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EFFECTS OF INSTRUCTIONAL MATERIALS, GENDER AND COGNITIVE ABILITY ON STUDENTS` ACADEMIC PERFORMANCE IN BASIC SCIENCE AND TECHNOLOGY IN UYO, AKWA IBOM STATE, NIGERIA

By

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Abstract

This study investigated the effect of instructional materials, gender and cognitive ability on students' academic performance in Basic Science and Technology in Uyo, Akwa Ibom State. To achieve the objectives of this study four research questions were raised and four null hypotheses were formulated to guide the study. A non-randomized pre-test post-test control group design was adopted for the study. The population of the study was 5,365 while the sample size was 230 students. The students were drawn from three intact classes in three co-educational public secondary schools in Uyo. Basic Science and Technology Performance Test (BSTPT) and Basic Science and Technology Cognitive Ability Test (BSTCAT) were used for data collection. These instruments were validated and subjected to the split half method of reliability determination. The test items were split into odd and even numbered items and scored separately. The scores obtained were correlated using Pearson's Product Moment Correlation (PPMC) and Spearman Brown Formula of reliability determination. The result showed reliability coefficient of 0.70 and 0.78 for BSTPT and BSTCAT, respectively. Students in the experimental group 1 were taught energy transformation using integrated-energy-model, those in experimental group 2 were taught using flip chart while those in the control group were taught using chalk board. The data obtained from the tests after the treatments were analyzed using Analysis of Covariance (ANCOVA). All hypotheses were tested at 0.05 level of significance. The results indicated a significant difference in the mean academic performance scores of students taught energy transformation using integrated-energy-model, flip chart and chalk board. There was no significant difference in the mean academic performance scores of male and female students in the three treatment groups. There was a significant difference among the mean performance scores of high, average and low ability students taught energy transformation using integrated energy model, flip chart and chalk board with high cognitive ability students leading. There was no significant interaction effects of instructional materials, gender and cognitive ability on students` performance on the concept of energy transformation. Based on the findings, it is concluded that integrated-energy-model is most effective in enhancing students` academic performance on energy transformation than flip chart and chalk board. It was recommended among others that, Basic science and Technology teachers should prepare energy-models and use same in teaching energy transformation with appropriate instructional methods in their classroom interaction.

Key Words: Instructional materials, Gender, Cognitive ability, Students' Academic Performance, Basic Science and Technology

Introduction

Questions are often raised by man and answered in order to give meanings to events in nature. These meanings are associated with certain objects distinct from others, depending on the attributes of such objects and events. For example, when a solution of Sodium chloride (common salt) and water is heated to dryness, the salt particles are left behind. The question raised is: Where has the water gone to? Another example is when students in our secondary schools are exposed to certain topics in Basic Science Curriculum such as energy transformation and evaluation carried out, the students performed poorly as indicated in the Chief Examiners Report of Junior Certificate Examination (2023). What could account for the high failure rate in the academic performance of these students?

In attempt to answer such questions, more questions are raised and answered in a systematic manner. The act of systematic collection of information in order to give meaningful explanation to happenings and events in nature could be referred to as science. Biddle (2016) defined science as a dynamic and objective process of seeking knowledge and an enterprise that involves people searching, investigating, or seeking verification of natural phenomenon. Alake and Ogunseemi (2016) saw it as a conscious and systematic search for an organized knowledge about events. Science contributes to the quality of life in so many areas: health, nutrition, agriculture, transportation, material and energy production, and industrial development. It ensures that the air we breathe, and the water we drink are life sustaining and free from vectors of disease and decay. Science is taught at all levels of education in Nigeria (primary, secondary and tertiary levels).

At the primary and junior secondary school levels, Basic Science and Technology is offered. It seeks to lay the foundation for the development of scientific knowledge, skills and attitudes that will make the learner capable of understanding and manipulating events and happenings in the environment. The subject also affords the students the opportunity to learn about themselves. Archibong (2017) affirmed that Basic Science and Technology is a beginner science course in the junior secondary school and it aims at combining both Science and Technology practices to enable the Nigerian child develop powerful tools for understanding and interpreting the world as well as for solution of the problems of human adaption to the environment. Olarewaju (2019) concluded that, Basic Science and Technology being the first form of science a child encounters at the secondary school level, aims at preparing the students at the junior secondary school level for the study of core science subjects at the senior secondary level. This implies that for a student to be able to study single science subjects at the senior secondary school level successfully, such a student has to be well grounded in Basic Science and Technology at the junior secondary school level. In view of this, Basic science and technology is given great emphasis in the junior secondary school level as a core foundational science subject. However, the teaching of Basic Science and Technology is faced with a lot of challenges and these have resulted in students' poor academic performance in schools. It has been observed that most Basic science and Technology teachers in our schools use lecture and discussion methods most frequently in teaching concepts in their classrooms thus presenting facts and principles as contained in textbooks to the students on the chalkboard only. Abstract concepts such as energy transformation may not be fully presented and the mastery sufficiently achieved without adequate utilization of appropriate instructional materials. Concepts like this should be taught with hands-on activities using suitable resource materials from the environment in order to reduce the abstraction and eliminate the difficulty. Teachers should always aim at using instructional materials that could trigger the students to be fully, consciously and actively involved in the learning process. In view of this, Basic Science teachers have continued to search for better instructional materials that will provide the bridge between unfamiliar concepts and prior knowledge in order to improve students' performance and retention in Basic Science and Technology.

In an investigation on students' performance in Basic Science and Technology, Ekom *et al.* (2016) stated that students are not performing up to expectation in the subject. Ezeano (2017) reported that the poor achievement of students in Basic Science and Technology in external examination is caused by lack of teaching materials which result to insufficient practicals before the examination. Udo (2017) concluded that, students' poor performance at the secondary school sciences (Biology, chemistry and physics) is as a result of them not being properly groomed for such tasks at the upper basic level of education. To overcome this, government had decided to step up her policy on school supervision to make teachers more committed to duties among others. Unfortunately, this effort according to Ekom *et al.* (2016) only yielded minimal result because Basic Science and Technology teachers still see the Chalk board method of presenting lessons to students as the easiest and convenient method for teaching the subject without using appropriate instructional materials. Thus, researchers in the field of science have advocated the use of suitable concrete materials such as models and charts in teaching abstract concepts in Basic Science and Technology curriculum. It is on this basis that the researcher has constructed integrated-energy-model and flip chart and seeks to find out the effects of these materials on students` academic performance and retention on the concept of energy transformation in Basic Science and Technology.

An integrated energy model is a large circuit board made up of a thin wooden board fixed at right angle to the base stand, a 6v bulb, a small piece of nichrome wire, a 6v toy motor with plastic fan blades, an iron bolt with several windings insulated copper wire (electro magnet) and two metal washers (one of copper and the other of iron) connected to the terminals, placed in plastic bottle voltameter with copper sulphate solution. These are connected in parallel with wires through sockets with a switch. The terminals are connected to a 2A battery eliminator ranging from 1.5v to 12v. A solar collector is attached to the board to charge the battery in the absent of an alternating power supply. If the circuit is switched ON, the bulb will glow, the nichrome wire will turn red hot, the fan blades will rotate, the iron bolt will attract small iron nails and electroplate. Through this model student learned how solar energy can be transformed into electrical energy, light energy, heat energy, mechanical energy, chemical energy and sound energy. The importance of this model in the teaching/learning of the concept "energy transformation" cannot be over emphasized as it supports learning contents, allow students to engage in the application of the concept, provides them with the background on the topic as well as show how the topic relate to

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other pertinent information on the subject. It also offers the students the opportunity to practice the concept and develop a product that demonstrates their level of understanding of the concept. The standard components of the model could be purchased and used by teachers in schools to demonstrate the concept of energy transformation with students. However, Effiong and Odey (2016) opined that, in the situation of our education system where inadequate resource materials for teaching science remains the order of the day, standard models may not be available for used by teachers in teaching science concepts such as energy transformation. In this case, teachers with or without the help of students can source for the components of the model, put them together and used to enhance their teaching- learning process. Another material that can be used in teaching energy transformation is flip chart.

A flip chart is a visual aid for presentations, consisting of large paper sheets hinged at the top that can be opened alternately. It provides information, parts of the message written or drawn in separate sheets, the sheets are then bundled into one (Koroka, 2023). Ngure (2024) stated that flip chart offers a visual alternative to traditional presentations, making information more accessible and engaging for students. Koroka (2023) added that the flexibility of the flipchart makes it easy to be used for teaching. During teaching, the teacher only needs to place the flipchart on an easel or hold it in such a way that students can have a clear view of it. This will aid in bringing about easy assimilation of the information by students thereby enhancing their academic performance and retention of the concept taught.

Other factors that can affect academic performance of students in basic science and technology are highlighted by Bosede (2018). Such factors include cognitive ability of students and gender. Students' cognitive ability level refers to the range of skills, knowledge and competencies that an individual student possesses in relation to learning and academic performance. Udo (2017) defined cognitive ability as a student`s intelligent quotient (IQ) or level of assimilation of information. It is the capacity of students to engage themselves meaningfully in any educational task. Adeyemo (2015), identified three ability levels in relation to teaching-learning situation namely: high, medium and low. Adeyemo (2015) noted that high ability learners are more intelligent than medium or low ability learners in solving task in science courses and maintained in his study on students; cognitive ability and competence in problem solving tasks in physics that, students' cognitive ability levels have significant influence on problem solving task. Eze (2020) stated that students ability level is an important feature that can help students succeed in an academic setting. Eze further added that, ability level is sometimes referred to as independent level as it relies on the student completing assigned work with little or no assistance. Information about students' ability level can be assessed through both direct and indirect measures. Direct measures include standardized tests, quizzes and exams, aptitude test and performance test which provides clear, quantifiable data on students' abilities while indirect measures include; classroom discussions, peer assessment, self-report measures and observational scales which provides valuable insights into student cognitive, emotional and social abilities, complementing traditional assessments. However, effort to promote equity and diversity in education are increasingly challenging gender stereotype and encouraging students to explore a wide range of interest and pursuit regardless of gender.

Gender is defined as a wide range of biological, behavioural, physical and mental characteristics regarding and differentiating the female and male population (Okeke, 2020).

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Gender is an aspect concerning the responsibilities, roles, opportunities, constraints and needs of males and females in all aspect of social context (Omotosho, 2019). Gender is the different socio-cultural stereotype roles and responsibilities expected of boys and girls. Some research works have shown contradicting evidence in students' academic performance in science due to gender. For instance, Umana (2019) and Udo (2024) asserted that there is no significant differences in the performance of male and female integrated science students while James and Alice (2020) observed gender differences in science favouring girls over boys.

James and Alice further added that the differences in performance of male and female students in science subjects are attributed to students' cognitive ability level in the concept learnt. These conflicting results and the inconsistency existing in literature on gender, pose a need to check if gender and cognitive ability level affects the academic performance of students taught the concept of energy transformation using Integrated-energy-model, flip chart and chalk board.

Statement of the Problem

In any science teaching and learning process, the main objective is to see that the learners are able to perform tasks and possibly transfer the experiences in solving problems to new situations and excel in both internal and external examinations. This objective is hardly achieved over the years. The rate of failure in Basic Science and Technology in recent time is a matter of concern to stakeholders which made many researchers to suggest that this ugly trend might have been due to the poor foundation of students in Basic Science and Technology. The poor performance of students in science in external examination has been attributed to several factors among which is the improper instructional delivery materials used by teachers during classroom instruction, Students` cognitive ability level and gender. These create the gap for this study on the effect of instructional materials, gender and cognitive ability on students' academic performance in Basic Science and Technology in Uyo, Akwa Ibom State.

Purpose of the Study

The purpose of this study is to investigate the effects of three instructional materials, gender and cognitive ability on students' performance on the concept of energy transformation in junior secondary schools in Uyo. Specifically, the study sought to:

i. find out the differences among the mean performance scores of students taught energy transformation using Integrated-Energy-Model, flip charts and chalk board, respectively.
ii. compare the mean performance scores of students taught energy transformation using Integrated-Energy-Model, flip charts and the Chalk board respectively based on gender.
iii. compare the mean performance scores of students taught energy transformation using Integrated Energy Model, flip charts and chalk board respectively based on cognitive ability.
iv. assess the interaction effects of Instructional materials, gender and cognitive ability level on students` performance in the concept of energy transformation.

Research Questions

The following research questions were raised to guide the study.

i. What difference exist among the mean performance scores of students taught energy transformation using Integrated Energy Model, flip charts and chalk board respectively?

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ii. What is the difference between the mean performance scores of male and female students taught energy transformation using integrated energy model, flip charts and chalk board respectively?
iii. What difference exists among the mean performance scores of high, average and low ability students taught energy transformation using integrated energy model, flip charts and chalk board respectively?
iv. Is there any interaction effect of instructional materials, gender and cognitive ability level on students` performance in the concept of energy transformation?

Research Hypotheses

The following research hypotheses were formulated to guide this study

i. There is no significant difference among the mean performance scores of students' taught energy transformation using integrated energy model, flip charts and chalk board.
ii. There is no significant difference between the mean performance scores of male and female students taught energy transformation using integrated energy model flip charts and chalk board.
iii. There is no significant difference among the mean performance scores of high, average and low ability students taught energy transformation using integrated energy model flip charts and chalk board.
iv. There is no significant interaction effect of instructional materials, gender and cognitive ability level on students` performance in the concept of energy transformation.

Methods

The design of the study was quasi-experimental research design. Specifically, the non-randomized pre-test- posttest control group design was used. The study was carried out in Uyo Local Government Area of Akwa Ibom State. The population size of this study was five thousand three hundred and sixty-five (5365). It consisted of all the JSS2 Students in the fourteen co-educational public secondary schools in Uyo Local Government Area in the 2024/2025 academic session. The choice of upper basic two (JSS2) students for this study was based on the fact that the concept energy transformation is taught in this class. The sample size of the study was 230 JSS2 students. The students were drawn from three (3) intact classes in three (3) co-educational public secondary schools in Uyo. Simple random sampling technique was used in selecting the three schools from the existing fourteen co-educational public secondary schools in Uyo. The three randomly selected schools were assigned as experimental group1, experimental group 2 and control group respectively by balloting, which pieces of paper served as ballots.

Two researcher-made instruments tagged; Basic Science and Technology Performance Test (BSTPT) and Basic Science and Technology Cognitive Ability Test (BSTCAT) were used for data collection. These instruments were validated and subjected to the split half method of reliability determination. The test items were split into odd and even numbered items and scored separately. Each correct answer was scored one (1) mark and incorrect answer scored zero (0). The scores obtained were correlated using Pearson’s Product Moment Correlation (PPMC) and Spearman Brown Formula of reliability determination. The result showed reliability coefficient of 0.70 and 0.78 for BSTPT and BSTCAT, respectively. On the basis of the high reliability values, the instruments were deemed suitable to be used for the study. The scores of the students on BSTCAT were used to categorized them into the three cognitive levels (high, average and low).

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The researcher-developed lesson packages for the three respective groups were used as guide by the research assistants. 79 students were used as experimental group 1 in the first school, 80 students as experimental group 2 in the second and 71 students as control group in the third school. Students in the experimental group 1 were taught energy transformation using the integrated energy model, those in experimental group 2 were taught the concept using flip charts while those in the control group were taught using chalk board. The classroom interaction lasted for four weeks in each of the groups after which the BSTPTET was administered as post-test to the three groups. The data obtained were analyzed using descriptive analysis, and Analysis of Covariance (ANCOVA) were used to test the hypotheses at 0.05 level of significance.

Results

Research Question 1: Research Question 1: What difference exist among the mean performance scores of students taught energy transformation using Integrated energy model, flip chart and chalk board respectively?

Table 1: Descriptive statistics showing the pretest and performance test scores of students` taught energy transformation using integrated energy model, flip chart and chalk board.

Instructional materials		Pre-test		Post-test		Mean Gain
	N	$\bar{x}$	**SD**	$\bar{x}$	**SD**	
Integrated Energy Model	79	5.26	3.92	38.59	12.71	33.33
Flip Chart	80	5.14	3.70	29.96	14.33	24.82
Chalk Board	71	5.12	3.10	27.32	13.59	22.20

Source: Field data (2025).

Results in Table 1 show that the mean pretest scores of students taught energy transformation using Integrated energy model, flip chart and chalk board are 5.26, 5.14 and 5.12 respectively with standard deviation scores as 3.92, 3.70 and 3.10 respectively, while their respective mean performance scores are 38.59, 29.96 and 27.32 with standard deviation scores as 12.71, 14.33 and 13.59 respectively. This indicates that the mean performance scores of the three groups (Integrated energy model, flip chart and chalk board) increased from pre-test to post-test.

The table also shows that the mean gain performance scores of students taught energy transformation using integrated energy model is 33.33, that of those taught with flip chart is 24.82 while that of students taught with chalk board is 22.20. This indicates that students taught energy transformation using integrated energy model performed better than those taught the concept using flip charts and chalk board with the mean differences of 8.51 and 11.13 respectively. Those taught with flip chart performed better than those taught with chalk board with a mean difference of 2.62

Research Question 2: What is the difference between the mean performance scores of male and female students taught energy transformation using integrated energy model, flip chart and chalk board respectively?

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Table 2: Descriptive statistics showing the pretest and performance test scores of male and female students' taught energy transformation using integrated energy model, flip chart and chalk board

Treatment Groups	Gender	Pre-test			Post-test		Mean Gain
		N	$\bar{x}$	SD	$\bar{x}$	SD	
Integrated Energy Model	Male	33	5.18	3.10	30.67	13.901	25.49
	Female	46	7.09	5.57	33.70	14.531	26.61
Flip Chart	Male	38	4.39	3.32	26.29	15.512	21.90
	Female	42	5.46	3.58	27.54	13.181	22.08
Chalk Board	Male	30	4.27	3.59	21.46	12.572	17.19
	Female	41	3.78	3.80	20.30	10.713	16.52

Source: Field data (2025).

In Table 2, the results show that the mean gain performance score of male students taught energy transformation using integrated energy model is 25.49 and that of their female counterparts is 26.61. The mean gain performance score of male students taught energy transformation using flip chart is 21.90 and that of their female counterparts is 22.08. The mean gain performance score of male students taught energy transformation using chalk board is 17.19 and that of their female counterparts is 16.52. It can be inferred from the results that female students performed higher than their male counterparts when taught energy transformation using integrated energy model and flip chart while male students performed higher than their female counterparts when taught energy transformation using the chalk board.

Research Question 3: What difference exist among the mean performance scores of high, average and low ability students taught energy transformation using integrated energy model, flip chart and chalk board respectively?

Table 3: Descriptive statistics showing the pretest and performance test scores of high, average and low ability students taught energy transformation using integrated energy model flip chart and chalk board.

Treatment Groups	Ability level	Pre-test			Post-test		Mean Gain
		N	$\bar{x}$	SD	$\bar{x}$	SD	
Integrated Energy Model	High	28	6.82	3.35	38.64	13.54	31.82
	Average	32	5.03	3.16	29.91	15.18	24.88
	Low	19	4.79	2.57	32.37	12.69	27.58
Flip Chart	High	22	5.99	3.42	31.91	14.96	25.92
	Average	35	5.02	3.35	27.06	14.21	22.04
	Low	23	4.46	3.58	21.41	12.39	16.95
Chalk board	High	20	5.89	3.13	23.40	13.04	17.51

	Average	30	5.25	2.89	19.67	11.82	14.42
	Low	21	4.98	2.67	15.70	8.523	10.72

Source: Field data (2025).

Results in Table 3 show the mean gain performance scores of students with high cognitive ability taught the concept of energy transformation using integrated energy model, flip chart and chalk board to be 31.82, 25.92 and 17.51, respectively. Students with average cognitive abilities taught energy transformation with integrated energy model, flip chart and chalk board had mean gain performance scores of 24.88, 22.04 and 14.42, respectively. Those with low cognitive ability taught with integrated energy model, flip chart and chalk board had mean gain scores of 27.58, 16.95 and 10.72 respectively.

This indicates that students with high cognitive ability in experimental group 1 (integrated energy model group) performed better than their counterparts in experimental group 2 (flip chart) and in the control group (chalk board) with the mean difference of 5.9 and 14.31 respectively. Students with high cognitive abilities in experimental group 2 (flip chart) performed better than their counterparts in the control group (chalk board) with the mean difference of 8.41. Students with average cognitive ability in experimental group 1 performed better than their counterparts in experimental group 2 and those in the control group with the mean difference of 2.84 and 10.46 respectively. Students with average cognitive ability in experimental group 2 performed better than their counterparts in the control group with the mean difference of 7.62. Students with low cognitive ability in experimental group 1 performed better than their counterparts in experimental group 2 and those in the control group with the mean difference of 10.63 and 16.86 respectively. Students with low cognitive ability in experimental group 2 performed better than their counterparts in the control group with the mean difference of 6.23.

The results in Table 3 also indicate that high ability students taught energy transformation using integrated energy model had the highest mean performance score when compared with that of average and low abilities students in that group with the mean difference of 7.94 and 5.24 respectively. The low ability students performed better than the average ability students with a mean difference of 2.7. Also, high ability students taught energy transformation using flip chart had the highest mean performance score when compared with that of average and low abilities students in that group with the mean difference of 3.88 and 8.97 respectively. Lastly, high ability students taught energy transformation using the chalk board had the highest mean performance score when compared with that of average and low abilities students in that group with the mean difference of 3.09 and 6.79 respectively.

Research Question 4: Is there any interaction effect of treatments, gender and ability level on students` performance in the concept of energy transformation?

Table 4: Estimated Marginal Means of male and female students' performance scores by treatments, gender and ability levels

Gender	Ability level	Instructional Materials		
		Integrated Energy Model $\overline{X}$	Flip Chart $\overline{X}$	Chalk board $\overline{X}$

Male	High	33.67	18.27	12.82
	Average	30.15	29.32	26.19
	Low	28.82	27.09	21.00
Female	High	41.00	34.50	19.22
	Average	29.74	24.37	22.47
	Low	37.25	24.55	18.67

The results in Table 4 show that the estimated marginal mean of male students with high cognitive ability taught energy transformation using integrated energy model, flip chart and chalk board is 33.67, 18.27 and 12.82 respectively. The estimated marginal mean of male students with average cognitive ability taught energy transformation using integrated energy model, flip chart and chalk board is 30.15, 29.32 and 26.19 respectively. The estimated marginal mean of male students with low cognitive ability taught energy transformation using integrated energy model, flip chart and chalk board is 28.82, 29.09and 21.00 respectively. This indicates that male students with high cognitive ability taught energy transformation using integrated energy model had the highest estimated marginal mean followed by that those taught with flip chart and those taught with the Chalk board had the least estimated marginal mean. The same thing applies to male students with average and low cognitive abilities in the three groups.

Table 4 also shows that the estimated marginal mean of female students with high cognitive ability taught energy transformation using integrated energy model, flip chart and Chalk board is 41.00, 34.50 and 19.22 respectively. That of female students with average cognitive ability taught energy transformation using integrated energy model, flip chart and Chalk board is 29.74, 24.37and 22.47 respectively and that of female students with low cognitive ability taught energy transformation using integrated energy model, flip chart and Chalk board is 37.25, 24.55 and 18.67 respectively. This indicates that female students with high cognitive ability taught energy transformation using integrated energy model had the highest estimated marginal mean followed by that those taught with flip chart and those taught with the Chalk board had the least estimated marginal mean. The same thing applies to female students with average and low cognitive abilities in the three groups.

It can be inferred from the results that the graph lines of ability levels (high, average and low) by gender of students (male and female) produced from the treatment groups (integrated energy model, flip chart and chalk board) are parallel and do not interact (see Fig.1 and 2) indicating that there is no interaction between the instructional materials, gender and ability level on students` performance in the concept of energy transformation.

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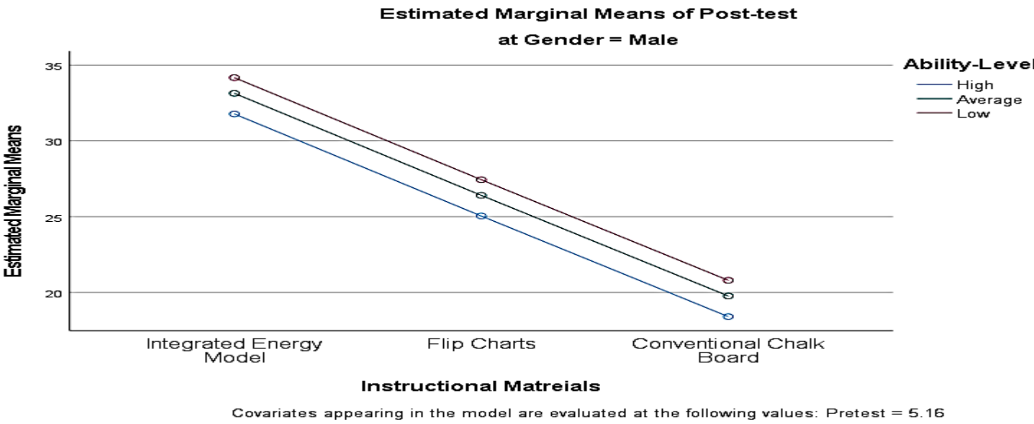

Figure 1: A graph of the interaction effect of treatments, gender and ability level on male students' academic performance on the concept of energy transformation.

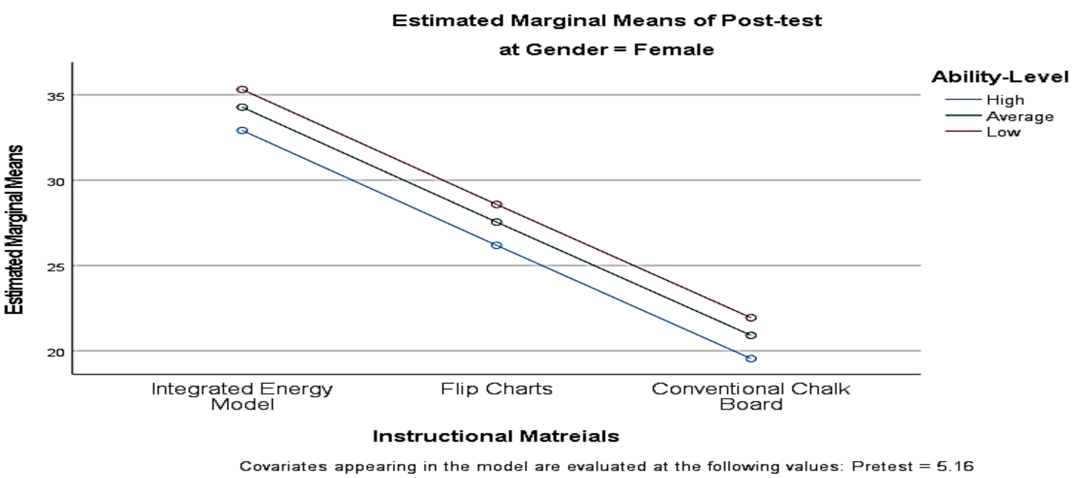

Figure 2: A graph of the interaction effect of treatments, gender and ability level on female students' academic performance on the concept of energy transformation.

Testing of the Null Hypotheses

Research Hypotheses 1, 2, 3 and 4 are reported respectively using Table 5.

Research Hypotheses 1: There is no significant difference among the mean performance scores of students taught energy transformation using integrated energy model, flip chart and chalk board respectively.

Table 5: Summary of Analysis of Covariance (ANCOVA) of students` post-test scores classified by instructional materials, gender and ability level with pretest scores as covariate

Source	Type III Sum of Squares	Df	Mean Square	F-value	P-value.
Corrected Model	15411.172[a]	18	856.176	5.708	.000
Intercept	86450.468	1	86450.468	576.338	.000

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Pretest	37.925	1	37.925	.253	.616
Materials	4446.364	2	2223.182	14.821	.000
Gender	2.689	1	2.689	.018	.894
Abilitylevel	8093.875	2	4046.938	26.980	.002
Materials * Gender	156.447	2	78.223	.521	.594
Materials * Abilitylevel	430.409	4	107.602	.717	.581
Gender * Abilitylevel	384.981	2	192.491	1.283	.279
Materials * Gender * Abilitylevel	415.986	4	103.997	.693	.597
Error	31649.889	211	149.999		
Total	284248.000	230			
Corrected Total	47061.061	229			

a. R Squared = .327 (Adjusted R Squared = .270)

Source: Field data (2025).

The results in Table 5 show that the calculated F-value (14.821) having a calculated p-value (.000) of the main effect of instructional materials on students` performance is less than the significant level (.05), therefore, the null hypothesis one is rejected. This implies that there exists a significant difference among the mean performance scores of students taught energy transformation using Integrated energy model, flip chart and chalk board. In order to determine the direction of significance, the scores were subjected to post hoc analysis as shown in Table 5.1.

Table 5.1: Summary of Scheffe's pairwise comparison of students` performance scores by Instructional materials.

(I) Instructional Materials	(J) Instructional Materials	Mean difference (I – J)	Std. Error	Sig.[b]
Integrated Energy Model	Flip Chart	8.632*	2.151	.000
	Chalk board	11.271*	2.218	.000
Flip Chart	Integrated Energy Model	-8.632*	2.151	.000
	Chalk board	2.639	2.211	.492
Chalk board	Integrated Energy Model	-11.271*	2.218	.000
	Flip Chart	-2.639	2.211	.492

*. The mean difference is significant at the 0.05 level.

Source: Field data (2025).

Table 5.1 shows the post hoc analysis of performance scores of students taught energy transformation using Integrated energy model, flip chart and chalk board. Students taught energy transformation using Integrated energy model and flip chart had significant higher performance when compared with those taught with the chalk board. A significant difference also existed between the performance scores students taught energy transformation using Integrated energy model and flip chart.

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Research Hypotheses 2: There is no significant difference between the mean performance scores of male and female students taught energy transformation using Integrated energy model, flip chart and chalk board respectively.

Results in Table 5 on the main effects of gender show that the calculated F-value (.018) having a calculated p-value (.894) is greater than the significant level (.05), therefore, the null hypothesis two is not rejected. This implies that there is no significant difference in the mean performance scores of male and female students taught energy transformation using Integrated energy model, flip chart and chalk board.

Research Hypotheses 3: There is no significant difference among the mean performance scores of students with high, average and low cognitive abilities taught energy transformation using integrated energy model, flip chart and chalk board.

The result in Table 5 on the main effects of cognitive ability level on students` performance shows that the calculated F-value (26.980) having a calculated p-value (.002) which is less than the significant level (.05), therefore, the null hypothesis three is not rejected. This implies that there is a significant difference in the mean performance mean scores of students with high, average and low cognitive abilities taught energy transformation using integrated energy model, flip chart and the chalk board. In order to determine the direction of significance, the scores were subjected to post hoc analysis as shown in Table 5.2.

Table 5.2: Summary of Scheffe's pairwise comparisons of the mean performance scores of students by cognitive ability level.

(I) Ability Level	(J) Ability Level	Mean Difference (I-J)	Std. Error	Sig.^{b}
High	Average	3.442*	1.403	.015
	Low	5.641*	1.525	.000
Average	High	-3.442*	1.403	.015
	Low	2.200	1.341	.102
Low	High	-5.641*	1.525	.000
	Average	2.200	1.341	.102

*. The mean difference is significant at the .05 Alpha level.

Source: Field data (2025).

Table 5.2 shows the post hoc analysis of students mean performance scores based on their cognitive ability. It indicates that students with high cognitive ability taught energy transformation using integrated energy model, flip chart and the chalk board performed significantly better than those with average and low cognitive abilities. The comparison between the mean performance scores of high and average ability students was significant, that of high and low ability students was also significant while that of average and low ability students was not significant.

Research Hypotheses 4: There is no significant interaction effect of treatments, gender and cognitive ability level on students' performance on the concept of energy transformation.

Results in Table 5 on the interaction effect of instructional materials, gender and cognitive ability level show that the calculated F-value (.693) having a calculated p-value (.597) is greater than the significant level (.05), therefore, the null hypothesis four is not rejected. This implies that there is no significant interaction effect of treatments, gender and cognitive ability on students' academic performance on the concept of energy transformation.

Discussion of Findings

The results of this study showed that there existed a significant difference among the mean performance scores of students taught energy transformation using integrated energy model, flip chart and chalk board. Students taught energy transformation using integrated energy model performed significantly better than those taught with flip chart and those taught with the chalk board. The observed significance effects of integrated energy model on students' performance in the concept of energy transformation may be attributed to the facts that the integrated energy model initiated, stimulated, motivated and rekindled the students to take active part in the learning process. It may also be due to the fact that the materials that make up the model are visual aids which provided a tangible representation of the concept, making it easier for the students to understand and remember. This finding agrees with the findings of Demirçalı, and Selvi (2022) who investigated the effects of model-based science teaching on students' academic achievements and science process skills for a science and technology course and reported that the model-based science teaching made a significant positive contribution to the development of the students' academic achievement and scientific process skills that might henceforth be successfully applied in science and technology courses. It also agrees with that of Akang, (2023) compared the effects of models, simulations and charts usage on achievement and retention of senior secondary school students in Biology in Akwa Ibom State and reported that there was significant difference in the mean achievement scores of Biology students taught using models, simulations, charts and textbook, with the students taught with simulations having the highest mean posttest scores, followed by models and charts while those taught with textbook had the least mean posttest scores.

On the aspect of gender, the results of this study showed that there is no significant difference between the mean performance scores of male and female students taught energy transformation using integrated energy model, flip chart and chalk board. Both male and female students performed at the same level in the three treatment groups. The insignificance difference between the performance scores of male and female students taught energy transformation using integrated energy model, flip chart and chalk board could be attributed to the fact that the materials captured the students' interest and make them develop deeper attachment and concentration to the concept taught. This indicated that the materials had same effects on gender. This is in line with the findings of Ani, Obodo, Ikwueze and Festus (2021), Mattox (2019), Berkant (2019) and Olupide (2017) who reported that gender is not a significant determinant of students' performance in science. This finding however disagrees with that of Eseine-Aloja (2021) and Nnamani and Oyibe (2016) who reported significant effects of gender on students' performance.

On the aspect of Cognitive ability, the results of this study showed that there was a significant difference between the mean performance scores of high, average and low ability students taught energy transformation using integrated energy model, flip chart and chalk board. High ability students performed significantly better than the average and low ability students in the three treatment groups. The observed significant effect of student`s cognitive ability on their academic performance on energy transformation may be attributed to the fact that, the materials captured the attention of students and aroused their interest in the learning process, offered opportunities for independent and individual learning, created concrete basic for conceptual thinking, as well as offered opportunities for the students to develop abilities and skills. This finding is in line with the findings of Gemma and Mjokaya (2024) and Adeyemo (2015) who reported in their studies that students' cognitive ability levels have significant influence on their academic performance in science.

The results of this study showed that there is no significant interaction effects of treatments, gender and cognitive ability on students` performance on the concept of energy transformation. A non-significant interaction effect between instructional materials, gender, and cognitive ability levels on student performance on the concept of energy transformation means that the effects of the instructional materials on student performance is not significantly different for different genders and levels of cognitive ability. In other words, the effectiveness of instructional materials does not significantly vary based on whether a student is male or female, or based on their cognitive abilities. It also implies that instructional materials can be designed and implemented without specific tailoring for different gender or cognitive ability levels. This finding is in line with the findings of Odo (2023) who investigated the interaction effect of instructional model, gender and cognitive ability on students' achievement, interest and retention in Mathematics and reported that there was no statistically significant interaction effect of instructional model, gender and cognitive ability on students' achievement and interest in Number and Numeration. The result of this findings however disagrees with that of Ani, Obodo, Ikwueze, and Festus (2021) who examined the interaction effect of treatments, gender and cognitive ability levels on Basic Science students' academic performance in secondary school and reported a significant interaction effect of treatment, gender and cognitive ability on students' academic performance in Basic Science and Technology.

Conclusion

Based on the findings, it was concluded that the integrated energy model is most effective in facilitating students' academic performance on energy transformation. Flip chart was also effective in facilitating students' academic performance on energy transformation. These two materials are not gender sensitive rather they are sensitive to student`s cognitive ability.

Recommendations

Based on the findings of the study, the following recommendations were made.

i. Basic Science and Technology teachers should prepare energy models and charts and use same in teaching energy transformation with appropriate instructional methods in their classroom interaction.
ii. Instructional models and flip charts helped encourage visualization and easy understanding of the concept taught. Therefore, the use of instructional models and flip charts in Basic Science classroom should be encouraged.
iii. The Federal, State and Local Government should in collaboration with the ministry of education purchase adequate and relevant science instructional models and charts and distribute to all secondary schools to enhance the teaching of various concepts in basic science.
iv. Seminars, workshops and conferences should be organized more frequently for basic science teachers to update their knowledge on the production and use of instructional models and charts.

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