Effect of 5E Instructional Design Model on Academic Achievement of Junior Secondary School Students in Basic Technology

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Abstract

This study investigated the effect of the 5E instructional design model on the academic achievement of junior secondary school students in Basic Science and Technology in Ogun State, Nigeria. The study was guided by two research questions and two hypotheses. The study adopted a quasi-experimental pretest–posttest non-equivalent control group design. A total sample of 136 students from two intact JSS II classes in two public junior secondary schools participated in the study. One group was taught using the 5E instructional design model, while the other group received instruction through the conventional lecture method. An instrument developed from past JSSCE questions, titled Work, Energy, and Power Achievement Test, was used to collect the data. The reliability coefficient of the instrument was found to be 0.82. Mean scores were used to answer the research questions, while Analysis of Covariance was used to test the hypotheses at 0.05 level of significance. The results revealed that students taught with the 5E instructional design model performed better than those taught with the conventional method. Findings also showed that there was no significant difference in the academic achievement of male and female students taught using the 5E model. The study concluded that the 5E instructional design model is an effective learner-centered strategy for improving students' academic achievement in Basic Science and Technology. It was recommended that 5E instructional design model should be adopted in teaching Basic Science and Technology.

Keywords: 5E instructional design model, academic achievement, Basic Science and Technology, junior secondary school, gender.

Introduction

Science and technology education is important to national development because it equips learners with the knowledge, skills, and attitudes required for participation in a technologically driven society. Basic Science and Technology is designed to introduce students at the junior secondary school level in Nigeria to the rudiments of technology to lay the foundation for technological awareness and practical skills needed for daily living and future careers (Federal Republic of Nigeria - FRN, 2013). This integrates concepts from physics, chemistry, biology, as well as fundamentals of woodwork technology, metalwork technology, building construction technology, electrical/electronics technology with the aim of guiding students toward future technical/vocational training, developing essential technological know-how for everyday use, and encouraging innovative and creative thinking (FRN, 2013).

Despite the importance of Basic Science and Technology, students' academic achievement in the subject has been a source of concern. Several studies have reported persistent poor performance among junior secondary school students, particularly in calculation-based topics such as Work, Energy, and Power (Kayode et al., 2014; Akinbobola & Afolabi, 2010). The increasing number of students who perform poorly in Basic Science and Technology and show reluctance to choose the subject for specialization suggests that the subject may not be effectively transmitted. These challenges have been attributed to factors such as inadequate instructional strategies, overreliance on teacher-centered lecture methods, limited student engagement, large class sizes, non-availability of well-trained teachers and insufficient emphasis on hands-on and inquiry-based learning (Akinkahunsi, 2020; Ogheneovo et al., 2022; Isa et al., 2025). Since one of the factors attributed to poor achievement in science and technology is the use of the traditional teaching methods, there is a need to investigate alternative instructional approaches that can improve students' performance.

Contemporary science education research emphasizes the need for learner-centered instructional approaches that actively engage students in the construction of knowledge. One such approach is the 5E instructional design model. This approach is grounded in constructivist learning theory which posits that learners actively build new knowledge by connecting new experiences with previous experience through exploration, reflection, and interaction (Piaget, 1972; Vygotsky, 1978; Bybee, 2009).

According to Bybee et al (2006), the 5E model is a teaching approach used to plan hands-on lessons that are well connected, arranged step by step, and designed to help students gradually improve their understanding over time. The 5E model comprises of five phases. They are Engagement phase, Exploration phase, Explanation phase, Elaboration phase, and Evaluation phase (Bybee et al., 2006).

The Engagement phase helps to get students interested and brings out what they already know. The Exploration phase allows students to learn by doing activities. In the Explanation phase, students share what they understand and the teacher gives clear explanations. The Elaboration phase helps students apply what they have learned to new situations. The Evaluation phase checks students' understanding and skills during and after the lesson (Bybee et al., 2006). Research has shown that the 5E instructional model enhances conceptual understanding, academic achievement, and retention by actively involving students in learning and encouraging partication (Ahmad et al., 2018; Wilson et al., 2010). Studies conducted in different educational contexts have reported improvements in students' achievement and retention when taught using the 5E model compared to traditional methods (Comfort et al., 2018; Cakir, 2017; Achor et al., 2010; Akinbobola, 2015). Due to these evidences, the 5E instructional design model is therefore considered capable of improving students' academic achievement in Basic Science and Technology. Another important issue in science and technology education is gender disparity in academic achievement. However, the 5E instructional model has been identified as a gender-friendly approach that supports equitable learning opportunities for both male and female students due to its emphasis on collaboration, inquiry, and hands-on learning, (Wilson et al., 2010).

Given the persistent challenges of low achievement and concerns about gender equity in academic achievement, there is a need to investigate effective instructional strategies suitable for junior secondary school students in Basic Science and Technology. This study therefore examined the effect of the 5E instructional design model on the academic achievement of junior secondary school students in Basic Science and Technology. The following research questions and hypotheses guided the study:

Research Questions

1. What is the effect of the use of the 5E instructional design model on the academic achievement in Basic Science and Technology among junior secondary school students?

2. What is the effect of the 5E model on the academic achievement of male and female students in junior secondary school?

Hypotheses

1. There is no significant difference in the mean achievement scores of students taught Basic Science and Technology concepts using the 5E model and those taught with the traditional lecture method.
2. There is no significant difference in the mean achievement scores of male and female students taught Basic Science and Technology concepts with the use of the 5E model.

Methodology

The study adopted a quasi-experimental design involving a pre-test, post-test, and non-equivalent control group design. Two groups were designated as experimental and control groups. The population of this study comprised all Basic Science and Technology II students in the nine (9) public junior secondary schools in Odogbolu Local Government Area, Ogun State. The total population consisted of 1,788 junior secondary school students; 998 males and 790 females. The JSS 2 Basic Science and Technology class was selected because the topic under investigation *(Work, Energy, and Power*) is taught at this level as stipulated by the curriculum.

A multistage sampling approach was employed.. First, two (2) out of the nine (9) public junior secondary schools in Odogbolu Local Government Area were selected through simple random sampling. The selected schools were then randomly assigned to the treatment and control groups. In each school, one intact JSS 2 Basic Science and Technology class was used. The two intact classes yielded a total sample of 136 students, comprising 74 males and 62 females; the treatment group consisted of 70 students (40 males and 30 females), while the control group also consisted of 66 students (34 males and 32 females). The instrument used for this research was an achievement test tagged: Work, Energy, and Power Achievement Test (*WEPAT)* was used as both a pretest and as a posttest. The instrument was developed from past Junior Secondary School Certificate Examination (JSSCE) questions. Three experts conducted face and content validation of the 20 multiple-choice test items. Their comments were used to improve the instrument. Test-retest method was used to determine the reliability of the instrument. The Pearson Product Moment Correlation Coefficient (PPMCC) statistical tool was applied to calculate the reliability coefficient. A sample of 32 JSS 2 students from a school within the study area but not part of the main sample was used for the reliability test, and a reliability coefficient of 0.82 was obtained.

Before the commencement of the treatment, the WEPAT was administered as a pretest to students in both the experimental and control groups, with the assistance of the regular Basic Science and Technology teachers. After the pretest, the treatment was administered to the students over a period of two weeks. The experimental group was taught the concepts of *Work, Energy, and Power* using the 5E instructional design model, while the control group was taught the same concepts using the conventional method. The teaching was conducted by the regular Basic Science and Technology teachers who had previously been trained in the use of the 5E Instructional Design Model. At the end of the two-week teaching period, the posttest was administered to both the experimental and control groups by the teachers who taught the groups. The scores from both the pretest and posttest for the experimental and control groups were recorded and compared.

Mean was used to answer the research questions while the hypotheses were tested at the 0.05 level of significance using Analysis of Covariance (ANCOVA). For each hypothesis tested, the null hypothesis was rejected if the calculated p-value was less than 0.05 ($p < 0.05$).

Results

Research Question 1: What is the effect of the use of 5E instructional design model on the academic achievement in Basic Science and Technology among Junior Secondary School Students?

Table 1: Mean Achievement Scores of Junior Secondary School Students in Basic Science and Technology

	Control	Experimental
	Mean ($\bar{X}$)	**Mean ($\bar{X}$)**
Pretest	6.05	6.25
Posttest	6.57	14.70
Mean Gain Score	0.52	8.45

Control (N=66), Experimental (N=70)

Table 1 shows that both the control and experimental groups had similar mean scores at the pretest stage (6.05 and 6.25), indicating comparable entry behaviour. However, at the posttest stage, the experimental group recorded a much higher mean score (14.70) and mean gain (8.45) than the control group. This result show that 5E instructional design model had a positive effect on students' academic achievement in Basic Science and Technology.

Hypothesis 1: There is no significant difference in the mean achievement scores of students taught Basic Science and Technology concept using 5E model and those taught with conventional method.

Table 2: Analysis of Covariance (ANCOVA) for the Effect of Treatment on Students' Achievement in Basic Science and Technology Concepts

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	686.826[a]	2	343.413	58.422	.000
Intercept	128.315	1	128.315	21.829	.000
Pretest	9.974	1	9.974	1.697	.201
GROUP	660.614	1	660.614	112.385	.000
Error	223.369	38	5.878		
Total	5,462.000	41			
Corrected Total	910.195	40			

*Significant at Sig. F (p) < .05

Table 2 reveals that the treatment effect is statistically significant ($F = 112.385$, $p < 0.05$). This indicates a significant difference in achievement between students taught using the 5E instructional design model and those taught with the conventional method. Therefore, the null hypothesis is rejected.

Research Question 2: What is the effect of the 5E model on the academic achievement of male and female students in junior secondary school?

Table 3: Mean Achievement Scores of Male and Female Students in Basic Science and Technology Concepts

Group	Gender	N	Pretest Mean (x̄)	Posttest Mean (x̄)	Mean Gain	Difference
Control	Male	34	6.50	6.67	0.17	
Control	Female	32	5.44	6.44	1.00	
Experimental	Male	40	6.00	14.23	8.23	
Experimental	Female	30	6.71	15.57	8.86	0.63

Table 3 indicates that both male and female students in the experimental group recorded higher mean gain scores than their counterparts in the control group. Although female students in the experimental group recorded a slightly higher mean gain score (8.86) than their male counterparts (8.23). The difference between them was insignificant (0.63); this means that the 5E instructional model was effective for both genders.

Hypothesis 2: There is no significant difference in the mean achievement scores of male and female students taught Basic Science and Technology concepts using the 5E model.

Table 4: Analysis of Covariance (ANCOVA) Results for Male and Female Students' Achievement

Source	Sum of Squares	df	Mean Square	F	Sig. (p)
Corrected Model	26.216[a]	2	13.108	0.563	.574
Intercept	86.811	1	86.811	3.732	.061
PRETEST	25.959	1	25.959	1.116	.297
GENDER	.003	1	.003	.000	.990
Error	883.979	38	23.263		
Total	5462.000	41			
Corrected Total	910.195	40			

Table 4 shows that gender had no significant effect on students' achievement when taught using the 5E model (F = 0.000, p > 0.05). Therefore, the null hypothesis is retained. This indicates no significant difference in the achievement of male and female students.

Discussion of Findings

The findings of this study revealed that the use of the 5E instructional design model had a positive effect on the academic achievement of junior secondary school students in Basic Science and Technology. Students taught using the 5E model had a higher posttest mean score and mean gain score than those taught using the conventional lecture method. This finding supports the view that learner-centered and inquiry-based instructional strategies are more effective than traditional teacher-centered approaches, particularly in science and technology subjects (Akinkahunsi, 2020). The result further confirms concerns raised in earlier studies that poor performance in Basic Science and Technology, especially in calculation-based topics such as Work, Energy, and Power, may be associated with the use of traditional teaching methods (Kayode et al., 2014; Akinbobola & Afolabi, 2010).

The findings also revealed that that there is a significant difference in achievement between students taught using the 5E instructional design model and those taught with the conventional method. This finding aligns with constructivist learning theory, which emphasizes active knowledge construction through exploration and interaction (Piaget, 1972; Vygotsky, 1978). The structured phases of the 5E model provide meaningful learning experiences that promote deeper conceptual understanding (Bybee et al., 2006). This explains why students exposed to the 5E model demonstrated better academic performance than their counterparts taught through the traditional lecture method.

The effectiveness of the 5E model observed in this study is in line with previous research that reported improved academic achievement when inquiry-based learning cycles are used in science instruction (Comfort et al., 2018; Cakir, 2017; Akinbobola, 2015; Ahmad et al., 2018). These findings confirms the suitability of the 5E instructional model for teaching Basic Science and Technology at the junior secondary school level. Analysis of gender differences revealed no significant difference in achievement between male and female students taught using the 5E model. This implied that the 5E instructional model is gender-inclusive and equally beneficial to both sexes. The result supports earlier studies that indicated that learner-centered approaches promote gender equity in science education through equal opportunities for participation and engagement (Wilson et al., 2010). The findings of the study supports the adoption of the 5E model as an alternative to conventional methods used in junior secondary Basic Science and Technology classrooms.

Conclusion

From the findings of the study, it is concluded that the 5E instructional design model is a more effective and learner-centered teaching strategy than the traditional method for improving academic performance of junior secondary school students in Basic Science and Technology. It promotes deeper understanding and gender equity. Therefore, the adoption of the 5E instructional design model in junior secondary school Basic Science and Technology classrooms is strongly recommended.

Recommendations

1. Basic Science and Technology teachers should adopt the 5E instructional design model in teaching.
2. Education authorities and school administrators should organize in-service training programmes to equip teachers with the skills needed to effectively implement the 5E instructional design model in the classroom.
3. Schools should be adequately equipped with facilities that are essential for the successful implementation of the 5E model.

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