and collected the same day, so no questionnaire was lost. Data obtained was analyzed using mean (x).

Bench mark mean=10/4=2.5

For decision making, any mean >or= to 2.5 is accepted as being good while mean value less than (<) 2.5 is rejected as not being good. The hypothesis was tested using x^2 at 0.5 level of significance.

Table 1: Extent to which teachers engineer research findings to improve teaching and learning in science Education

S/N	ITEMS	SA	A	D	SD	X	Decision
1	Science teachers are not sponsored to conferences and workshops therefore find it difficult to engineer research findings.	320	90	16	12	3.65	SA
2	Time allocated to science teaching and learning is not enough for engineering research findings	324	54	20	11	3.40	A
3	Science teachers carry excess credit load which makes it difficult to engineer research findings	312	36	32	04	3.2	A
4	Lack of imprest allowance to science teachers is a threat to engineering research findings.	280	108	18	05	3.42	A
5	Science teachers do not comprehend research findings adequately.	40	27	140	31	1.98	D
6	Voluminous science curriculum is a threat to engineering research findings	276	96	24	07	3.35	A
7	Lack of adequate equipment and materials is a threat to engineering research findings.	224	162	48	06	3.67	A
8	Teachers are not well informed on current research findings	204	150	24	07	3.20	A
9	Research findings are difficult to engineer in overcrowded classroom.	276	108	16	07	3.39	A
10	Science teachers exposed to current research findings actually apply them.	196	156	14	12	3.15	A
	Cluster Mean					**3.24**	

From table 1 above, all the respondents agreed in all the points but disagreed in point 5 which says that science teachers do not comprehend research findings adequately. The cluster mean is 3.24 which means that science teachers that are exposed to current research findings actually apply them. Again they agree that teachers are not sponsored to conferences and workshops, those science teachers carry excess credit load, science curriculum is voluminous, equipment and materials are inadequate, classrooms are overcrowded.

Table 2. Level of acquisition of science process skills by science teachers

Science process skills	$\bar{X}$ **level of acquisition**	**Decision**
Observing	4.30	Acceptable
Classifying	3.60	Acceptable
Using space/time relations	3.40	Acceptable
Using numbers	3.40	Acceptable
Measuring	3.5	Acceptable
Inferring	2.51	Acceptable
Predicting	3.24	Acceptable
Defining operationally	3.40	Acceptable
Formulating models	2.80	Acceptable
Controlling variables	2.65	Acceptable
Interpreting data	4.21	Acceptable
Hypothesizing	3.60	Acceptable
Experimenting	3.50	Acceptable
Cluster mean	**3.13**	Acceptable

From table 2 above, the mean level of acquisition of science process skills by science teachers is 3.13; which is acceptable. In other word, the level of acquisition of science process skills by science teachers is acceptable because it is greater than 2.50.

Table 3: Meanrating of the extent to which teachers use innovative strategies in teaching.

Items	$\bar{X}$	**Remarks**
Demonstration method	4.10	Acceptable
Investigative laboratory approach	3.60	Acceptable
Computer Assisted instruction	2.20	Not Acceptable
Computer simulation	2.10	Not Acceptable
Field trip/Excursion	3.21	Acceptable
Concept mapping	1.36	Not Acceptable
Co-operative learning	2.56	Acceptable
Project method	4.25	Acceptable

Use of analogies	3.20	Acceptable
Expository/ questioning	3.86	Acceptable
Cluster mean	**3.5**	Acceptable

From table 3 above the mean rating of the extent to which teachers use innovative strategies in teaching is 3.50. This is greater than bench mark mean of 2.50, therefore is acceptable. This means that science teachers use some of these innovative strategies in teaching science except items 3, 4, 6 which has mean values below 2.50.

H_{O1}:A statistically significant number of the respondents will indicate that engineering research finding has no significant relationship with the acquisition of science process skills.

Table 4: x^2 table showing relationship between engineering research findings and acquisition of science process skills

Respondents	Fo	Fe	Fo-fe	$(fo-fe)^2$	$\sum\frac{(fo-fe)^2}{fe}$	X^2	DF	Lev.of Sig.	X^2 critical
Yes	30	60	-30	900	15	30	1	0.05	3.84
No	90	60	30	900	15				

From table 4 above, the calculated X^2 is 30 while the critical value of X^2 is 3.84. Since the calculated value is higher than the critical value, the null-hypothesis which states that a statistically significant number of the respondents will indicate that engineering research findings has no significant relationship on the acquisition of science process skill is rejected. In other words, engineering research findings has significant relationship on the acquisition of science process skills.

DISCUSSION OF FINDINGS

From the result of the study, it was revealed that science teachers that are exposed to current research findings actually engineer them. In contrast to this findings, (NRC, 2009) found that the background knowledge of teachers on research findings utilization is very poor, resulting in lack of spread of information on research finding. Again Abimbode (2005) reported that teachers are unable to make use of research finding because they lack the time needed to fully prepare and research materials for teaching as they are busy with overloaded academic schedules. Again the result of the study also revealed that science teachers' level of acquisition of science process skills is acceptable. Abimbode (2005) in Etiubon and Okopide (2015) in contrast to this findings said that, there is declining interest in the use of creativity in teaching among science teachers. They fail to utilize skills that can enhance students understanding and performance. Again Anaekwe and Ezeuchi (2015) discovered that science teachers

who are aware of innovative instruction strategies and able to utilize them may more likely effect the desired positive impact toward acquisition of science process skills.

The result of the study also revealed that science teachers' use of innovative strategies in teaching is acceptable. This finding agrees with Anaekwe and Ezeuchi (2015) where they reported that the innovative strategies were perceived by science teachers as efficacious in facilitating students acquisition of science process skills. Finally, the result of this present study discovered that there is a significant relationship between engineering research findings and acquisition of science process skills. This is in agreement with FRN (2014) which states that the general goal of science is to prepare the individual to cultivate inquiring, knowing and rational mind for learning science process and principles that will be applied to research in technologically advancing world. Again it states further that this goal gives relevance to science education and encourages the application of researches that will help individuals acquire and build science process skills that will enable them make decision for their lifelong careers and for sustainable development of our nation.

CONCLUSION/RECOMMENDATIONS

The findings of the study revealed that science teachers that are exposed to current research findings, engineer them. These are privileged few, who may have received financial support to attend conferences and seminars form their principals. But majority of the science teachers are not sponsored and therefore not exposed to current research findings in their field. Science teachers Association of Nigeria (STAN) organizes conferences and workshops for science teachers every year but still science teachers attendance is very poor due to poor financial assistance to these teachers.

- It is therefore recommended that STAN should intensify her effort in capacity building and profession development of STAN teachers.
- Government should encourage and sponsor teachers to workshops and conferences.
- Workshops should be organized for science teachers in different local government areas/zones to enable them have an overview of innovative instructional strategies which will help to link gap between research and classroom practices.
- Experienced teachers should mentor the inexperienced ones in order to learn new techniques and approaches in science.
- Important educational materials such as science education journals, conference proceedings, workshop proceedings etc can be provided in school libraries for teachers to update their knowledge.

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