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TEACHING PHYSICS AT THE SECONDARY SCHOOL LEVEL USING ANALOGY, PROBLEM-SOLVING AND CONCEPT-MAPPING STRATEGIES: IMPLICATION FOR PERFORMANCE

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Abstract

The various approaches to imparting knowledge are generally termed teaching/learning strategies. Students adopt different types of teaching strategies during the learning process to attain the learning objectives. Teaching strategy has a considerable effect when explaining science performance; this study investigated the effects of analogy, problem solving and concept mapping strategies on students' performance in Physics. Two research questions and two hypotheses guided it. The study adopted a quasi-experimental design; it was specifically a non-equivalent control group design. The population of the study comprises 1060 SS II students in government senior secondary schools in Jalingo Education zone of Taraba state. The sample comprised 242 students (110 males & 132 females) from three intact classes in the study area. One instrument was used for data collection namely the Physics Performance Test (PAT) which was developed by the researchers. The validity and reliability of the instrument was established. The validity of PAT was established using face and content validity. The Kuder-Richardson formula 20 ($K\text{-}R_{20}$) for PAT. Mean and standard deviation were used to provide answers for the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. It was found that there was a significant difference among the mean performance scores of students in physics when taught with the analogy, problem-solving and concept-mapping strategies in the Taraba State (F, 234) = 20.53, $p < 0.05$). There was no significant difference between the mean performance of male and female students taught physics using analogy (F1, 82 = 0.28, $p > 0.05$; problem solving (F1, 71 = 0.66, $p > 00.05$) and concept mapping (F1, 79 = 80.53, $p > 0.05$). Based on these findings, the researchers among others recommended that Physics teachers should be encouraged to develop and adopt the use of analogy, problem solving and concept mapping strategies in teaching physics.

Keywords: Analogy, problem solving, concept mapping, performance, physics, gender.

Introduction

Physics is a cross-cutting discipline that has applications in many sectors of economic development, including health, agriculture, water, energy and information technology (Macmillan, 2012). There is no doubt that a good part of the scientific knowledge is derived from the principles of Physics. Indeed, the knowledge of physics has led to so many inventions such as the production, application and utilization of integrated circuits, production and use of machines and other contrivances. It also accounts for the discovery and production of hydroelectric power, gas turbine and thermonuclear power plants, telephones, refrigerators, heaters and gas/electric cookers. The invention of modern technologies such as Information and Communication Technology (ICT) which has made the world a global village is also part of the benefits of Physics. Other benefits that are derivable from the knowledge of physics include the construction of modern vehicles, rockets, nuclear bombs, missiles, diodes, computers and other electronic systems (Jegede & Awodun, 2013). Physics provides the basic knowledge and understanding of principles, whose applications contribute immensely to the quality of life in society.

In Nigeria, despite the enormous role that physics plays in national development and the efforts of government in the provision of necessary science equipment in schools with good teachers and parents/guardians in providing for their children/wards educational needs at improving science education, students' results in physics examination conducted by examination bodies like West African Examinations Council (WAEC) and National Examinations Council (NECO) have not been satisfactory. In particular, reports on WAEC results of the Senior School Certificate Examination in Taraba State over the years often revealed low performance of students in physics from 2012-2022 (WAEC, 2014a; 2017, 2019; 2023).

The poor performance of students in physics can cripple the realization of national goals for scientific and technological development (Njoku & Ezinwa, 2014). Some of the reasons identified for the abysmal performance of students include among others; inadequate laboratories, abstract and difficult nature of many physics concepts, lack of instructional materials, examination malpractice, time constraint for conducting of practical, non-coverage of syllabus, class size, non-professionalism, environment, poor methods employed by most physics teachers as well as lack of interest among physics students (Njoku, 2014; Jegede, 2017; Idris & Sule, 2024). Aluko (2018) considered poor instructional delivery approaches as one of the major factors contributing to the persistence students' poor performance. In a similar vein, the West African Examination Council (WAEC, 2014b), Chief Examiners Reports (2017-2021) and a study by Ezeugwu and Egbo (2017) have attributed the observed students' poor performance in physics to use of inappropriate and ineffective teaching methods by physics teachers.

Persistent use of traditional teaching methods such as the lecture in physics classrooms have been advanced as the underlying factor for students' poor performance in the subject (Filgona, 2016). According to Arokoyu and Chukwu (2017), lecture method which is predominantly used in secondary schools in Nigeria contributes to the poor academic performance of students of physics. Hence, the need to explore other teaching strategies such as concept-mapping, analogy and problem-solving amongst others to teach physics. The core of education is teaching and learning, and the teaching-learning process works better when teachers use appropriate techniques working with students otherwise, they struggle to understand. Different methods and techniques for imparting instructions in a formal classroom setting have been changing over time such that old ones are replaced. The analogy, concept mapping and problem-solving strategies are techniques that could provide remedy to students' difficulties in physics and could be used for such replacement.

National Business and Technical Examination Board (NABTEB, 2014) Chief Examiner's report attributed the low performance of students in the National Technical Certificate (NTC) examination to the inappropriate use of instructional strategies by teachers NABTEB, (2014). It has been observed by these researchers that the current technique adopted by most secondary school teachers to teach physics in Jalingo metropolitan schools is the conventional lecture method. Glym, Taasoobshirazi and Fowler, (2014) observed that the continuous use of the lecture method to teach students some abstract concepts like atom, current, voltage and others reduce their ability to grasp the meaning which could be resolved when they are taught using instructional strategies like analogy that build on their pre-existing ideas. Novak and Cana (2018) observe that knowledge is actively constructed by the learner on the grounds of constructs already available to him/her in the mind.

The researchers feel that the analogy could be used as a good teaching strategy to impart knowledge to students as well as clarify explanations, thereby serving a communicative function. A physics problem must be well-defined to achieve the goals for which the problem is posed. Some of these problems may be fundamental to future problems students or learners may encounter in physics since learning is from simple to complex, known to unknown, concrete to abstract (Ellah, Achor & Enemari, 2019). When such problems are solved by a learner, performance in physics may be enhanced. Thus, the exposure of problem-solving strategies that students receive can help them improve their performance in Physics and change students' attitude toward learning physics. According to Ellah and Achor (2014), problem-solving is a complex process that engages various cognitive operations such as collecting and sorting information, heuristics and meta-cognitive strategies.

Problem-solving has been considered a higher-order cognitive process that requires the modulation and control of fundamental skills (Hilbert, 2020). Hence, problem-solving involves steps that students will take to achieve their own goals. Most students are not weak in solving problems, but rather unskilled in planning strategies when solving a given problem (Ezeadu, 2013). Problem-solving strategy is a method that can potentially produce effective and meaningful teaching and learning. The application of this strategy in teaching and learning can help improve students' problem-solving skills. The deployment of problem-solving in learning consists of identifying problems, finding relevant information about problems through reading activities, analysing problems, and group discussion through mind mapping providing solutions and sharing of mind mapping (Adeyenu, 2018).

Concept mapping helps students to understand the interrelationship among concepts predict, observe and explain subjects to improve students' understanding of abstract terms (Ezeadu, 2013). Concept mapping takes into account the innovativeness of building up an arrangement of reasoning that includes the capacity to think comprehensively on themes and considered learning in a corporation (Abdulkarim & Hassan, 2013). Concept mapping is a teaching strategy that gives exact data about the information considered. Concept mapping strategies in Physics enable students to reason through an issue or topical issue by imagining the communication between contention, concepts, subject and proof. (Ajayi *et al*., 2017).

According to Sakata, (2016), concept mapping serves as a tool to help learners organize their physics cognitive strategy which assists the learners to identify the hierarchical conceptual propositional nature of knowledge. This indicates that the organization of the cognitive process in learning a concept creates meaningful learning, understanding and enhances memory in the learner. Concept mapping teaching approach likewise constitutes fascinating assistance to help the learning procedures of reasonable substance regardless of whether inside a structure of independent learning exercises or with the assistance of the educator. Appoji and Shailaji (2017) opined that concept mapping can become an excellent process of integrating in a social environment that is cooperative and constructivist. The researchers add that concept mapping are excellent tool for formative evaluation in the learner, the students' early conception hence enabling them to identify relationships and new meanings. Sakata, (2016) opined that concept mapping is a student-centered teaching approach that engages students in critical thinking about the relationship that exists between concepts. Concept mapping presents information in a least complex but interconnected manner which discourages rote learning.

According to Agogo and Naakaa (2014), gender is a socially ascribed attribute that differentiates feminine from masculine. The researchers have advanced some reasons for the differences, including comprehension quality and accuracy of answers of tests, quality and accuracy of problem-solving frequency and quantity of desired outcome, time or rate to the solution, time on task level reasoning and critical thinking; creativity and transfers of tasks and students' performance are essential factors in quality education in physics. In the same vein, according to Ajayi *et al*., (2020) the reasons for these differences include use of inappropriate methods, lack of instructional materials and and inability of students to identify their learning styles.

Statement of the Problem

The re-occurring poor performance of students in science especially, physics, in SSCE, has been a source of concern to all stakeholders including parents, teachers, students, science education researchers, government and the general public. Science teachers have applied various methods and strategies like field trips, laboratory, excursion and cooperative learning in the teaching of physics, yet there has been poor performance among secondary school students in the West African Examination Council results. Science educationists have identified factors such as inadequate instructional materials, teachers' poor improvisation skills, specialty and competency among others as some of the causative factors of low performance in science. However, this could probably be related to the inability of the instructional strategy employed in the teaching of physics. A major challenge in implementing appropriate teaching strategies in Physics classrooms perhaps lies in developing and equipping students with the relevant learning strategies that will enhance the learning of Physics.

This issue has denied many Nigerian students the opportunity of getting admission into institutions of higher learning to continue their study in physics and physics-related courses since a credit pass in WASSCE or NECO is one of the pre-requisite to study such courses. Based on the aforementioned this study intends to ascertained which of analogy, problem-solving and concept mapping strategies could improve students' academic performance in physics.

Purpose of the Study

This study investigated the effects of analogy, problem solving, and concept mapping strategies on students' performance in physics in SSS in Taraba State, Nigeria. Specifically, this study sought to:

i. To investigate the performance of all students taught physics using analogy, problem-solving and concept mapping strategies.
ii. To examine the academic performance of male and female students taught physics using analogy, problem-solving and concept mapping strategies.

Research Questions

Based on the objectives stated, the following research questions raised were answered in this study:

i. What are the mean performance scores of students taught physics using analogy, problem-solving and concept mapping strategies?
ii. What is the mean performance of male and female students taught physics using analogy, problem-solving and concept mapping?

Research Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance to guide the study:

$H0_1$: There is no significant difference in the performance scores in physics when taught with analogy, problem-solving and concept-mapping methods in Taraba State, Nigeria.
$H0_2$: There is no significant difference in the male and female students' performance in physics when taught with analogy, problem-solving and concept-mapping methods in the study area.

Materials and Methods

The study employed a quasi-experimental design. The design was a non-randomized pre-test, post-test, type using intact classes. his is considered as compromise design since there is no random selection. As also observed by Achor and Ejigbo (2006), some classroom situations do not lend themselves to excessive manipulations, intact group was therefore used. This study consists of three instructional strategies (analogy, problem-solving and concept mapping strategies) which forms the independent variables, students' performance in physics which is the dependent variable.

The population of the study comprises 1060 SS II students in government senior secondary schools in Jalingo Education zone of Taraba state. The multistage sampling method was used and it is focused on the target population as outlined by Appinio Research (2024). In the first stage, the study was stratified into Ardo Kola, Lau and Jalingo LGAs. In the second stage, one school from each stratum of the study area was selected using the purposive sample method. Schools with graduate-level physics teachers (those with teaching credentials and at least three years of classroom experience) were the basis for selection. A total of three schools were selected for the investigation; one each from Ardo Kola, Lau and Jalingo LGAs.

Using a sampling intensity of 23%, a sample size of 242 SS II students (respondents) made up of 110 males and 132 females who offer physics from the three schools was randomly assigned to various groups in the third stage.

Instrument, Validation and Reliability

The study made use of primary source of data. Physics Performance Test (PAT) developed by the researchers was used for data collection. PAT is divided into two sections. Section A consists of the respondent's bio-data which have name of school and gender. Section B comprises of 00-items multiple choice question. The selection of multiple choice questions by the researchers was based on the physics topics which include rectilinear propagation of light, electrostatic, electronics, atomic and nuclear physics, magnets and magnetic fields. These topics were part of senior secondary class curriculum and which challenging to them. A table of specification was drawn to cover the topics. Each item in the test has options lettered A to D. Each correct answer carries one (1) mark; the PAT was scored over hundred (100) marks using the marking guide.

To determine the validity of the instrument, two experts in the field of science education and one expert in measurement and evaluation from Taraba State University critically evaluated it for face and content validity. The experts were requested to check for ambiguity of items concerning the appropriateness of the items, relevance to the issue under investigation and content coverage of items.

To ensure content validity, each of the experts was provided with a copy of PAT and topic of the research, lesson plans, and the extract of the curriculum on the content to be covered in the table of specifications, research questions and purposes. The experts' collected useful inputs were integrated into the final copy of the instrument. The PAT was subjected to psychometric analysis to ensure that they have acceptable characteristics.

A pilot test was conducted; the aim was to estimate the reliability of the research instrument. The Physics Performance Test was administered to the students and the results were used to calculate the reliability coefficient of the instrument. Using Kuder-Richardson (K-R_{20}) since the performance test is dichotomously scored; the scores obtained by the students in Physics performance test were used to calculate the reliability coefficient, which was found to be 0.870.

Method of Data Collection and Analysis

A pre-test was administered to determine the initial knowledge of the students and to determine the equivalence of the groups which participated in the study. The three experimental groups received instruction using analogy, problem solving and concept mapping strategies. For group A, intact classes were taught the selected topics using the lesson plan prepared for the analogy learning strategy. In the same vein, group B intact classes were also instructed on the selected topics using the lesson plan prepared for the problem solving learning group and group C intact classes was also instructed on the selected topics using the lesson plan prepared for the learning group. The teaching lasted for 6 weeks.

The PAT was administered within the duration of 100 minutes that's 1hour 40 minutes. The essential information of the respondents in section A was filled before answering the questions to ensure easy identification of the respondents with their performance in the test. In addition to the instruction written on the test, the students were given verbal instructions where necessary.

The scores obtained from the pre-test and post-test were analyzed using descriptive statistics of mean and standard deviation to answer the research questions. An inferential statistic of Analysis Co-variance (ANCOVA) was used to test the null hypotheses at 0.05 significant levels. The major assumption for the use of ANCOVA is for homogeneity of regression slope and linearity of relationship between the dependent variable and the covariate. Also, Levene's test for homogeneity of variance was used to confirm homoscedasticity. ANCOVA was found suitable for this study because it has ability to correct initial differences among the respondents by co-varying the pretest with the post test.

Results

This unit presents the analysis and interpretation of the data of this study in line with the research questions and hypotheses formulated and tested.

Research Question One

What are the mean performance scores of students taught physics using analogy, problem-solving and concept-mapping strategies?

Table 1: Mean performance Scores and Standard Deviations of Students Taught Physics Using Analogy, Problem-Solving and Concept Mapping Strategies

Strategies		Pretest	Posttest	Mean Gain
	Mean	25.65	34.32	8.67
Analogy	N	85	85	
	Std. Deviation	5.39	4.35	
	Mean	19.99	29.50	9.51
Problem Solving	N	74	74	
	Std. Deviation	2.51	4.63	
	Mean	24.52	29.82	5.30
Concept Mapping	N	82	82	
	Std. Deviation	3.56	3.89	

Students who were taught physics by the analogy strategy had a pretest mean performance score of 25.65 (SD = 5.39), which rose to a post-test mean of 34.32 (SD = 4.35), establishing a 8.67 improvement, according to Table 1's statistics. The pretest mean performance score for students taught the problem-solving method was 19.99 (SD = 2.51) and the post-test mean was 29.50 (SD = 4.63), indicating a 9.51 improvement in performance mean score. Similarly, students who were taught the concept-mapping strategy showed a 5.30 rise in mean performance scores from their pretest of 24.52 (SD = 3.56) to 29.82 (SD = 3.89) on the post-test.

Students taught using the analogy method showed a substantial improvement in their performance score towards physics, with a mean increase of 8.67 points from the pretest to the post-test. The decrease in standard deviation from the pretest to the post-test suggests that the post-test scores were more consistent among the students. The problem-solving method led to a slightly higher improvement than the analogy method, with a mean increase of 9.51 points. However, the standard deviation increased slightly from the pretest to the post-test, indicating a slight increase in variability in the students' performance scores after the intervention. The concept-mapping method resulted in the least improvement in students' performance scores, with a significant mean increase of 5.30 points. The relatively small change in standard deviation suggests that while there was a significant improvement in mean scores, the consistency of scores among students remained relatively stable.

Research Question Two

What is the mean performance of male and female students taught physics using analogy, problem-solving and concept mapping?

Table 2: Mean performance and Standard Deviations of Male and Female Students Taught Physics Using Analogy, Problem-Solving and Concept Mapping Strategies

Analogy		**Pretest Analogy**	**Posttest Analogy**	**Mean Gain**
Male	Mean	25.22	33.81	8.59
	N	27	27	
	Std. Deviation	5.34	4.41	
Female	Mean	25.84	34.55	8.71
	N	58	58	
	Std. Deviation	5.44	4.34	
Problem Solving		**Pretrest Problem Solving**	**Posttest Problem Solving**	**Mean Gain**
Male	Mean	19.81	29.11	9.30
	N	47	47	
	Std. Deviation	2.75	4.29	
Female	Mean	20.30	30.19	9.89
	N	27	27	
	Std. Deviation	2.05	5.17	
Concept Mapping		**Pretest Concept Mapping**	**Posttest Concept Mapping**	**Mean Gain**
Male	Mean	25.09	29.69	4.60
	N	35	35	
	Std. Deviation	2.97	3.75	
Female	Mean	24.11	29.91	5.80
	N	47	47	
	Std. Deviation	3.92	4.03	

Students taught physics using the analogy strategy showed improvements. The pretest mean score for males was 25.22, which increased to 33.81 at post test indicating an average improvement of 8.59 points. Females had a pretest mean score of 25.84, which rose to 34.55, resulting in an average improvement of 8.71 points. Using the problem-solving strategy, males had a pretest mean score of 19.81, which increased to 29.1 at post test, showing an average improvement of 9.30 points. The pretest mean score for females was 20.30, rising to 30.19, with an average improvement of 9.89 points. With the concept-mapping strategy, males had a pretest mean score of 25.09, which rose to 29.69 at post test resulting in an average improvement of 4.60 points. Females had a pretest mean score of 24.11, which increased to 29.91, showing an average improvement of 5.80 points. These results suggest that different strategies may have varying levels of effectiveness based on gender. Consistently, all the three strategies favoured male students compared to their male counterparts.

Hypothesis One

There is no significant difference in the performance scores in physics when taught with analogy, problem-solving and concept-mapping methods in the Taraba State.

Table 3: One-way ANCOVA of the Method of Teaching on Students' performance in Physics

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2211.47	6	368.58	25.67	.000	.397
Intercept	2608.78	1	2608.78	181.69	.000	.437
Pretest	986.34	1	986.36	68.70	.000	.227
Strategies	589.64	2	294.82	20.53	.000	.149
Gender	24.11	1	24.11	1.68	.196	.007
Strategies * Gender	1.62	2	.81	.06	.945	.000
Error	3359.80	234	14.36			
Total	241783.00	241				
Corrected Total	5571.28	240				

a. R Squared = .397 (Adjusted R Squared = .381)

Table 4: Pair Wise Comparison of Mean Performance of Students in the Three Strategies

(I) Strategies	(J) Strategies	Mean Difference (I-J)	Std. Error	Sig.
Analogy	Problem Solving	1.780*	.717	.041
	Concept Mapping	3.911*	.614	.000
Problem Solving	Analogy	-1.780*	.717	.041
	Concept Mapping	2.131*	.681	.006
Concept Mapping	Analogy	-3.911*	.614	.000
	Problem Solving	-2.131*	.681	.006

The corrected model is the overall test of whether the factors included in the model (intercept, pretest, and method) explain a significant portion of the variance in the dependent variable (post-test). The F-value is 20.53, and the p-value is .000, indicating that the model is statistically significant ($p < .05$). The partial eta squared (.149) suggests that about 14.9% of the variance in the post-test is explained by the model. The intercept represents the mean of the dependent variable when all predictors are zero. It is highly significant ($p < .000$) with a large effect size (partial eta squared = .437), indicating that the overall mean level of the post-test is significantly different from zero. The pretest variable significantly affects the post-test ($p < .000$). The partial eta squared value of .227 indicates that the pretest accounts for 22.7% of the variance in the post-test, suggesting a moderate effect size. The model explains 39.7% of the variance in the post-test, as indicated by the R-squared value. Therefore, the hypothesis of no significant difference in the performance scores in physics when taught with the analogy, problem-solving and concept-mapping methods in the Taraba State is rejected.

Table 4 indicates clearly that the pair wise comparisons of the strategies show significant difference between mean performance of students in analogy and problem solving groups ($p = .04 < .05$), analogy and concept mapping groups ($p = .00 < .05$), problem solving and concept mapping groups ($p = .00 < .05$). This implies that the strategies had varying effects on students.

Hypothesis Two

There is no significant difference between the male and female students' performance in physics when taught with analogy, problem-solving and concept-mapping methods in Taraba State.

Table 5: Two-way ANCOVA of Male and Female Students' Performance when Taught Using Analogy Strategy in Physics

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	824.00	2	412.00	44.20	.000	.519
Intercept	1338.09	1	1338.09	143.54	.000	.636
Pretest Analogy	813.99	1	813.99	87.32	.000	.516
Gender Analogy	2.61	1	2.61	.28	.598	.003
Error	764.42	82	9.32			
Total	101693.00	85				
Corrected Total	1588.42	84				

a. R Squared = .519 (Adjusted R Squared = .507)

Table 6: Two-way ANCOVA of Male and Female Students' Performance when Taught Using Problem Solving Strategy in Physics

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	81.35	2	40.67	1.95	.150	.052
Intercept	555.65	1	555.65	26.60	.000	.273
Pretrest Problem Solving	61.39	1	61.39	2.94	.091	.040
Gender Problem Solving	13.77	1	13.77	.66	.420	.009
Error	1483.16	71	20.89			
Total	65963.00	74				
Corrected Total	1564.50	73				

a. R Squared = .052 (Adjusted R Squared = .025)

Table 7: Two-way ANCOVA of Male and Female Students' Performance when Taught Using Concept Mapping Strategy in Physics

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	148.97	2	74.49	5.47	.006	.122
Intercept	679.03	1	679.03	49.89	.000	.387
Pretest Concept Mapping	147.92	1	147.92	10.87	.001	.121
Gender Concept Mapping	7.18	1	7.18	.53	.470	.007
Error	1075.28	79	13.61			
Total	74127.00	82				
Corrected Total	1224.26	81				

a. R Squared = .122 (Adjusted R Squared = .099)

Results in Tables 5, 6 and 7 indicate that there is no significant difference between the mean performance of male and female students taught using analogy($F_{1, 82} = 0.28$, $p > 0.05$; for problem solving ($F_{1, 71} = 0.66$, $P > 00.05$) and for concept mapping ($F_{1, 79} = 80.53$, $P > 0.05$). The partial eta for analogy is 0.3%, problem solving is 0.9% and for concept mapping is 0.7%. These effect sizes are very small. These values indicate that the model explains approximately less than 10% of the variance in the post-test.

Discussion of Findings

There is a significant difference in the mean performance scores of students in physics when taught with the analogy, problem-solving and concept-mapping methods in Taraba State. This finding agrees with the findings of Gok and Silay (2010), who found that the Problem-solving strategy is effective in the teaching and learning of physics and enhances students' performance in physics. This result agrees with the findings of Adegoke (2011) that explicit problem-solving instruction is more effective on the students' performance in Physics. Similarly, it also agrees with the findings of Neji and Merenukwu (2016), Achor and Bileya (2022) that the experimental groups taught using concept mapping performed significantly better than their counterparts taught without use of concept mapping. This shows that the Problem-Solving method is a more effective method that can enhance students' academic performance in physics compared with analogy and concept mapping. It also agrees with the findings of Agbidye et al (2019) who reported that all students who participated in problem-solving activities performed better than their counterparts in the control group.

It was found that there is no significant difference between the mean performance of male and female students taught using analogy ($F_{1, 82} = 0.28$, $p > 0.05$; problem solving ($F_{1, 71} = 0.66$, $P > 00.05$) and concept mapping ($F_{1, 79} = 80.53$, $P > 0.05$). This finding is not in consonance with that of Awodun (2020) who found out that female students performed better than their male counterparts in science subjects such as physics. This finding is in disagreement with the findings of Apata (2021) who found that male students were academically superior to their female counterparts in sciences. The insignificant difference noticed could be attributed to the fact that the three strategies are activity oriented.

The result was made possible because according to Ishaka, (2015), problem solving strategy is a learner centered teaching approach which makes sure that learners describe the problem related principles and concepts perform research and learn how to learn and in which real life problems are used. Problem solving instructional strategy provides a functional environment in which the learner receives peer and teacher support, recommendation and feedback when face with problem. It is a strategy in which learning is changed from one directional into multi-directional and where real problems and solutions are available. Concept mapping addresses different forms of learning and individual differences between students. It can encourage student-teacher interaction when they create a map together by discussing and very useful for showing alternative relationships within a system. Thus their performance was encouraging but lower than those in problem solving class. Concept maps are used as a tool for meaningful learning, assessment, instructional planning and finding out the alternative concepts or misconception shield by the learners (Ahmad & Munawar, 2013). Students in an analogy is a comparison through which an idea, a thing or a process is contrasted to another that is quite different from its counterpart. The aim is in explaining that idea, thing or process by comparing it to something that is familiar makes it clearer. Analogical reasoning is a key feature of the learning processes within a constructivist perspective; every learning process includes a search for similarities between what is already known and the new, as well as the familiar and the unfamiliar, to actively apply prior knowledge in a new situation (Wittrock & Alesandrini, 2014).

Conclusion and Recommendations

Based on the findings of this study, it was concluded that students' performance in physics was enhance when analogy, problem solving and concept mapping strategies were used as a medium of instruction. Both gender benefited equally well when taught using Analogy, problem solving and concept mapping strategies. That is, Analogy, problem solving and concept mapping strategies promote academic performance across gender.

Based on the findings emanating from this study, the following recommendations were made:

i. The Analogy, Problem solving and Concept mapping strategies should be incorporated into the main stream of pedagogy in the teaching of physics at secondary school levels by the Nigerian Educational and Research Development Council (NERDC) since the three strategies were effective in enhancing learning of physics.

ii. In-service training for physics teachers should be organized and focus more on how to use Analogy, Problem-solving and Concept mapping strategies for the teaching physics concepts by the government research centers like the Nigerian Educational and Research Development Council (NERDC), Nigeria Institute of Physics (NIP) and relevant professional bodies like Science Teachers" Association.

iii. Seminars, workshops and conferences should be organized and focus more on how to use Analogy, Problem-solving and Concept mapping strategies among low, medium and high ability for the teaching of physics concepts by the government agencies of education and relevant professional bodies like Science Teachers' Association of Nigeria, Nigeria Institute of Physics (NIP) and research centers like Nigerian

iv. The analogy, problem solving and concept mapping strategies are gender friendly and established that gender does not play a significance role in the learning of physics concepts using analogy, problem solving and concept mapping strategies. Hence, methods are recommended as they are gender friendly and aided learning between male and female students.

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