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Does the Method of Instruction Matter in Middle Basic Pupils' Science Process Skill Acquisition? An Examination of Field-Based Inquiry and Conventional Strategies

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Authors' contributions

This work was carried out in collaboration between both authors. Author VMS managed the experiment, collected the necessary data and wrote draft of the entire work. Author EEA carried out data analysis, managed all technical sections and editorial works. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: This study investigated the extent to which the field-based, inquiry method of instruction (FBIMI) will be effective in impacting middle basic (5th grader) pupils' science process skill acquisition as compared to the conventional strategy.
Study Design: The study adopted a quasi-experimental design particularly a non-equivalent control group type.
Place and Duration of Study: The study was in Makurdi, Benue State Nigeria. The duration for the study was January to March in 2012.
Methodology: The sample for the study consisted of three hundred and twenty-nine pupils from six schools selected by random sampling. Acquisition of Science Process Skills Test (ASPST) was the instrument used in this study. The reliability estimate for ASPST was found to be 0.95.
Results: It was found that teaching method, FBIMI is an important factor in science process skill

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acquisition of learners and the students exposed to FBIMI acquired process skill significantly higher than those exposed to conventional strategy. The experimental group showed a higher aptitude than the control group. Gender was found to have no significant effect in the acquisition of science process skills in the experimental group.

Conclusion and Recommendation: FBIMI is found to be suitable for instruction of pupils of primary school age, therefore; Basic Science and Technology Curriculum by Nigeria Education Research and Development Centre (NERDC) should include the use of outdoor, field-based experiences among its teaching and learning materials. Also, school supervisors should ensure that teachers use FBIMI as teaching strategy for basic science and technology.

Keywords: Inquiry method; field-based inquiry strategy; science process skill acquisition; basic science.

1. INTRODUCTION

The process of inquiry is aimed at enhancing learning by increasing learner involvement, multiple ways of knowing and sequential phases of cognition. Inquiry-based curriculum has been shown to develop independent and critical thinking skills, positive attitudes and curiosity toward science and increased achievement [1-5]. Despite its advantages, few people practise inquiry-based education. As it is the case with any new pedagogy, there are a lot of forces opposing the practice of inquiry. For example, Abel and Roth [6] and Beerer [3] enumerated some of the factors influencing science teaching in primary school as insufficient instruction time in comparison to other subjects, teacher perception of the importance of science in an elementary curriculum, limited content knowledge held by elementary teachers, limited experience through formal course work in participating in and presenting hands-on science and lack of administrative support for the teaching of science. But Thiers [7] argued that there are important economic, environmental and social realities that demand new skills and literacy from our students today. Igboko and Ibeneme [8] identified globalization and rapid technological changes as some of the contributory factors to the shift from traditional educational practices such as programmed instruction, demonstration method and lecture or expository methods which have proved incapable of producing the effects required for coping with the challenges posed by globalization and rapid technological development. They further advocated that the realities of globalization earnestly calls for turning out skilled workers who are flexible, adaptable and imbued with higher-order thinking, problem-solving and collaborative work skills. Polman [9] cited the Secretary's Commission on Achieving Necessary Skills (SCANS) as saying that the information-oriented and service-oriented sectors of the economy require more active problem-solvers, rather than passive direction followers, and that inquiry based curricula and pedagogy are out to address this need.

It is necessary to test pupils process skills in this research because inquiry focused learning was portrayed to have a positive impact on both students' content understanding and skill acquisition, Matyas [10] explained that the National Science Education Standards (NSES) are talking about infusing inquiry based teaching into the curriculum, not replacing all forms of science teaching with inquiry-based teaching. The ultimate goal is to utilize inquiry based teaching where it is appropriate and where it enhances learning of both content and skills [11-13].

Inquiry is central to science teaching and learning. When engaged in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current or prevalent scientific knowledge and communicate their ideas to others [14,3]. Beerer concurs with the idea that inquiry approach is multifaceted and he outlined its benefits which include fostering curiosity as a habit of the mind and providing teaching strategies for motivating learning. Albert [15] added that knowledge gained by inquiry approach is more likely to be retained and incorporated permanently into the students' view of the world than knowledge gained otherwise.

The emphasis on inquiry based approach to teaching is not found in reports, standards and reform movements in America alone. In Africa and Nigeria in particular, frantic efforts have been made towards this direction of teaching and learning science. The African Primary Science Project (APSP) later called Science Education

Programme for Africa (SEPA) and the Nigerian Integrated Science Project (NISP) are good examples of efforts towards inquiry based instruction. Topmost on the list of the aims of APSP is to develop children with first hand familiarity with a variety of biological, physical and man-made phenomena in the world around them. Secondly, to develop children in further exploration of the world around them based on their own initiative. Thirdly, it is to develop in children the ability to find out things for themselves and to see problems and be able to set about resolving them. On the basis of these aims the curriculum was focused on the study of concrete phenomena.

Despite the overwhelming acceptance of inquiry focused learning based on concrete, biological, physical and man-made phenomena, research reports on how to teach using such a method are not common. Presently the philosophy of science education has slightly changed to emphasize technology education as early as primary school level so that learners acquire the skills they need for life and work. Achor [16] observed that besides making the technology aspect of the curriculum so outstanding early in a child's education, basic science and technology requires that learning be made practical to depict its inquiry oriented nature and so make it easier to understand.

Direct field experiences with opportunities for active, authentic scientific investigation offers promise of helping pre-service teachers develop the needed skills for inquiry-based teaching [17-21]. It is hoped that this approach will also be useful in helping primary school pupils' to improve their acquisition of science process skills. As earlier mentioned, the science community worldwide has accepted the superiority of the inquiry approach to teaching and learning science over other methods. However, research on the impact or effectiveness of field-based inquiry method of instruction on primary school pupils' learning of science is scarce, especially at the lower basic level in Benue State Nigeria.

This researcher is interested in finding out the impact of a field-based inquiry method of instruction on basic science and technology acquisition of process skills. Thus, this research assessed the influence of field activities, as compared to classroom-contained activities on primary school pupils' science acquisition of process skills. Rickinson, Dillon, Teamey, Morris, Choi, Sanders and Benefield [15] concluded that well planned and delivered field work provides experiences that cannot be duplicated in the classroom; it positively impacts learning leading to reinforcement between affective and cognitive domains of learning and higher level learning [11,12,22].

The question as to whether there are gender differences in mathematics and science achievement remains unanswered. While some findings indicate that there are differences, it is unclear whether such differences are actually gender or age – specific or they are due to differences in attitudes or opportunities for mathematics and science [23,24]. Reviewers such as Santos, Ursini, Ramirez and Sanchez [25], Lee [24] have consistently concluded that males perform better than females on mathematics test. An examination of age trends indicated that girls showed a slight superiority in computation in elementary school and middle school. There were no gender differences in problem solving in elementary or middle school, but differences favouring males emerged in high school and in college. This researcher is interested in finding out what obtains in primary school class five (lower basic five or 5th grader) in Makurdi, Benue state.

The psychological theories that have application to this study are those of Jean Piaget and Jerome Bruner. Bruner is actually a supporter of Piaget's theory but with some deviations. For instance, Bruner argued for the importance of "models in the head" and the importance of first hand experiences in developing those models. He argued that the young learner should not be talking of physics or about history or about mathematics but should be doing physics or history or mathematics. Bruner taught that concrete experiences should be heavily emphasized in childhood learning. Bruner hypothesized that any subject could be taught effectively in some intellectually honest form to any child at any stage of development. This hypothesis deviates from Piaget who holds strongly that a child's readiness to learn depends on maturation and intellectual development [26].

Piaget developed the theory that there are stages of cognitive development through which all people progress. He identified four of such stages but pointed out that the stages are not abrupt divisions, but that associated cognitive behaviour develops continuously. Piaget also cautioned that although all children go through the four stages they do so at their own pace [27]. The implication of Bruner's cognitive theory is that instruction should be geared to the level of the child's cognitive functioning. As Anglin in Maduabum [28, p. 25] asserts, "the role of the teacher is to translate or convert knowledge into a form that fits growing minds. The material to be transmitted in a course of study should be tailored, sequenced and embodied in a form appropriate to the young learner's existing mode of representation so that he will be better able to assimilate it"

2. THE CONCEPT OF SCIENCE PROCESS SKILLS AND THE TEACHING OF SCIENCE

The process by which scientists do their work lead to problem solving and discovery. All humans need these skills to function well in life. Science education has two distinct and inseparable parts or aspects which deal with the how and what. The how talks about the process skills while what, talks about the content. At the elementary level, a great deal of emphasis needs to be placed on learning how to learn – becoming competent in using the skills of inquiry. It is important to maintain a focus on developing the skills, not just on learning scientific facts. Students can memorize facts, but they must experience, practice and internalize if they are to learn the skills. You do not learn how to swan dive by reading a book and you do not learn science skills by memorizing definitions.

Wenning [4] identified these skills under four headings elementary, basic integrated and advanced skills. Basically the commission on science education of the American Association for the Advancement of Science (AAAS) has identified two process skills which are categorized into two groups.

(i) Basic process skills i.e. observing, measuring, inferring, predicting, classifying and collecting and recording.
(ii) Integrated process skills i.e. interpretation of data, controlling variables, defining operationally, formulating hypotheses and experimenting [29].

Since this list varies from one source to another Tolman's [19] list which he considers appropriate for elementary grades will be adopted in this study.

2.1 Observing

This is an ability to perceive the natural world through the five senses. Pupils should be encouraged and given frequent occasions to express themselves – to talk about what they see, hear, smell, taste and feel. In observation of rocks for instance they could talk about colour, size, texture and weight as they observe changes in nature such as new flowers, insects around the house, changes in weather and temperature, they can observe their feelings. Pupils should be provided with practice in recording observations. When pupils cannot write, they should practice using adjectives and verbs in verbal descriptions and sketch what they observe. At primary school level younger pupils can explain their observation for teachers or older pupils to record as they practice this, it will sharpen their perception. Observation should be recorded qualitatively and quantitatively.

2.2 Inferring

Inferring implies interpreting or explaining one or more observation based on prior experience or perception. It refers to assumptions based on observation. Inferences are less certain and prone to error than observation. When one perceives an aroma from the kitchen, he may mention stew or any other specific food that gives the teacher an excellent opportunity to talk about inference. Students learn to recognize the difference between observations and inferences by talking about and classifying them.

2.3 Classifying

Classifying is an act of grouping objects or events based on their characteristics. For a learner to do proper activity on classification there must be good practice in observation and skillfulness in recognizing characteristics of objects, in terms of likeness and differences. The following are examples of classification exercises.

1. Children are given assorted geometric shapes to group those that are alike.
2. Children can be given rocks to sort them out considering their colour, texture and hardness.
3. Other objects include buttons, greeting cards, shoes, seeds and the children themselves.

2.4 Measuring

Science provides experience with numbers in practical use. Children attempt to measure, compare things using terms like taller, heavier or larger than. Many properties of objects have to do with numbers. For example children may classify buttons according to the number of holes they have for thread or shoes by the number of holes they have for laces. When children have classified a number of objects into groups, they can count and compare subsets. They may further explore and discuss the implication of such numbers as to which group is best or worst or most preferred. If numbers represent test scores, children quickly notice interpret their performance and if they indicate time, they know when they are late.

Apart from measuring weight and height, other numerical characteristics are usually needed in science. This could be width or hand span, strides, foot and other interesting experiences with numbers.

2.5 Predicting

Prediction is possible as a result of the orderly manner conditions and events in the world happen. The weather however notorious is predictable to some extent even by untrained meteorologists. For example in areas of cold winter people can predict that the next winter will also be very cold. Children in such areas also know early enough what kinds of clothes are protective for them. They look forward to the signs for every season, Leaf fall in autumn, warm days for outdoor activities in summer. Other things children can predict are approximate times of holiday in a school year, reactions of parents and responsible adults to certain misbehaviors. The duty of parents and teachers is to help them connect these ideas to the term.

Prediction is based on the first three process skills namely, observations, measurements and inferences about observed events. If a child gets familiar with pendulums keeping tract with data regarding length, distance of the first swing, mass of the bob, they learn to notice patterns regarding the effect of one variable on the number of swings per minute.

2.6 Communicating

It is the ability to share what you have discovered with others in accurate and precise manner. Children learn this early by communicating verbally their observations and ideas in discussions. This skill of communication can be strengthened in writing, by reading, discussing what is read and writing observations and ideas. Feedbacks from their readers such as teachers, parents, peers help them to refine their skills of communication.

As they grow they discover that communication is not just spoken language or written language but by graphical presentations, charts, sometimes all the means are employed to make clear meaning.

2.7 Using Space – Time Relationships

All events occur at certain times in certain places. Location and timing are more significant with some events than with others. For example, if a child is studying the floatation of objects – using a bowl of water and objects to test – location and time are important. And if the task is to check the outdoor temperature in the shade of the building each hour throughout the day, both timing and location are crucial in the comparisons that are made [19 p.50].

The skill can be developed by relating stories or experiences, paying attention to sequence and location of events.

2.8 Formulating Hypotheses

If a scientist, teacher, child wants to find new information about something, he must examine information already available. He further clarifies perception about information by making an educated guess about such a problem, such a guess is referred to as a hypothesis.

If a class is working with magnets and answering the question of what magnets do or do not attract. A list of objects attracted to magnet may reveal that magnets attract only metals and do not attract non – metals. Careful studies will however, reveal that some metals are not attracted to magnets e.g. brass and copper.

With the knowledge that fertilizer promotes growth of plants a group of students may formulate the hypotheses that the more fertilizer they use, the faster their tomato plants will grow. If this is tested it will be found that there is an optimum amount of fertilizer a plant needs to grow well beyond which the plant will be affected negatively.

2.9 Identifying Variables

The conditions and factors that are not constant in an experiment are called variables. Each variable does not always affect a particular outcome and the outcome itself is a variable. Variables that are manipulated to affect outcome are called manipulated variables. In testing the amount of fertilizer on tomato plant growth, the fertilizer is the manipulated variable while the plant growth is the responding variable. The manipulated variable is also called the independent variable while the responding variable is called the dependent variable.

Variable testing requires careful analysis of the problem; only one variable should be changed at a time. If the amount of fertilizer, sunshine and water are altered at the same time, the researcher will not know what is responsible for the outcome of plant growth.

In testing variables, the experimenter can use controls. In the example of tomato plant, the control is a plant or cluster of plants kept under normal conditions. The control in this case should receive the recommended amount of fertilizer. It becomes a standard to compare the experimental plants.

2.10 Experimenting

An experiment involves a problem to which the experimenter does not know the solution. A true experiment involves testing a hypothesis and if necessary using controls. Primary school children are usually involved in scientific activities and not experiments as a result of the mature thought processes involved but they can use the same processes with careful guidance and selected projects designed for their level.

3. RESEARCH QUESTIONS AND HYPOTHESES

The study aimed at finding answers to the following questions:

1. What is the difference in pupils' acquisition of science process skills when taught using field-based inquiry method and lecture method?
2. How do boys and girls differ in their mean scores of acquisition of science process skills when taught using FBIMI?

The following null hypotheses (Ho) set to guide the study were tested at 0.05 alpha level of significance:

$Ho_{1.}$ There is no significant difference in the mean process skills scores of pupils taught science using the FBIMI and those taught using the lecture method.

$Ho_{2.}$ The mean process skills scores of boys and girls who are taught using the FBIMI will not differ significantly.

4. MATERIALS AND METHODS

4.1 Design

The study adopted a quasi-experimental design, investigating cause - effect relationship. The type of quasi-experimental design adopted was the non-equivalent control group design. This is because intact classes existing in the primary schools were used in order not to disrupt school operations. Specifically the result of the experimental group which was taught using the field-based inquiry method was compared with the control group, which was taught using the lecture method. Quasi-experimental design approximates the conditions of true experiments in a setting which does not allow control and manipulation of variables. Sambo [30] is of the view that it is natural to use existing classrooms in schools for a study and a lot simpler than to start creating classroom groups through random selection and random assignment. He further comments that the non-equivalent control group design is worth using when the true experimental designs are not possible.

4.2 Population

The study population consists of all Middle Basic 2 (5^{th} graders) pupils of the 118 government approved private primary schools in Makurdi, Benue state. Available data in the Ministry of Education statistic department, Makurdi area dated April, 2011 showed that there were 10,620 primary five pupils. Primary five pupils are particularly chosen because they are expected to have covered a significant amount of what should be taught in primary school in basic science and technology curriculum. The choice is also to check the interference of pupils' literacy level and the comprehension of concepts taught since at this level, most pupils can read and write.

4.3 Sample

The sample for the study consisted of three hundred and twenty-nine pupils from six schools selected by random sampling. Ali [31] said that smaller samples are preferred for experimental studies in order not to make the study unwieldy or intractable since experimental studies impose more rigorous demands on the researcher. The sample size was selected in consideration of the fact that the study was a quasi-experimental design and the time and attention primary school pupils needed to be given to do the activities. Purposive and random sampling was used to select six government-approved private schools within the different parts of Makurdi local government area. The purpose for choosing the private schools was to avoid interruption of the research work through any unforeseeable strike actions of teachers of the public schools.

4.4 Instrumentation

Acquisition of Science Process Skills Test (ASPST) was initially a 30-item practical test meant to elicit responses from pupils by applying the relevant process skills in performing activities with real objects available in the environment (on the field). The instrument was constructed by the researcher and patterned after Okoli's [32] Test of Science Process Skills Acquisition (TOPSA). The skills that were tested are observing, classifying, measuring, drawing and labeling correctly, making tables, recording data, experimenting predicting and inferring.

The instrument was also presented to the same set of three science education experts in the department of curriculum and teaching for validation and the 20 items that met the purpose of the research were used for data collection.

ASPAT and the two-types of lesson notes were given to two professors and a senior lecturer in science education, Benue State University for critical examination. They were requested to study the objectives of the research and ascertain if the items had face validity and content validity; that is, if they both covered the topics to be taught, were grammatically correct and tested the objectives of the topics treated and were relevant to the research objectives and questions. They were also requested to make their recommendations as to whether they were suitable for primary school children to appropriately interpret and respond to. Similarly, they examined the suitability of the lesson notes in teaching inquiry-focused lessons and lecture lessons. Some of the tests items were rephrased for clarity and easy understanding to the primary school pupils.

The lesson notes for field-based inquiry method were also corrected to highlight their specific use as well as align with the expected format of lesson note preparation. The corrected instrument and lesson plans were further subjected to trial testing and pilot study.

The scores from the trial testing were used for item analysis in order to determine the difficulty index of the test items for Basic Science and Technology Achievement Test. Only 25 items out of 30 initial items constructed were found to possess the acceptable difficulty index of 0.3 to 0.7. The twenty-five items were then used for reliability analyses of the instrument using Kuder Richardson 21. The reliability estimate for BSTAT was found to be 0.87. Sowell and Cassey in Ogbeba [33] explained that for achievement and intelligence tests, 0.80 is the required minimum internal consistency of the instruments. The reliability value of 0.87 was therefore considered to be adequate as a measure of internal consistency of the instrument.

ASPST served as pretest band post test. It was only reshuffled by item numbering and option position. This was intended to eliminate or reduce greatly pupils' familiarity with the instrument.

4.5 Data Collection Procedure

Six research assistant teachers were trained. The first phase of the training involved handing them with lesson plans written by the researcher for use. The method was explained to them and the objectives of the research were made known to them. The teachers were allowed to privately study the six lesson plans and another meeting was conveyed for them to ask questions and have their difficulties and doubts cleared. The second phase involved taking a walk round the school premises to find out the possibility of teaching the individual lessons in their respective school environments. The research assistants helped mainly in conducting test and marking.

The researchers along with the research assistants went round to conduct the pre-test in the six schools selected. The teachers were allowed to teach for six weeks, with occasional visits from the researchers to clarify issues and observe lessons. The experimental group was taught using the field-based inquiry method while the control group was taught using the conventional strategy. After the six weeks teaching the researcher went round the schools to administer the post-test having reshuffled the items in the BSAT. All teachers who participated in the teaching were duly motivated. Where pupils needed exercise books they were supplied with some. All the tests were administered and marked by the researchers and research assistants.

5. RESULTS AND DISCUSSION

5.1 Results

Mean and standard deviation were used to answer the research questions. All the hypotheses were tested using Analysis of Covariance (ANCOVA) in agreement with Ali [31] who asserted that it is a more rigorous statistics than Analysis of Variance (ANOVA) and is used for multi-group comparison. He further stated that ANCOVA is specifically used in a pre-test/post-test quasi experimental research design and/or when subjects are selected. When intact classes are used for treatment and control respectively, the gain score, the difference between the pre and post test means are analyzed to determine the statistical significance between and within groups, as covariates between pre-test and post-test.

5.1.1 Research question 1

What is the difference in pupils' acquisition of science process skills when taught using field-based inquiry method and lecture method?

The results of data analysis to answer this research question is as presented in Table 1.

Table 1 shows that the mean gain that is the difference between the pretest and posttest means of the experimental group which was taught using the FBIMI was 5.86 and that of the control group which was taught using lecture method was 3.80. The mean difference of 2.07 existed in favour of the experimental group. This implies that pupils taught using the FBMI achieved higher on the ASPST than their counterparts who were taught using the lecture method.

This difference was further investigated by testing hypothesis three.

5.1.2 Hypothesis 1

There is no significant difference in the mean process skills scores of pupils taught science using the FBIMI and those taught using the lecture method.

The results of data analysis to test hypothesis 3 is as presented in Table 2.

Table 2 shows that calculated F value 75.62 was significant because P value of 0.001 is less than 0.05 alpha value. Therefore the null hypothesis was rejected. This implies that there is a significant difference between the acquisition of science process skills of the experimental group taught using the FBIMI and those taught using the lecture method.

5.1.3 Research question 2

How do boys and girls differ in their mean scores on acquisition of science process skills when taught using the FBIMI?

The results of data analysis to answer this research question is as presented in Table 3.

Table 1. Means and standard deviation for pretest and posttest for experimental and control groups in ASPST

Method		Pre-process skill	Post-process skill	Mean gain
Field-Based Inquiry Method (FBMI)	Mean	9.0330	14.8956	5.8626
	N	182	182	
	Std. Deviation	3.1164	3.0889	
Conventional Strategy	Mean	7.0884	10.8844	3.7960
	N	147	147	
	Std. Deviation	2.9235	3.5799	
Mean Gain Difference				2.0666

Table 2. Results of test of between subjects effects for students process skill acquisition by method

Source	Type III sum of squares	Df	Mean square	F	Sig.
Corrected model	2478.773a	4	619.693	82.704	.000
Intercept	2500.700	1	2500.700	333.741	.000
Pre process skill	1138.368	1	1138.368	151.925	.000
Method	566.601	1	566.601	75.618	.0001
Gender	.068	1	.068	.009	.924
Method*Gender	11.339	1	11.339	1.513	.220
Error	2427.714	324	7.493		
Total	61395.000	329			
Corrected total	4906.486	328			

R Squared = .505 (Adjusted R Squared = .499)

Table 3. Mean and standard deviation for pretest and post test for experimental male and female students in ASPST

Gender		Pre Process Skill	Post Process Skill	Mean Gain
Male	Mean	8.9806	15.0388	6.0582
	N	103	103	
	Std. Deviation	3.0454	2.9270	
Female	Mean	9.1013	14.7089	5.6076
	N	79	79	
	Std. Deviation	3.2249	3.2978	
Mean Gain Difference				0.4506

Table 3 shows the mean gain of male pupils to be 6.06 and that of female to be 5.61 with a mean difference of 0.45 in favour of males.

To ascertain the significance of this difference the hypothesis seven was tested.

5.1.4 Hypothesis 4

The mean process skills scores of boys and girls who are taught using the FBIMI will not differ significantly.

The results of data analysis to test hypothesis 7 is as presented in Table 4.

Table 4 shows that the calculated F value of 0.95 was not significant at 1 and 181 degrees of freedom because the P value of 0.33 was higher than 0.05 alpha value. This implies that there is no significant difference in the mean score acquisition of science process skills by male and females under the FBIMI. The null hypothesis was therefore not rejected, meaning that gender is not a significant factor in process skills acquisition of pupils.

5.2 Discussion of Findings

The study was centered on the impact of a field-based inquiry method of instruction on pupils' science achievement, retention and acquisition of science process skills. Since primary schools are usually males and females, gender was incorporated as one of the variables. Discussion of results is based and tailored along the variables in the study as guided by the results of research questions and hypotheses.

Results in Table 1 show that pupils in the experimental group had higher mean score on the ASPST than their counterparts in the control group. This observation was further confirmed in the hypothesis testing in Table 2. It therefore implies that, method is a significant factor in acquisition of science process skills. This means that the use of FBIMI enhances acquisition of science process skills above the lecture method. That is what the National Research Council [29] meant when it emphasized that effective teaching methods must reflect the nature of the particular discipline in question. Science by its nature is content and process and should not be taught by mere exposition of content to those learning to be scientists but rather emphasis should be placed on students' acquisition of the process of science which are basically stable over time.

Pupils' were seen to be very active in class and sometimes gave answers that sounded like superstition. For instance a pupil when asked

Table 4. Results of test of between-subject effects for experimental students process skill acquisition by gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	443.987a	2	221.994	30.971	.000
Intercept	2057.419	1	2057.419	287.038	.000
Pre Process Skill	439.119	1	439.119	61.263	.000
Gender	6.808	1	6.808	.950	.331
Error	1283.029	179	7.168		
Total	42109.000	182			
Corrected Total	1727.016	181			

R Squared = .257 (Adjusted R Squared = .249)

why red litmus paper changed to blue explained that because the container in which the ash mixture was poured was blue but after practice with lemon juice, blue litmus turned red in the same container, pupils understood the test for bases and acids. No amount of verbal explanation could bring about such understanding to the mind of a young child. As pupils came in contact with materials in the environment, permanent impressions were created and observed in their performance on the ASPST. Children could also draw better things they saw practically than those they only saw in text books [19,22,32]. Another key observation was the arousal of their curiosity as they requested for pieces of litmus paper to take home for more practice.

Nugent, Kunz, Levy, Harwood and Carson [17] discovered in their study that direct field experiences with opportunities for active, authentic scientific investigation offers promise of helping pre-science teachers develop the needed skills for inquiry-based teaching, this assertion agrees with the findings of this research. Okoli [32] also confirmed that students taught biology concepts by investigative laboratory approach performed better on Test of Science Process Skills Acquisition (TOPSA) than those taught using the lecture method. Furthermore, these findings agree with what Matyas [10] and Polman [9] said that inquiry curricula and pedagogy addresses the need of enhancing learning of both content and skills [equally supported by 11, 20] as it was observed that the experimental group performed better both on the BSTAT and the ASPST.

It is found both that boys and girls had similar mean scores on their acquisition of process skills when taught using FBIM. The difference was found to be insignificant. This implies that gender is not a significant factor in the acquisition of science process skills by primary school. The works of Okoli [32] also discovered no gender disparity in acquisition of science process skills. I-shin [34]; Gbodi and Dantani [35] Manning [23 and Lee [24] also found that gender was an insignificant factor in science learning this applies to skill acquisition.

6. CONCLUSION

The teaching method FBIMI is an important factor in science instruction, and thus skill acquisition depended on the method of teaching (FBIMI). The study revealed no gender disparity in process skill acquisition with the use of FBIMI at primary school level. If the right method is employed for teaching it is hoped that both boys and girls will continue to acquire process skill equally well in their science career.

7. RECOMMENDATIONS

The following recommendations are made based on the findings of this research:

1. FBIMI is very suitable for pupils of primary school age therefore, Basic Science and Technology Curriculum by NERDC should include the use of outdoor, field-based experiences among its teaching and learning materials in column six of the Basic Science and Technology Curriculum. School supervisors should also ensure that teachers use it as teaching method for basic science and technology.
2. Teacher training institutions such as colleges of Education, University Faculties of Education should train pre-service teachers in the use of FBIMI
3. Proprietors should make school environment conducive for the use of FBIMI. Teaching aids like school gardens and animal farms should be necessary features of schools.

4. The result showed that FBIMI is gender-friendly as it does not discriminate in its impact on pupils' acquisition of process skills in science. Both male and female learners should be given equal opportunities.
5. Teachers should not restrict themselves to the four walls of the classroom they should explore the environment as they lead pupils to study phenomena and materials on the field.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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