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Enhancing Junior Secondary School Students' Acquisition of Science Process Skills through Activity-Based Instruction in Basic Science

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Abstract
The lack of laboratory experiment at the junior secondary level of education has led to poor acquisition of science process skills at the foundation level of science learning. There is thus, the need for an innovative instructional approach that can incorporate such experimental activities in the learning process. The study focused on enhancing junior secondary school students' science process skills acquisition through activity-based instruction in basic science. Two research questions guided the study and six hypotheses were tested. The quasi-experimental design was used. A sample of 58 Junior Secondary School year two (JSS 2) Basic science students from Aguata Education Zone were involved in the study. The instrument for data collection was Basic Science Process Skill Acquisition Test (BSPSAT) validated by three lecturers in science education and two experienced basic science teachers. The reliability of BSPSAT was established using Kudder-Richardson formula 20 to be 0.79. Data were collected by administering the instruments as pretest and posttest. The data obtained were analyzed using mean to answer research questions, standard deviation and Analysis of Covariance (ANCOVA). The results showed that there is significant difference in the mean science process skills acquisition scores of students in the experimental and control groups in favour of the experimental group. It was recommended that Curriculum planners should design activity relating to each subject matter contents of Basic science to enable the students improve achievement, acquire and master science process skills while participating in such activities.

Keywords: *Basic science, activity-based instruction, crude oil, radiation*

1. Introduction

Science process skill is widely acknowledged in the area of science. However, the learning and development of science process skills are affected by a number of factors. One of the factors that could enhance science process skill acquisition is the teachers' familiarity with the skills and the method for teaching it. When teachers are familiar with the science process skills, they use them in demonstration and model some of the skills for the students to learn. The teachers' knowledge of the science process skills and the method of teaching them affect the students' perception about science process skills (Ward, Roden, Hewlett & Foreman, 2008). It gives students the impression that they too can acquire such skills when they see their teacher use them with ease at any point in time for demonstrations.

Science process skills, according to Screen in Badri and Shri (2013) are the sequence of activities that scientists or researchers engage in during the course of scientific investigation. Science process skills are mental and physical abilities and competencies which serve as tools needed for effective study of science (Akinyemi & Folashade, 2010). Padilla (1990) defined science process skills as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behaviour of scientists. They are categorized into basic and integrated science process skills. The Basic science process skills, according to Akinyemi and Folashade (2010) are the simpler skills that provide the foundation for learning the integrated ones. The basic science process skills include: observation, classification, inferring, measuring, scientific thinking, predicting and communication.

Science process skill acquisition equips the students with the ability to apply scientific knowledge they have learnt in school. The constant emphases on the importance of this skills and exposure to situations or conditions where they can be applied as well as creating problems that students can solve with such skills give them satisfaction and motivation to want to master these skills. Thus, interest and motivation can influence the acquisition of science process skills. These notions give the indication that activity-based instructions are necessary for students to acquire the science process skills needed for proper learning of science in the future.

Science process skills have been described by Badri and Shri (2013) as very necessary in the presentation of science to learners. They prepare students to become scientists by emphasizing the use of our five sense organs (Badri & Shri, 2013). Since the objectives of teaching science emphasize doing science, developing science process skills in the learners becomes a necessary pre-requisite for future studies in science and science practices. Also, the acquisition of these skills can positively improve the students' achievements in science subjects in schools. Acquisition of science process skills therefore is an important part of the basic science curriculum that must be inculcated in the learners at such elementary and foundational science teaching and learning. Notably however, the approaches adopted by teachers at the junior secondary level of education do not emphasize these skills. Teachers barely do experiments in basic science at the junior secondary level of education and it is from such experiments that students can acquire the science process skills needed as future scientists. Therefore, there is the need for a method of instruction where these skills can be properly taught to students particularly in Basic science lessons.

Basic science forms the foundations of science from an integrated perspective. It is a pre-requisite for later studies in any of the science disciplines. One major problem as observed by the researcher with the teaching and learning of Basic science is that its unifying nature makes it difficult for teachers to choose the teaching methods that can enhance students' achievement and acquisition of process skills. Basic science therefore demands special guidelines for its teaching and for acquisition of the Basic science process skills needed to further carry on in the area of science. The nature of the subject creates a problem that is based on the question of which teaching method could better be used to attain its objectives. It is no wonder students' achievement has remained poor over the years (Mbaliki et al, 2009). The under-achievement in Basic science and poor acquisition of science process skills have also reflected in the continual poor achievement of students in sciences in the senior secondary and tertiary institutions.

There is neither any study to the researcher's knowledge geared towards developing an instructional method that can be specifically used in teaching Basic science in Aguata Education Zone, given its peculiarity nor an in-depth investigation of the effects of available teaching methods on students' science process skill acquisition in Basic science. The researcher saw the need to investigate whether the use of activity-based instruction can improve the achievement and science process skill acquisition of Basic science students. Anactivity is a behaviour or action of a particular kind, something that is done as work or for a particular purpose. Academic activities are behavioural dispositions or actions taken towards academic objectives. Among such activities is inquiry learning, laboratory practical, indoor and out-door experiences, field trips, project, discovery exercise, excursion, class exercise, group discussion and so on.

Activity-based instruction is student centered instructional method whereby concepts are taught with practical exercises that emphasize hands-on experiences relating to the concepts. It is a method of instruction that tasks the students to carry out a practical activity that explains and facilitate the proper understanding of the concept being taught while at the same time helping the students in the acquisition of the skills required to carry out similar exercise in the future (Badri&Shri, 2013). Activity-based instructions encompass a number of teaching methods such as problem-based learning, inquiry learning, discovery learning, laboratory approach, field trip, and project. Science objectives stress the importance of learning science by doing science whereby science teachers adopt a method of teaching science that would enable the learners to acquire science process skills needed to carry out scientific study and investigations.

The concept of activity-based instruction includes a mix of many activity-oriented teaching methods (Balfaki, 2010). In this study, activity-based instruction is conceived as a combination of indoor and outdoor activities that are related to the lesson, discovery, laboratory and practical activities, science process skill teaching approach and demonstrations. It is thought that when instructional process is activity oriented, the students internalize the learning materials and properly conceptualize the concepts taught. The use of activity-oriented teaching learning also enables students to take responsibility for their own learning.

Activity-based instruction describes a range of pedagogical approaches to teaching. Its core premises include the requirement that learning should be based on doing some hands-on experiments and activities. The idea of activity-based learning is rooted in the common notion that students are active learners rather than passive recipients of information. If students are provided the opportunity to explore by their own and provided an optimum learning environment then the learning becomes joyful and long-lasting (Yustina, Osman, &Meerah, 2011). The key feature of the activity-based instruction is that it uses student-friendly educational aids to foster self-learning and allows a child to study according to his/her aptitude and skill. Under the system, the curriculum may be divided into small units, each a group of Self-Learning Materials (SLM) comprising attractively designed study cards for science. When a student finishes a group of cards, he completes one 'milestone'. Activities in each milestone may include games, drawing, calculations, experiment, do mathematics and science, or understand a concept. This is a student-friendly way to evaluate and reinforce learning. If a student is absent one day, he/she continues from where he/she left unlike in the old system where the children had to learn on their own what they missed out on. Activity-based instruction therefore, is an activity-oriented instruction that draws up series of activity that can engage the students in such a way as to facilitate meaningful learning. This is what Edward Thorndike's behaviourist theory advocated for in learning.

Thorndike's theory states that learning was incremental and that people learned through a trial-and-error approach. The behaviourist theories of learning did not consider that learning took place as a result of mental constructs. Instead, it described how mental connections are formed through positive responses to particular stimuli. For Thorndike, learning was based on an association between sense impressions and an impulse to action. Thorndike favoured students' active learning and sought to structure the environment to ensure certain stimuli that would 'produce' learning. The implication of this theory is that when students attempt to engage in activities that teach science process skills, they develop their science process skills through the trials and errors residents in their continuous practice. It builds on their motivation, such that they try to correct the mistake made in formal attempts in new and trial activities. Thus, students need to be engaged in activities that provide rich experiences and learning environments that can enhance their achievement and science process skills acquisition.

2. Purpose of the Study

The study was focused on enhancing junior secondary school students' acquisition of science process skills through activity-based instruction in basic science. Specifically, the study sought to find out the:

- Effects of activity-based instruction and lecture method on basic science students' acquisition of basic science process skills.
- Influence of gender on basic science students' acquisition of basic science process skills.
- Interaction effect of teaching methods and gender on the basic science students' science process skills acquisition.

3. Research Questions

- What is the difference in the mean science process skill scores of students taught basic science using activity-based instruction and that of those taught using lecture method?
- What is the difference between the mean basic science process skill (BSPS) acquisition scores of male and female students?

4. Hypotheses

The following hypotheses were tested at 0.05 level of significance.

- There is no significant difference in the mean science process skill scores of students taught basic science using activity-based instruction and that of those taught using lecture method.
- There is no significant difference between the mean Basic science Process Skill (BSPS) acquisition scores of male and female students.
- There is no significant interaction effect of teaching methods and on the mean scores in the Basic science process skill acquisition test.

5. Method

5.1. Research Design

The design adopted for the study was quasi-experimental. The pretest-posttest non-equivalent control group design was used. This design according Nworgu (2015) is one that seeks to establish the cause and effect relationship between the variables of interest in this study but where random assignment of subjects to experimental and control groups is not possible. Nworgu further noted that in such research, intact or pre-existing groups are used. The design is appropriate for the study as it will allow for observations and assignment of subjects into groups without randomization. The quasi experimental design was adopted for this study because the administrative set up of the school may not allow for random assignment of students to treatment group as it may disrupt school activities. The design of the study is given in Figure 1.

Group	Pre-test	Treatment	Post-test
E	0_1	X	0_2
C	0_1	~X	0_2

Figure 1: Design of the Experiment

Where,
E_1 = Experimental Group
C = Control Group
0_1 **=** Pre-test
0_2 = Post-test
X = Experimental treatment – Activity-based instruction
~X = No experimental treatment – Lecture method

5.2. Area of the Study

The area of study was Aguata Education Zone of Anambra State. The area is chosen for the study because there many skill acquisition centres where the science process skills can be utilized if they acquire such skills. There are also, so many secondary schools in the area where they findings of this study may be applied. The educational stakeholders in this area may therefore find the study of great benefit as it may serve as a guide to planning activity-based instructions in the secondary school in the area and may also help in conducting scientific verifications at the junior secondary level of education.

5.3. Population of the Study

The population of the study comprised 4352 junior secondary school year two (JSS II) students in 20 secondary schools in Aguata Education Zone (Source: Department of Planning, Research and Statistics, Post Primary School Service Commision, Awka, 2015).

5.4. Sample and Sampling Technique

The sample size for the study was 58 (34 males and 24 females) junior secondary school year two (JSS 2) students obtained using multi-stage sampling. First the schools were stratified according to ownership (public and private). The public schools were stratified into single-sex and coeducational schools. From the public coeducational schools, 2 schools were selected at random (balloting without replacement). In the two schools selected, the various arms of the JSS two class were listed in separated piece of paper and folded. The folded papers were picked at random without replacement, and the selected arm became the intact class used in the study. The two selected arms were at random assigned to experimental and control group. The experimental group had 11 females and 16 males while the control group had 18 males and 13 females.

5.5. Instrument for Data Collection

The instrument used for data collection was Basic science Process Skill Acquisition Test (BSPSAT) constructed by the researcher. The Basic science Process Skill Acquisition Test (BSPSAT) was designed by the researcher to measure only the students' acquisition of Basic science process skills. The instrument had twenty (20) questions that measured the Basic science process skills acquired by the student through their application of such skills in answering the questions. Also, an instructional package designed with activity-based instruction was prepared by the researcher which was used to teach the students in the experimental group.

5.6. Validation of the Instrument

The initial copies of the instrument along with the instructional plan were sent to three lecturers in Nnamdi Azikiwe University, Awka for validation. The validators were asked to vet the lesson plan and the BSPSAT for the clarity of words and appropriateness of the distractors. The corrections and suggestions by the validators were affected in the instruments in order to standardize them.

5.7. Reliability of Instrument

The reliability of the instrument was established using Kuder-Richardon-20 Formula 20. This method of reliability estimate was used because the questions are dichotomously scored and had heterogeneous level difficulty. Consequently, the instruments were administered once to 40 students in Community Secondary School in Nnobi town. The generated scores were tested for reliability co-efficient. The reliability coefficient obtained was 0.70.

5.8. Experimental Procedure

In the experimentation, the experimental group was exposed to the lesson contents using activity-based instruction with particular emphasis on the Basic science process skills. The lesson included, assignment/discovery learning, projects, out-door activities, in-class practicals, road-side observations, and calculations. The lesson package lasted for four weeks. Before the treatment, the students were given a pre-test. The same instruments were administered immediately after the lesson after reshuffling the serial numbering of the question items.

The teacher exposed the students to the concept of Crude Oil and Petrochemicals. Using simple explanations, questioning and examples the teacher familiarized the students with the concepts. The students were then engaged in the activity of identifying all the petrochemical products in their classroom and outside their classroom. The students also made a list of the petrochemical products in their various homes as an assignment. The second concept taught was Radiation. The teachers explained to the students the theory behind the concept. The activity involved with the learning of the concept of radiation involved students coming out of their class to touch the pole bearing the school flag, their teachers' cars and correspondent attempt to differentiate the process of heat transfer of conduction and radiation going on with each object touched. The teacher guided the students through to the lesson while at the same time emphasizing the skills of observation and classification by asking the following question:

- Did you feel any heat?
- How does the heat of the sun reach us?
- How did the heat from the pole and the car reach you?
- Classify the heat transfer in both instances (heat from the sun and heat from the car)

The teacher then asked the students to kindle a fire outside the classroom. The students were told to come close to the fire and observe and record what happens as they slowly moved away from the fire to help them learn the skills of calculation, recording and communication. The teacher boiled water in a kettle until it is slightly warm and emptied the kettle into an aluminum cup for each student and asked them to insert a metal spoon into the cup. The teacher asked the students to observe what happens to the temperature of the spoon. The teacher further put some gravels in a wire gauge on fire. The teacher then provided for the student's clean water in a white transparent bowl and using a tong, the teacher picks a hot gravel and drops in the bowl and asked the students to record what happened to the gravel and the water in terms of temperature change and heat transfer. The teacher also asked the students to put forward a conclusion from their observation about what happens when two bodies of different temperatures are brought together.

Further, the teacher asked the following question to stimulate the students into scientific thinking: A small amount of water in an open container is placed on a lighted gas cooker, the water boiled until it dried up. Explain the different processes of heat transfer and at what stage they happened in the setup.

The teacher in another lesson divided the class into three groups with each group ready to carry out the experiments. Each group is given two-meter rules and thermometers, one tin sheet, polish and dark surface sheets, pieces of candle wax, a stove. The teacher guided each group as they lit the stove, heat the candle wax on fire and have them stuck to the tin sheets at the same distance from the tip of the sheets. The students were required to measure the same distance and mark them off. The two sheets are placed at the same distance away from the stove. The students were to also measure the temperature changes in iron sheets, the time it took for the candles wax to melt and the distance it moves away from where it was on the iron sheets. The students were requested to record the observations, timing, and temperature changes and put forward their conclusions after discussing in group. The students were also asked to predict what would happen if the fire coming out of the stove were increased. The control group was exposed to the same lesson content using the lecture method of teaching. They were also given the pre-test and posttest before and after the lessons. The whole exercise lasted for six weeks.

5.9. Control of Extraneous Variables

- Teacher variable: The lesson plans were prepared by the researcher. Also, the researcher taught the participant classes used in the study. This is because the regular class teachers were engaged with academic workloads that could not afford them the chance to conduct the teaching by themselves.
- Howthorne Effect: This is the tendency that noticeable difference may occur if the students became aware that they are engaging in an experiment. The researcher was therefore introduced to the students as a supporting class teacher brought in to assist the regular class teachers.
- Initial group difference: Analysis of covariance (ANCOVA) was used to control for the initial group difference among the groups. In this case, the pretest scores act as a covariate measures on the posttest scores.
- Effect of Pre-test on Post-test: The study lasted for six weeks. The pretest was administered in the first week before the experimentation while the posttest was administered in the sixth weeks. The instruments were also reshuffled before they were also administered as posttest.

5.10. Method of Data Analyses

Mean and standard deviation were used to analyze data related to the research questions. The hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). The choice of ANCOVA is to eliminate any initial imbalances that existed among the groups. The decision rules are that when P-value is less than 0.05, reject the null hypotheses; otherwise we do not reject the null hypotheses.

6. Results

- Research Question 1: What is the difference in the mean science process skill scores of students taught basic science using activity-based instruction and that of those taught using lecture method?

Groups	N	Pretest Mean	Posttest Mean	Gain Mean	Pretest SD	Posttest SD
Experimental	27	34.26	60.37	26.11	11.91	5.36
Control	31	35.00	55.48	20.48	12.11	5.97

Table 1: Mean Science Process Skills Acquisition Scores of Students Taught Using Activity-Based Instruction and Those Taught Using Lecture Method

Table 1 shows that the group taught using activity-based instruction had mean gain science process skill acquisition score of 26.11, while those taught using lecture method had mean gain score of 20.48. The activity-based instruction group had a higher mean gain science process skills score than those in the lecture method group with mean gain scores of 20.48. In both groups, the standard deviations of their scores are lower in the posttest compared to their pretest.

- Research Question 2: What is the difference between the mean basic science process skill (BSPS) acquisition scores of male and female students?

Gender	N	Pretest Mean	posttest Mean	Gain Mean	Pretest SD	Posttest SD
Male	16	32.71	58.13	25.42	13.51	6.05
Female	11	36.03	57.50	21.47	10.64	6.31

Table 2: Mean Basic Science Process Skills Scores of Male and Female Students Taught Using Activity-Based Instruction

Table 2 shows that the male students had gain mean basic science process skill acquisition score of 25.42 than the female students had gained mean science process skill acquisition scores of 21.47. The standard deviation of the scores for male and female students decreased in the post-test compared to the pre-test.

- Hypothesis 1: There is no significant difference in the mean science process skill scores of students taught basic science using activity-based instruction and that of those taught using lecture method.

Source of variation	SS	Df	MS	F	Sig.	Decision
Corrected Model	917.240[a]	4	229.310	9.790	.000	
Intercept	14625.876	1	14625.876	624.443	.000	
Pretest	467.797	1	467.797	19.972	.000	
Gender	22.005	1	22.005	.939	.337	NS
Method	287.468	1	287.468	12.273	.001	S
Method*Gender	139.307	1	139.307	5.948	.018	S
Error	1241.381	53	23.422			
Total	195650.000	58				
Corrected Total	2158.621	57				

Table 3: ANCOVA on Significant Difference in the Mean Science Process Skill Scores of Students Taught Basic Science Using Activity-Based Instruction and Those Taught Using Lecture Method

Table 3 shows that there was a significant main effect of the treatment won the science process skills acquisition scores of basic science students, F (1, 57) = 12.273, P (0.001) <0.05. Thus, the null hypothesis was rejected. Therefore, there is significant difference in the mean science process skill scores of students taught basic science using activity-based instruction and those taught using lecture method in favour of activity-based instruction with higher gain in mean of 26.11.

- Hypothesis 2: There is no significant difference between the mean Basic science Process Skill (BSPS) acquisition scores of male and female students.

Table 3 also shows that there was no significant main influence of gender on the basic science process skills acquisition scores of the male and female students, F (1, 57) = 0.939, P (0.337) >0.05. Thus, the null hypothesis was not rejected. Therefore, there is no significant difference between the mean basic science process skill (BSPS) acquisition scores of male and female students.

- Hypothesis 3: There is no significant interaction effect of teaching methods and on the mean scores in the Basic science process skill acquisition test.

Table 3 further shows that there is significant interaction between teaching methods and gender on the process skill acquisition scores of basic science students, F (1, 57) = 5.948, P (0.018) < 0.05. Therefore, the null hypothesis was rejected. Thus, there is a significant interaction effect teaching methods and gender on science process skill acquisition scores of students. This implies that the students' science process skill acquisition scores relative to the teaching methods was influenced by gender.

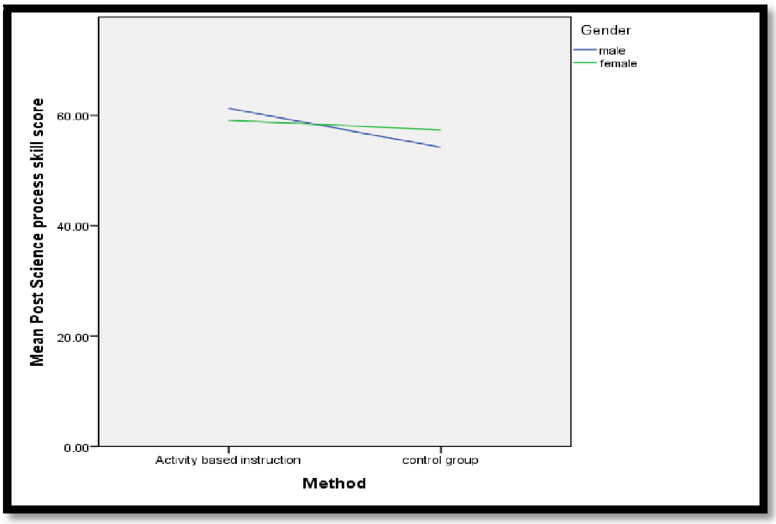

Figure 3: Plot of the Interaction between Teaching Methods and Gender Indicating a Significant Interaction Effect

The plot of the interaction effect of teaching methods and gender was significant and disordinal. This shows that the teaching methods have different effects on different conditions, for example, the effect of the teaching methods on interest would change when gender is put into consideration.

7. Discussion and Recommendations

The results of the analysis of data also revealed that the activity-based instruction group had a higher mean gain science process skills score than those in the lecture method group. Significant main effect of the treatment which accounted for 34.7 percent of the students' science process skills acquisition scores was observed. Thus, there was significant difference in the mean science process skill scores of students taught Basic science using activity-based instruction and those taught using lecture method. The significant effects of activity-based instruction on the acquisition of students' science process skill is attributed to the fact that teachers' knowledge of the science process skills and the method of teaching them affect the students' perception about science process skills (Ward, Roden, Hewlett & Foreman, 2008). Such approach to teaching and learning gives students the impression that they too can acquire such skills when they see their teacher use them with ease at any point in time for demonstrations. This is the central point emphasized by the behaviourist theory of learning. Also, activity-based instruction gives students the opportunity to interact with resources relating to what is learnt giving them the opportunity to try a particular skill over and over till they master them (Balfaki, 2010).

This finding of the study is in line with the findings of Kan and Nyet (2014) who conducted a study on effects of Outdoor School Ground Lessons on Students' Science Process Skills and reported significant improvement in science process skills. Kan and Nyet noted that activity-based instructions in form of outdoor classes give students the opportunity to interact with lesson materials and appreciate the applications of the science lessons. The findings of the study also provide support to the findings of Karamustafaoğlu (2011) who revealed that activity –based instruction resulted in 95% inference and interpreting data skills, 90% determining and controlling variables, and 100% hypothesizing skill acquisition. Roselyn et al. (2012) further supported the findings of the study in their report that the students taught using activity-based instruction out-performed those taught using lecture method.

In the study, the female taught using activity-based instruction had higher mean gain Basic science process skill acquisition score (26.56) than the male with mean gain score of 25.45. The findings of the study however relate that there is no significant difference between the mean Basic science process skill (BSPS) acquisition scores of male and female students taught using activity-based instruction. No significant interaction effects of gender and teaching method as measured by the mean science process skill acquisition scores of the students existed. The results revealed that the females improved more in their science process skills than the males owing to the use of activity-based instruction. The male students as well as the female students took part in the instruction and participated in the activities outlined for each lesson. Thus, the interaction between the students and the learning material enhanced their acquisition of science process skills irrespective of their gender.

The following recommendations are made in the light of the findings of the study:

- School administrators should provide teachers with financial motivation to acquire materials needed to conduct and carry out activities relating to what is taught.
- Basic science teachers should always attempt activities for every lesson while considering the duration of the lesson and level of the student's maturity.
- Curriculum planners should design activity relating to each subject matter contents of Basic science to enable the students improve achievement, acquire and master science process skills while participating in such activities.

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