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Research Article
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Analogy Strategy and Students' Application of Physics in Plateau Central Zone: Towards Enhancing National Development

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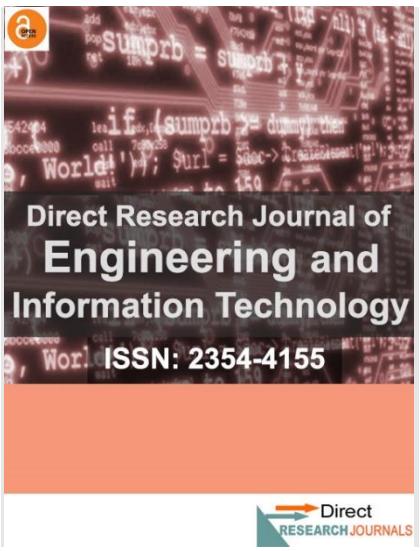
ABSTRACT

This study investigated how the Analogy Strategy, as an innovative teaching approach, enhances students' understanding and application of physics concepts in senior secondary schools in Plateau Central Zone, Nigeria. The study employed the non-equivalent control group, pretest post-test quasi-experimental design. Two intact SS2 classes with a sample 93 physics students were randomly assigned to experimental and control groups. The instrument, Electrostatics and Gravitational Application Test (EGAT), with a reliability coefficient of 0.87 obtained using Cronbach's alpha coefficient, was used for data collection. The experimental and control groups were taught electrostatics and gravitational fields using analogy strategy and traditional lecture method respectively. Pre-test was administered to both groups before the commencement of the teaching exercise that lasted five weeks, and post-test was administered immediately after teaching. Mean, standard deviation, t-test and ANCOVA were used for data analysis. The results revealed that students exposed to the analogy strategy demonstrated significantly improved conceptual understanding and application of physics, compared to their counterparts in the control group. Furthermore, it was also revealed that gender has no influence on the understanding and application of physics of students exposed to analogy strategy. The findings highlight the critical role of analogy strategy in fostering effective physics teaching that translates physics concepts into relatable learning experiences, and equipping students with practical skills for application of physics in real-life situations. Based on the findings, the study recommended among others, the need for physics teachers to adopt analogy strategy in teaching physics concepts.

Keywords: *Analogy, Electrostatics, Gravitational fields, Application, National Development*



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INTRODUCTION

Education is the acquisition and the application of knowledge to solve the societal problems. The aim of physics education is to acquire the knowledge, skills and potentials in physics and apply same to real life situations with a view to meet up with the societal needs; this contributes to make nations rise and become developed (Maries & Singh, 2023). The developed nations are so-called because they are able to put their acquired scientific knowledge and skills into practice toward development. Their application of scientific knowledge, in which physics is fundamental, made the developed nations to advance in both scientific and technological aspects of life. This can be seen in the use of advanced technological tools in the fields of medicine for medical examination and treatment;

agriculture for commercial farming; education for studies and research; engineering for transport and communications, nuclear energy for power generation, to mention but a few. This is clearly an indication to the application of physics knowledge to real life situations, which is an evolution toward national growth of any nation. However, the Nigerian case as a nation is not the same, as Nigeria has remained a developing nation for decades of years. Umaru and Mankilik (2020) observed that this is even against the backdrop that government has made considerable efforts toward the acquisition of knowledge and skills of science and technology in schools. It is also worrisome that physics graduates often find it difficult to apply the physics knowledge they have acquired to meet up with the real-life situations. This is evident in their inability to apply the acquired physics knowledge to create job for themselves in the society, hence they remain job seekers. This point to the fact that all is not right with the curriculum implementation at both secondary and tertiary levels (Coffie et al., 2020; Humphrey et al., 2023). The West African Examination Council (WAEC) Chief examiners' report (WAEC, 2017; 2021) revealed that students' achievement at secondary school physics in general have been consistently low. Furthermore, the reports indicated that students display weakness in answering questions in the concept areas of electrostatics and gravitational fields. This is due mainly to the factor of high quantitative demands, as both concepts use mathematical laws and equations for description, which students find difficult to manipulate. Electrostatics deal with behaviour of electric charges at rest and gravitational fields describe the force of gravity between objects.

Studies have identified some of the causes of low achievement in physics by secondary school students to include among others, socio-cultural stratification, students' attitudes to learning, poorly equipped laboratories and classrooms, and poor instructional strategies (Mansour, 2024; Mwima & Ounyesiga, 2025). Coffie et al. (2020) had earlier emphasized that some physics teachers are not qualified and hence, have been using the traditional lecture method to teach students concepts in physics. In spite of its seemingly advantages, for example, delivery of large content material to students in a short amount of time, the lecture method has been observed to be passive, teacher-centred and does not engage the students actively to bring about conceptual change in the learner. This is seen as an obstacle towards realising the aim of teaching physics which is geared towards having students who will apply the knowledge and skills acquired to real-life situations for national development.

In this regard, researchers have relentlessly demonstrated and advocated for the adoption of active learning strategies such as concept mapping, problem-based, mind mapping and analogy for the teaching of physics (Okoronka & Bitrus, 2014; David et al., 2020; Aragaw et al., 2022; Inyang et al., 2021; Nicholus et al., 2023; Emmanuel et al., 2024). Badmus and Jita (2022) described active learning strategy as a teaching approach that is learner-centred, it engages the learner through interactive activities during the process of learning. The strategy encourages the learner to participate, think critically and apply the acquired knowledge. The current study is focused on analogy strategy which Wesomo et al. (2018) and Efe and Abamba (2024) identified as one of the student-centred approaches that compares between two or more things or objects for effective learning to take place. Analogy involves comparing similarities between two concepts of knowledge: one is less familiar, called the target, and is the actual topic to be taught to the learners, while the other is familiar and is called the analog. The analog concept forms the basis for structural comparison since it is familiar to the learners.

Obi et al. (2021) and Efe and Abamba (2024) explained that analogy involves observing similarities between familiar and unfamiliar concepts and correlating the knowledge among the concepts so that there is a complete transfer of the target knowledge to the learners. This happens because the analog concept is more familiar to the learners than the target concept which appears abstract. An analogy is a vital cognitive process with motivational impacts in which familiar and less familiar concepts of knowledge are linked. Thus, it adequately aids in the transfer of the target knowledge to the learners. The analogy strategy is a constructivist-based theory teaching approach, in which its design will support bringing about conceptual change in learners. The group social interaction in the physics class with active participation will play a fundamental role in cognitive development, as the learners use familiar situations to explain a similar unfamiliar concepts.

Nwankwo and Madu (2014) investigated the effects of analogy teaching approach on students' conceptual understanding of the concept of refraction of light in physics in Ondo State, Nigeria. The study adopted quasi-experimental design. The result showed that the use of analogy teaching model has a positive effect on SS II physics students and that female students out-performed their male counterparts. Oniya and Adefila (2020) investigated the effects of analogy-enhanced instructional strategy on learning outcomes of students in Basic Science practical skills in Ekiti State, Nigeria. The study adopted quasi- experimental research design. The results showed that students' achievement in analogy-enhanced instruction class was significantly better than that of the control group, and that both instructional strategies were not gender sensitive. Efe and Abamba (2024) carried out a study to determine the effects of analogy and target task approach on students' achievement in gas laws in Delta State, Nigeria. Quasi-experimental design was adopted for the study. The results showed that students under analogy achieved and retained significantly higher than those in the Lecture method.

Studies have been conducted on the effects of analogy strategy on students' achievement with positive outcomes in different subject areas. The analogy strategy studies on

physics have been conducted in such concept areas like optics, current electricity and heat. However, the researchers have not come across any study on the effect of analogy strategy on students' understanding and application of electrostatics and gravitational fields within the study area, hence, the need for the current study.

Varying conclusions on the effect of gender on students' achievement on the use of analogy strategy have been reported: while Gongden (2016) and Emmanuel et al. (2024) reported in favour of male students, Obi et al. (2021) and Peter et al. (2025) reported in favour of female students. Although, the term gender refers to the social meanings associated with being a male or a female, Mushinzimana and de la Croix Sinaruguliye (2016) observed that gender had no bearing on how students felt about the subject, physics. Therefore, this study sought to determine if any difference exist among the SS II physics students' understanding and application of electrostatics and gravitational fields due to gender when exposed to analogy strategy.

In spite of the fundamental role physics plays in technological advancement and national development, students' achievement and application of physics concepts in Nigeria, particularly in Plateau central zone, remains low. A lot of students lack the ability to apply physics principles to real-life situations, leading to poor conceptual understanding and low achievement in the subject. This has been linked to the traditional lecture method of teaching physics in schools that is often employed by the physics teachers. It has thus failed to bridge the gap between theory and practice, since meaningful learning has not taken place. To this end, there has been growing advocacy for the use of innovative active teaching strategies, such as the analogy strategy, to improve on the teaching and learning of physics concepts. Empirical evidence on the effectiveness of analogy strategy in enhancing students' application of the concepts of electrostatics and gravitational fields, particularly in Plateau central zone is limited. Therefore, the current study is undertaken to investigate whether the analogy strategy can enhance students' understanding and application of electrostatics and gravitational fields in Plateau central zone.

Purpose of the Study

The purpose of the study was to determine the effects of analogy strategy on students' understanding and application of physics in senior secondary schools in Plateau central zone, Nigeria. Specifically, this research was designed to:

1. Establish the SS II physics students' level of understanding and application of knowledge of electrostatics and gravitational fields before exposure to analogy and traditional lecture strategies.
2. Ascertain the SS II physics students' level of understanding and application of knowledge of electrostatics and gravitational fields after exposure to analogy and traditional lecture strategies.
3. Determine if any difference exist among the SS II physics students' understanding and application of electrostatics and gravitational fields due to gender.

Research Questions

The following research questions guided this study:

1. What are the pre-test Electrostatics and Gravitational Application Test (EGAT) mean scores of the experimental and control groups before exposure to analogy strategy and traditional lecture method?
2. What are the post-test EGAT mean scores of the experimental and control groups after exposure to analogy strategy and traditional lecture method?
3. What are the post-test EGAT mean scores of male and female SS II physics students in the experimental group?

Hypotheses

Three null hypotheses were postulated in this study:

1. There is no significant difference between the pre-test EGAT mean scores of SS II physics students in the experimental and control groups.
2. There is no significant difference between the post-test EGAT mean scores of SS II physics students in the experimental and control groups.
3. There is no significant influence of gender on the post-test EGAT mean scores of the SS II physics students exposed to analogy strategy.

METHODOLOGY

The study employed Quasi-experimental design, particularly the non-equivalent control group design with pre-test and post-test to determine the effects of analogy strategy on senior secondary two (SS II) physics students' understanding and application of physics in Plateau central zone, Nigeria. The population of the study comprised of all the SS II physics students in Plateau central zone, Nigeria. Purposive sampling technique was used to select two schools which were randomly assigned to experimental and control groups. The intact class in each of the two schools was used as experimental and control groups respectively. A sample size of 93 SS II physics students took part in the study. The number of students in the experimental and control groups were 51 and 42 respectively. The instrument, Electrostatics and Gravitational Application Test (EGAT), developed by the researchers was used to collect data from the students. The face and content validity of EGAT were ensured: it was validated by three experts. A reliability coefficient of

0.87 was obtained using Cronbach alpha method for estimating internal consistency. The experimental and control groups were pre-tested on the concept of electrostatics and gravitational fields using the EGAT. The pre-test scores were used to find out the initial differences in the two groups in terms of level of understanding and application of knowledge of electrostatics and gravitational fields. The experimental and control groups were taught the concept of electrostatics and gravitational fields for five weeks. The experimental group was taught using analogy instructional strategy while the control group was taught using the traditional lecture method. After the treatment, a post-test was administered immediately to both experimental and control groups using the EGAT. The data obtained were analysed using mean and standard deviation for the research questions. t-test was used to test hypothesis one, while analysis of covariance (ANCOVA) was used to test hypotheses two and three. Each hypothesis was tested at 0.05 level of significance.

RESULTS

Research Question One

What are the pre-test Electrostatics and Gravitational Application Test (EGAT) mean scores of the experimental and control groups before exposure to analogy strategy and traditional lecture method?

Table 1 shows the pre-test EGAT mean scores of physics students in the experimental and control groups before exposure to analogy strategy and traditional lecture method. From the results, the pre-test mean scores of the experimental group was 21.17 with a standard deviation of 1.91 while the control group had a pre-test mean score of 20.39 with a standard deviation of 3.39. The result depicts generally low mean scores for both groups.

Table 1: The Pre-test EGAT Mean Scores of the Experimental and Control Groups before Exposure to Analogy Strategy and Traditional Lecture Method.

Groups	N	$\bar{X}$	SD
Experimental group	51	21.17	1.91
Control group	42	20.39	3.39

Research Question Two

What are the post-test EGAT mean scores of the experimental and control groups after exposure to analogy strategy and traditional lecture method?

Table 2 shows the post-test EGAT mean scores of physics students in the experimental and control groups after exposure to analogy strategy and traditional lecture method. From the results, the experimental group had a post-test mean score of 61.75 with standard deviation of 11.31, while the control group had a post-test mean score of 47.51 with standard deviation of 13.38. The results show that students' post-test mean scores improved in the two groups after exposure to analogy strategy and traditional lecture method. However, the mean score of students in the experimental group improved more than that of the students in the control group.

Table 2: The Post-test EGAT Mean Scores of the Experimental and Control Groups after Exposure to Analogy Strategy and Traditional Lecture Method.

Groups	N	$\bar{X}$	SD
Experimental group	51	61.75	11.83
Control group	42	47.51	13.38

Research Question Three

What are the post-test EGAT mean scores of male and female SS II students in the experimental group after exposure to analogy instructional strategy?

The results in Table 3 reveals the post-test EGAT mean scores of male and female SS II students in the experimental group after exposure to analogy strategy. From the results, male students had a mean score of 62.35 with a standard deviation of 11.94, while the female students had a mean score of 59.65 with a standard deviation of 12.21. The results indicate that the mean score of the male students is slightly higher than the female students.

Table 3: The Post-test EGAT mean scores of male and female students after exposure to analogy strategy.

Groups	N	$\bar{X}$	SD
Male Group	30	62.35	11.94
Female Group	21	59.65	12.21

Hypothesis One

There is no significant difference between the pre-test EGAT mean scores of the experimental and control groups.

The results of the t-test analysis in (Table 4) reveals that the experimental group had a mean of 21.17 with a standard deviation of 1.91 while the control group had a mean of 20.39 with a standard deviation of 3.39. The result further showed that the calculated t-test value of 0.199 is less than the table value of 0.844. This means that the null hypothesis was retained while the alternative hypothesis was rejected, meaning there is no significant difference between the pre-test EGAT mean scores of SS II students in the experimental and control groups before exposure to treatment.

Hypothesis Two

There is no significant difference between the post-test

Table 4: t-test analysis for the pre-test mean scores of the experimental and control groups

Groups	N	$\bar{X}$	SD	Df	t-cal	p-value	Decision
Experimental	51	21.17	1.91				
Control	42	20.39	3.39	91	0.199	0.844	Accepted

*Not significant at p > 0.05

Table 5: ANCOVA results of the post-test EGAT mean scores of experimental and control groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	126.946[a]	2	63.473	.205	.815
Intercept	5399.415	1	5399.415	17.442	.000
VAR00002	120.903	1	120.903	.391	.535
GENDER	9.786	1	9.786	.032	.860
Error	13311.489	90	309.570		
Total	62482.000	93			
Corrected Total	13438.435	92			

a. R Squared = 0.009 (Adjusted R Squared = -0.037) Dependent Variable: VAR00001

Table 6: ANCOVA results of post-test EGAT mean scores of male and female physics students in the experimental group.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	133.382[a]	2	66.691	.443	.655
Intercept	378.741	1	378.741	2.516	.147
VAR00002	6.332	1	6.332	.042	.842
GENDER	51.663	1	51.663	.343	.572
Error	1354.868	48	150.541		
Total	33625.000	51			
Corrected Total	1488.250	50			

a. R Squared = 0.090 (Adjusted R Squared = -0.113)

EGAT mean scores of SS II physics students in the experimental and control groups. Table 5 shows the summary of ANCOVA results of difference between the post-test EGAT mean scores of the SS II physics students in the experimental and control groups. The result reveals: F (0.032, 309.570) p = 0.860 > 0.05 is significant. This means that analogy strategy improved students' application in physics significantly. Hence, the alternative hypothesis was retained: there was significant difference between the post-test EGAT mean scores of SS II physics students in the experimental and control groups.

Hypothesis Three

There is no significant influence of gender on post-test EGAT mean scores of the SS II physics students exposed to analogy strategy. Table 6 shows a summary of ANCOVA results conducted to determine the influence of gender on the post-test EGAT mean scores of SS II physics students exposed to analogy strategy. The result reveals F (0.343, 150.541), p = 0.572 > 0.05; since the p value of 0.572 is greater than 0.05 level of significance, the null hypothesis was retained. Hence, there was no significant influence of gender on the post-test EGAT mean scores of SS II physics students exposed to analogy strategy.

DISCUSSION

The pretest results administered on the experiment and control groups indicated low students' application mean scores generally. The data analysed in (Table 4), revealed that there was no significant difference between the pre-test EGAT mean scores for both experimental and control groups. It showed that the two groups were equivalent before exposure to treatments. This finding is in consistent with the submission of Oniya and Adefila (2020) and Efe and Abamba (2024) who also established a result of equivalence between the experimental and control groups before the administration of treatments. However, after the treatments, results from (Table 5) indicated that the students in the experimental group that were exposed to analogy strategy gained significantly higher than those students in the control group who were exposed to the traditional lecture method. This shows that analogy instructional strategy helps to improve students' understanding and application of physics knowledge. The results support the findings of Oniya and Adefila (2020), Badmus and Jita (2022) and Akpomudiare and Ikechukwu, (2024) who found that analogy strategy helps students to visualize abstract concept, remove misconception, retain knowledge, organize their thinking and learn meaningfully. The findings of this study also revealed that there was no significant influence of gender on the EGAT application mean scores of SS II physics students, after the experimental group was exposed to analogy strategy. This implies that gender was not a major factor in determining the application ability of male and female students. Hence, analogy is seen as a strategy that brings about equal understanding and application of physics knowledge for both male and female physics students. These research findings indicated that analogy strategy is effective in

improving students' application, elimination of misconception and make learners to acquire scientific process skills. This result concurs with the findings of some earlier researchers such as Obi et al. (2021) and Peter et al. (2025). However, the result is in disagreement with the findings of Gongden (2016), Audu (2024) and Emmanuel et al. (2024) who reported that analogy strategy is gender sensitive, hence appears to be more beneficial for males.

Conclusion and Recommendations

The findings of the study revealed that analogy strategy can significantly improve physics students' understanding and application of physics concepts to real life situations. This would contribute to the development of physics students capable of contributing meaningfully to national development. Based on the findings of the study, it is recommended that:

1. Physics teachers should employ analogy strategy in teaching conceptual understanding of electrostatics, gravitational fields and other domains of physics.
2. Awareness should be created by organizing seminars and workshops for physics teachers on the use of analogy strategy during physics lessons.
3. Conducive learning environment for the use of analogy strategy should be provided by proprietors for easy implementation by physics teachers.

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