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EFFECT OF LABORATORY INSTRUCTION PLAN ON SCIENCE EDUCATION STUDENTS ACQUISITION OF PRODUCTION SKILL IN CANDLE MANUFACTURE IN FEDERAL UNIVERSITIES IN SOUTH-EAST, NIGERIA

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Abstract
This study determined the effect of laboratory instruction plan on science education students' acquisition of production skill in candle manufacture in federal universities in south-east zone of Nigeria. Two research questions and one null hypothesis guided the study. Quasi experimental research design was adopted for the study with a sample of 98 third year (300level) science education students' randomly selected from two out of four federal universities that offers science education programmes in south-east zone of Nigeria. Candle Production Skills Rating Scale (CPS_RS) was the instrument used for data collection. The CPS_RS was validated by five experts (three from science education and two from educational measurement and evaluation). Cronbach alpha reliability coefficient of 0.83 was established. Treatment in the two groups lasted for four weeks. Mean, standard deviation and analysis of covariance (ANCOVA) were used in analyzing the data. The findings revealed that students who were exposed to laboratory instruction plan attained higher production skills in candle manufacture than those taught using the conventional plan. It was concluded therefore that the use of laboratory instruction plans improved students' acquisition of production skills in candle manufacture. Based on the findings, it was recommended among others that science education lecturers should make their students become acquainted with candle manufacture using the laboratory instruction plan in order to develop production skills that will make them resourceful, self-reliant and employer/boss of labor upon graduation.

Keywords: laboratory instruction plan, science education, students, production skills, candle manufacture

Introduction

Science education courses like chemistry, biology and physics are among the main science subjects that encompass valuable activities. Some of those activities can be done practically or by theory. It can also be such that would make the learner acquire the requisite skills for a better future and livelihood. Because of how useful science education programmes/courses are to Nigeria as a developing nation, its teaching and learning at university level in Nigeria is expected to produce persons that are capable of being self-sufficient. Such individuals are expected to be employer of labour and independent and also have unlimited desire for science subjects, but today the reverse is the case.

In Nigerian universities, science education courses like chemistry, biology, physics and mathematics were part of the core science and general courses offered by all freshmen (year one) students at both first and second semesters in a session and its teaching and learning involves much of practical and laboratory activities. The practical activities carried out by the students in the laboratory provide the foundation for technical growth and equips them resourcefully with more process skills (Yadav and Mishra, 2023). Since science education courses/subject based more on experimentation, students' active involvement in the courses/subject needs to be encouraged by teaching it through practicable plan (Mahdi, 2021). These activities as stated by Ogunbiyi, (2024) include, touching, seeing, feeling, weighing, measuring, demonstrating, carrying out tests/experiments and any other practical activities in the laboratory.

Science education lecturers/teachers mostly in Nigerian universities have been lecturing/teaching science education courses using conservative plan such as talk technique, discussion and demonstration to ensure that the subject is well taught and understood by their students. Despite the application of these practices, students have not really been performing up to expectations (Omiko 2021; Okeke 2025). This could be because conservative plans do not actually give learners the privilege to contribute objectively during instruction and learning, therefore they become inert listener during lessons thus making the learners see the subject as a nonconcrete and boring subject (Cheung, 2022). Numerous studies had been undertaken to examine trends in students' achievement in science education and the factors influencing basic science learning. Regrettably, successive efforts to improve the teaching and learning of science courses/subject have not produced adequate development in students' performance in the courses/subject (Kirui and Kaluyu, 2018). This could be attributed to none acquisition of required skills in laboratory work by the students/learners.

Babafemi, (2023) and Odutuyi, (2025) suggested that students' skills acquisition and achievement in science could be improved by the application of innovative and quality instruction plan which can be useful in solving real life challenges. Alaribe (2020) and Uwaleke, Offiah and Okechukwu (2014) stated that teachers should help students acquire skills in science courses by reducing the rate of teaching the subject theoretically. It therefore becomes imperative to look for interventions that could be put in place to improve learning outcomes.

Across Nigeria, with particular reference to south-east zone in particular; great emphasis is being placed on industrial, technological development and advancement (Egolum, Njelita, and Ezeokeke, 2024). Studies conducted by researchers like, Terwase, et al (2019), Okigbo and Osuafor (2018) and Omiko (2021) has shown that some relationship exists between students' acquisition of skills when different technique are used, although their studies were mostly on automobile electric works and mathematics. The researchers were not aware of any current attention directed towards ascertaining the effect of laboratory instruction plan on science education students' acquisition of production skills in candle manufacture especially at university level and south-east zone of Nigeria.

Production skill can be defined as the process employed to transform tangible inputs (raw materials) and intangible input (ideas, information and knowledge) into goods. Okeke (2025) identified the following as some of the attributes/qualities one should possess for producing good/quality products: knowing what to produce, that is the definition of what you want/intend to produce; knowing the material to be used for/in the production; being able to know the accurate volume, quantity or measurement of the recipes/materials to be used for/in the production process and knowing the right steps to follow in order to have a quality product at the end of your production.

Production skill in candle manufacture is therefore the expertise to produce candle or transform raw materials into candle, which can be in small or large quantities. This implies that lecturers/teachers generally and science education lecturers/teachers in particular need to acquire the skills for effective teaching and learning to take place especially during practical (Okenyi, Olehi and Njoku, 2020). The researchers believe that when science education students acquire production skills like the ones needed in the production of candle, liquid soap, bleach, paint, shoe polish among others from their knowledge of science education/basic science (chemistry, biology and physics) in the university, they will become self-reliant after graduation. This corroborate Eze (2022); Egolum, Njelita, and Ezeokeke (2024) that if students are taught the production of simple valuable/consumable goods like matches, candles, ice cream, detergents and soaps through environmental and industrial chemistry/sciences, they can acquire self-reliant skills to create jobs for themselves and for others when they graduate. It is assumed that if science education students in Nigerian universities and south-east zone precisely, can effectively acquire production skills in candle manufacture before completing their university education, they will become self-reliant later in life, which can result in improve academic performance in the subject.

This study is based on Bruner's (1966) constructivist theory of learning which states that learning is an active process in which learners construct/acquire new knowledge/ideas based upon the current or past knowledge. Bruner's theory on discovery learning is an approach where the learner discovers, produces/manufacture things for himself/herself. Bruner's theory suggests that children must be motivated and challenged to learn, but this should be within their level of maturational readiness and cognitive abilities. However, the awareness of these cognitive developments by the science education lecturers/teacher and a conversion of the awareness into teaching especially in the chemistry, biology and physics (science education) laboratory will be a great challenge to the learner. The laboratory and the conventional plan of teaching science education courses will serve as a motivator and challenge to science education students. Hence, Brunner's constructive learning theory provides the theoretical base for this study which sought to determine how the use of laboratory instruction plan affects science education students' acquisition of production skills in candle manufacture.

Indication from studies in Nigeria shows that exposure to laboratory apparatus activities on acquisition of process skills is effective in enhancing students' science process skills and academic performance on difficult concepts (Babafemi, 2023). It was also found that laboratory-based instructional intervention on the learning outcomes of low performing senior secondary students in Physics, Mathematics and Automobile Electric Works yields better performances of SSII students than exposure to conventional plan (Ogunbiyi et al. 2024; Terwase et al. 2019). Although these studies are related to the present study in terms of exposure to laboratory activities but they are different in terms of education level, area, location, sample and design.

Purpose of the Study

The purpose of this study was to determine the effect of laboratory instruction plan on science education students' acquisition of production skill in candle manufacture in federal universities in south-east zone of Nigeria. Specifically, the study sought to determine the difference in mean production skill acquisition scores of federal university science education students taught candle manufacture using laboratory instruction plan and those taught using conventional plan.

Research Question

The following research question was posed for study:

1. What is the are the mean production skill acquisition scores of federal universities science education students taught candle manufacture using laboratory instruction method and those taught using conventional method?

Hypothesis

The following hypothesis was formulated and tested at 0.05 level of significance.

Ho_1: There is no significance difference in the posttest mean production skills scores of federal universities science education students exposed to laboratory instruction plan and those exposed to conventional plan after controlling for pretest.

Method

The study adopted a quasi-experimental research design which was focused on science education students from federal universities in south-east zone of Nigeria. It was aimed at determining the effect of laboratory instruction plan on third year (300level) science education students' acquisition of production skills in candle manufacture. Population of the study comprised all the 308 third year science education students in the four federal universities in south-east zone of Nigeria that offers science education courses/programmes. The universities are:

- *Alex Ekwueme, Federal University, Ndufu-Alike Ikwo (AE-FUNAI), Ebonyi State, Nigeria*
- *University of Nigeria Nsukka (UNN), in Enugu State, Nigeria*
- *Nnamdi Azikiwe University (NAU), Awka, in Anambra State Nigeria; and*

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- *Micheal Okpara University of Agriculture, Umudike (MOUAU), in Abia State Nigeria.*

A sample of ninety-eight (98) third year science education students was randomly selected from two (2) out of the four (4) federal universities in the zone that are offering science education courses. Candle Production Skills Rating Scale (CPS_RS) was the instrument used for data collection which was validated by experts from science education and educational measurement and evaluation.

The CPS_RS was designed to measure the extent to which students acquired production skills in candle manufacture/making. The scale consists of two sections A and B. Section A sought information on each student's school and sex, as well as date of the rating; while section B sought information on candle manufacture/production. It was assumed that any science education student who acquires production skills of candle manufacture should be able to identify the materials needed for the manufacture of candle, know the procedure to adopt, observe and reason from specific to more general principle in the specific process, as well as possess the ability to measure accurately the required quantity of materials needed for the manufacture of candle. Section B also has to do with rating the extent to which each student acquires the production skills in candle manufacture compared with students you know, using the following 4-point rating scale. Significantly Less Able (SGLA) = 1, Slightly Less Able (SLLA) = 2, Slightly More Able (SLMA) = 3, Significantly More Able (SGMA) = 4

Since candle manufacture involves eighteen (18) procedures/processes which yield a total acceptable score of 2.50 x 18 = 45.00. Therefore, in interpreting data for research questions 45.00 and above was used as benchmark to determine the effect of laboratory instruction plan on science education students' acquisition of production skills in candle manufacture. The reliability of the CPS_RS was established using Cronbach alpha method with a sample of 42 third year science education federal universities students from south-south zone of Nigeria which is outside the study area. The reliability co-efficient was 0.83 which is considered high and acceptable for the study.

Before the commencement of the experiment, the two federal universities chosen for this study (Alex Ekwueme Federal University Ndufu-Alike Ikwo 'AE-FUNAI', Ebonyi State, Nigeria and Nnamdi Azikiwe University, Awka 'NAU' Anambra State, Nigeria) were assigned to experimental and control groups by simple flip of a coin. Prior to the experiment, third year science education students in the two sampled groups were taken to the science education laboratory and the raw materials needed for the manufacture of candle were displayed on the laboratory benches and students were asked to use the materials to make candle and as they are doing it, the researcher along with the science education lecturers/teachers who were adequately trained rated them using the CPS_RS. This served as the pre-test and no feedback on the pre-test was given to them.

Data collection started after all the 98 randomly selected third year (300level) science education students from the two federal universities have been taught how to manufacture/make candle. The following materials were used for candle manufacture: candle wax, stove or gas for heating, thread, the candle mould, steric acid, color/pigment, petroleum jelly, perfume/fragrance, and vessel (example, pot) respectively. This could be called the recipes or raw materials used in candle manufacture. As their regular science education lecturers along with the researchers' was teaching them practically how to make candle, students learnt and produced theirs as well because all the recipes/materials needed for the production were made available by the researchers and were placed on their benches. The lecturers/teachers made use of the lesson plan prepared for the experimental group to serve as guide during the manufacture process. The lecturing/teaching took place in science education laboratory at the time of their normal lesson. Students were properly exposed on how to make/produce candle.

Also the science education lecturers/teachers with the guidance of the researchers taught the control group the same topic: candle manufacture. The control group was also exposed to how to make candle with the conventional lecture plan. The time for their normal lesson was used in conducting this study and the teaching also took place in their science education laboratory. The reason for using the science education laboratory to teach the control group was for them to be exposed to the same learning environment as the experimental group.

At the end of the four weeks teaching exercise all the students in the two intact classes (experimental and control groups) were rated on acquisition of production skills in candle manufacture using the CPS_RS immediately after the treatment. Mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypothesis at 0.05 levels of significance. The results of data analysis are presented in Tables 1 and 2.

Results

What is the difference between the mean production skill acquisition scores of federal universities students taught candle manufacture using laboratory instruction method and those taught using conventional method?

Table 1.
Mean and Standard Deviation of the Production Skills Acquisition Scores of federal university Students' taught candle Manufacture using Laboratory and Conventional Instruction Plans

Instruction Plan	n	Pretest		Posttest		
		Mean	SD	Mean	SD	Gain
Laboratory Plan	50	30.46	7.55	53.36	3.57	22.90
Conventional Plan	48	28.96	3.04	43.20	4.36	14.24

Table 1 shows that students that were exposed to laboratory plan had a pre-test mean score of 30.46 with a standard deviation of 7.55, while the post-test mean score was 53.36 and standard deviation of 3.57. The mean gain score between the pre-test and post-test for the experimental group was 22.90. The standard deviation of 7.55 at pre-test and 3.57 at post-test for the experimental group indicates that as the group mean score increases, the variability of the scores also increases somewhat. The students taught candle manufacture using the conventional plan had a pre-test mean score of 28.96 and a standard deviation of 3.04 and a post-test mean score of 43.20 and a standard deviation of 4.36. The mean gain scores of the experimental and control groups are 22.90 and 14.24 respectively. This implies that the students exposed to laboratory plan, acquired more production skills in candle manufacture than those in the control group. The post-test mean score of 53.36 as against the benchmark of 45.00 suggests that laboratory plan is effective in enhancing production skills acquisition in candle manufacture.

Result in Table 1 also reveals that with posttest mean score of 53.36 as against the benchmark of 45.0, student's acquisition of production skills in candle manufacture increased in level. Also the post-test means scores in both groups is higher than the pre-tests in the two plans (pretest 30.46 - posttest 53.36) and (pretest 28.96 – posttest 43.20) respectively.

Table 2.
Analysis of Covariance (ANCOVA) test for difference in the mean production skills acquisition scores of students taught candle manufacture using laboratory and conventional plans

Source	Type III Sum of Squares	Df	Mean Square	F	P-value
Corrected Model	2524.256[a]	2	1262.128	85.097	.000
Intercept	8094.510	1	8094.510	545.758	.000
Pretest	.428	1	.428	.029	.866
Method	2472.882	1	2472.882	166.730	.000
Error	1409.009	95	14.832		
Total	233388.000	98			
Corrected Total	3933.265	97			

Table 2 shows a one-way ANCOVA which was conducted to compare the effectiveness of teaching candle manufacture (laboratory plan and conventional plan) while controlling for pretest effect. The Table shows that there was a significant difference in the mean posttest scores [F(1, 95) = 166.730, *p* = .000]. This means that the observed difference in mean posttest production skills of the students taught with laboratory plan and conventional plan as shown in Table was significant and cannot be attributed to error associate with the study.

Discussion

The finding of this study shows that there is a significant difference between the mean production skills acquisition scores of science education students taught candle manufacture using the laboratory and conventional plans in favor of laboratory group. Students' level of acquisition of production skills in candle manufacture increased when exposed to laboratory and conventional plans as can be seen in their respective pretest and posttest mean scores.

The findings of this study is consistent with findings of Okeke (2025) , Udosen (2015) and Babafemi (2023) that students exposed to laboratory plan acquires more production skills than those exposed to the convention plan. The results of this study also corroborates the findings of Katcha and Wushishi (2015) and Onwukwe (2011) which revealed that the use of the laboratory plan aids science education students to develop scientific skills for practical's and problem solving more than the conventional plan. It agrees with Eze (2022), Omosewo (2014), Ojirindan, Oludipe and Ehindero (2014) and Terwase et al. (2019), who call for a shift from the conventional lecture plan of instruction to innovative instruction plan in teaching Science and Technology for efficiency. The finding may be credited to the fact that laboratory plan is based on the principles of learning by doing, observation and proceeding from concrete to abstract. The implication is that laboratory plan should be used as a more effective strategy of enhancing students' acquisition of production skills in candle manufacture and other products than the conventional lecture plan. Using laboratory plan can enhance the development of entrepreneurial skills needed for making science education students resourceful, employers of labor and self-sufficient.

Conclusion

Based on the findings of the study, it was concluded that laboratory plan was effective in enhancing federal universities science education students' acquisition of production skills in candle manufacture.

Recommendations

1. Science education universities students should be exposed by their lecturers/teachers to the use of laboratory plan since the findings have shown that laboratory plan enhances the acquisition of production skills in candle manufacture.
2. Science education lecturers/teachers should endeavor to identify the level of acquisition of production skills by students.
3. Lecturers/teachers should therefor put in place well-thought-out instructional plan that will help students develop high level production skills which will enhance their attainment in science education and other life endeavors.

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APPENDIX

CANDLE PRODUCTION SKILLS RATING SCALE (CPS-RS)

Dear Rater,

The Candle Production Skills Rating Scale (CPS-RS) is designed to measure the extent to which third year (300level) science education students possess production skills required for candle manufacture. The scale consists of two sections A and B. Section A seeks information on each students, school and sex, as well as date of the rating; while section B – seeks information on candle manufacture/production.

It is assumed that any science education student who possess production skills of candle making should be able to identify the materials needed for the production/manufacture of candle, know the procedure to adopt in making candle, observe and reason from specific to more general principle in the specific process, as well as possess the ability to measure accurately the required quantity of materials needed for the production/manufacture of candle.

Section A: Students Personal Date

Name of the Student____

Name of your School____

Sex: Male ( ) Female ( )

Date__________________________________

Section B: Production/Manufacture Skills

Rate the extent to which each student possess the production/manufacture skills in candle compared with students you know, using the following 4-point rating scale.

Significantly Less Able (SGLA) = 1
Slightly Less Able (SLLA) = 2

Slightly More Able (SLMA) = 3
Significantly More Able (SGMA) = 4

S/No	CANDLE PRODUCTION SKILLS	SGLA (1)	SLLA (2)	SLMA (3)	SGMA (4)
	Materials for candle production				
1	Candle wax	1	2	3	4
2	Stove or gas for heating	1	2	3	4
3	Thread	1	2	3	4

4	The candle mould	1	2	3	4
5	Steric acid	1	2	3	4
6	Color/pigment	1	2	3	4
7	Petroleum jelly	1	2	3	4
8	Perfume/fragrance	1	2	3	4
9	Vessel (example, pot)	1	2	3	4
	Procedure for candle production				
10	Add parafin wax, steric acid into the cooking vessel (pot) **/** The candle wax which is in a solid form is being melted by subjecting it to heat	1	2	3	4
11	Put pigments, if you want to produce colored candle must be oil soluble	1	2	3	4
12	Heat the mixture to a temperature range of 100^{O}C or 120 ^{O}C	1	2	3	4
13	Put the wick/thread at the middle of the candle mould / The thread is being ran through the mould	1	2	3	4
14	Drain the mass of molten mixture (molten mixture is a mixture that has been reduced from solid to liquid form) by heating the candle mould / Then the melted wax is poured into the mould and allowed to cool down	1	2	3	4
15	Allow the molten mixture to cool in the mould by circulating water through the surface of the candle mould / It then solidifies and assumes the shape of the mould when removed from the mould	1	2	3	4
16	Hardener can be added to increase the hardness of the candle stick	1	2	3	4
17	Drive the piton plate into the mould to bring out the finished product (that is, the candle stick)	1	2	3	4
18	The candle is now set and okay for use	1	2	3	4