Fostering students' academic performance in physics using cognitive conflict instructional strategy and conceptual change pedagogy

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ABSTRACT

This study investigated how to foster students' academic performance using cognitive conflict instructional strategy and conceptual change pedagogy on Senior Secondary (SS2) two in thermal physics in Kogi East Education Zone of Kogi State. The study adopted a quasi-experimental design, specifically, pretest-posttest non-equivalent-control group type. The study population was all the 7380 senior school two physics students in 153 co-educational secondary schools during the 2018/2019 academic session. The sample consisted of 294 SS two physics students (187 males and 107 females) drawn from six secondary schools using a multi-stage sampling technique. Thermal Physics Performance Test (TPPT) with reliability coefficients of 0.79 was used for data collection. Data collected were analyzed using mean, standard deviation, and bar graphs to answer the eight research questions and Analysis of Covariance (ANCOVA) to test the null hypotheses at 0.05 level of confidence. The study's findings revealed that there was a significant difference in mean academic performance among students taught thermal physics using cognitive conflict instructional strategy, conceptual change pedagogy, and traditional instructional strategy. The result equally revealed that cognitive conflict instructional strategy enhances students' academic performance more than conceptual change pedagogy. In addition, male and female students taught using cognitive conflict instructional strategy differ significantly in academic performance scores $F(1, 99) = 24.409$; $p = 0.000 < 0.05$. Likewise the male and female students taught using conceptual change pedagogy differ significantly in academic performance scores at $F(1,95) = 33.974$, $p = 0.000 < 0.05$. Furthermore the finding revealed that there is significant interaction effect of strategy and gender on students' mean academic performance scores $F(2, 293) = 6.307$; $p = 0.002 < 0.05$. It was also found that both cognitive conflict instructional strategy and conceptual change pedagogy foster students' academic performance in Physics more than traditional instructional strategy. Based on the findings, it was recommended that Physics teachers be encouraged to use both cognitive conflict instructional strategy and conceptual change pedagogy to teach Physics in secondary schools to enhance students' academic performance.

1. Introduction

Science is as an intellectual activity carried out by humans that is designed to discover information about the natural world in which human beings live and to discover the ways in which this information can be organized into meaningful patterns [1]. Nwosu further defines science as a dynamic and

objective process of seeking knowledge and an enterprise involving people searching, investigating and seeking verification of natural phenomena. This involves investigation and verification which lead to the discovery of new knowledge and facts about the natural world. These can be achieved through the teaching of science [2].

The essence of teaching science among other things is to enable learners develop knowledge of scientific concepts for problem solving at the secondary and tertiary levels of education. When the teaching and learning of science are faulty, the aims and objectives of teaching and learning of science will not be achieved. Attempt at making science teaching and learning more meaningful and relevant to national aspirations has led to the identification of necessary factors for meaningful learning. Crucial factors identified by researchers in the last few decades are learners' preconception and misconceptions of science [3]. The current emphasis in Nigeria is therefore on teaching Physics being one of the branches of science for conceptual change that will enhance students' performance rather than for indoctrination of superior knowledge [4].

Physics is a pure science subject that deals with behaviors of matter and energy and how it relates with other physical properties. This conceptual meaning of Physics shows that it is a basic physical science subject that deals with the behaviour and interaction of matter and energy which are referred to as physical phenomena. According to Okeke [5], the Physics concepts that pose challenges to students at the secondary school level in terms of conceptual understanding include waves, light waves, sound waves, electricity, magnetism, nuclear Physics, pressure and simple harmonic motion. Similarly, Erinosho [6] observes that the concepts that students have challenges in their conceptual understanding are energy quantization, AC circuit, projectile motion and electric field, previous researches carried out on the branches of Physics did not address the issue of students' misconception in area of thermal physics concept. The challenges students experience in understanding Physics concepts may have resulted from lack of the use of student centered strategies (cognitive conflict instructional strategy and conceptual change pedagogy) and inability to retain students' attention. It is envisaged in this study that by using cognitive conflict instructional strategy and conceptual change pedagogy for instruction, the poor performance of students in Physics due to misconception at SSCE may improve, considering the important roles of Physics in technological development.

Despite the importance, students perform poorly in Physics as documented in the Chief Examiners' report of West Africa Senior Secondary School Certificate Examination, (WASSCE) from 2008 – 2018 [7]. Science educators, examination bodies and parents/ guardians all over Nigeria today complain of students' poor academic performance in Physics and other science subjects at Senior Secondary Certificate Examination (SSCE). Appendix A, shows a persisted low academic performance of students in Physics over the years under review in SSCE results (2008 – 2018). From the analysis of the results, only 58.1% and 51.3% number of students were found to score above average in the year 2008 and 2013 respectively. Apart from these two years, percentage performances of the students were below average. The performance of students is at average level and therefore calls for more attention. The low academic performance could be as a result of the teaching strategy adopted by Physics teachers. This has made a number of Physics educators in the country like Ochchuku [8]; Madu [9]; Achor [10]; Orji [11] and Musa [12] to study the problem empirically with the hope of finding causes and possible solutions.

According to Ryder [13], performance can be defined as the act of accomplishing a task well. In this study, students' performance in thermal physics depends on their level of conceptual gain. It is to be noted that misconceptions in some topics in a particular area like thermal physics could affect the students' performance.

The need to explore constructivist-based instructional strategies like cognitive conflict instructional strategy (CCIS) and cognitive-based instructional strategy such as conceptual change pedagogy strategy (CCPS) which take students' conception positions as starting points for instruction appear to be appropriate [14] to enhance performance. Hence, this study sought to identify students with alternative conceptions before treatment and those who shifted after formal instructions using cognitive conflict instructional strategy (CCIS) and conceptual change pedagogy (CCP).

The cognitive conflict instructional strategy involves: (1) identifying students' current state of knowledge, (2) confronting students with contradictory information which is usually presented through texts and interviewers, which only guide the debate with the students or among peers/small groups or the whole classroom, (3) evaluating the degree of conceptual change between students' prior

ideas or beliefs and a post-test measure after the instructional intervention. If the students did not have strong confidence in a well formulated preconception or if they consider the anomalous situation as a deception, they would not experience cognitive conflict. Thus, the preliminary stage is the stage before cognitive conflict. In this model, the cognitive conflict process occurs when the learner (a) recognizes an anomalous situation (b) expresses interest or anxiety about resolving the cognitive conflict and (c) engages in cognitive re-appraisal of the situation. For instance, when learners recognize that a situation is inconsistent with their conceptions, they become interested in or anxious about the situation [15]. Samba, Achor and Ogbeba [16] suggest the use of innovative strategies like constructivist instructional strategy (cognitive conflict) to Physics teaching that can enhance students understanding for optimal performance.

Conceptual change pedagogy could help students overcome misconceptions and learn difficult concepts. In it, existing conception is changed or even replaced with new ones. This restructuring of existing knowledge distinguishes it from other types of learning strategies. In conceptual change pedagogy, there are many instructional strategies developed in line with constructivist theory. These strategies include four-step, five-step, and seven-step conceptual change pedagogies. In this study, five-step strategy was adopted partly because it has similar steps with cognitive conflict instructional strategy. This is aimed at having baseline condition for investigating the effects of the two strategies in promoting students' conceptual change and thereby enhancing their performance.

One issue of concern in science education is gender achievements. Gender refers to social construct, characteristics, behavior and roles which society ascribes to males and females. In recent times, educators have expressed diverse views about gender performance in Physics as one of the science subjects. Some scholars are of the view that males do better than females while others disagree with this view [17]. In a report by the West African Examination Council Senior Secondary Certificate Examination [18], statistics of result in Nigeria by subject, grade and sex revealed low enrollment and achievement of girls in Physics. Therefore, one sees that the issue of gender in science performance of students has not yet been resolved particularly in relation to performance in Physics. This necessitated the need for further study of the influence of gender on students' performance.

Statement of the Problem

Students in all parts of the globe, Nigeria inclusive have been found to have a lot of misconceptions on Physics topics such as force and motion, current electricity, elasticity, atoms and molecules, heat and temperature which affect their understanding of Physics. Also the abstract nature of the subject, demands that both theoretical and practical aspects of the course be taught with methods that require minds-on and hands on activity. That is, methods that are both inquiry and conceptual change strategy based.

Studies have revealed that among other things, the inability of Physics teachers to use such inquiry and conceptual change based methods in teaching Physics such as cognitive conflict instructional strategy and conceptual change pedagogy account for the poor attention and academic performance among both genders in Physics in Nigeria. It is noted that no research seem to have investigated whether or not students under consideration in this study equally have misconceptions in thermal physics (that is, heat or temperature) concepts and also how to repair such misconceptions if found to improve performance.

Therefore, a more learner-centered and hands-on- activity teaching strategy that is conception focused need to be investigated for effective conceptual paradigm shift on the part of the students for better performance in thermal physics concepts. Hence, the problem of the study put in a question form is what is the effect of cognitive conflict based instruction and conceptual change pedagogy on senior secondary two students' academic performance in thermal physics?

Research Questions

The following research questions were answered in this study: (1) What are the mean academic performance scores of SSII students taught thermal physics using cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy? (2) What are the mean academic performance scores of male and female students taught thermal physics using cognitive conflict instructional strategy? (3)What are the mean academic performance scores of male and female

students taught thermal physics using conceptual change pedagogy? (4) How does interaction effect of treatments and gender affect students' mean academic performance scores in thermal physics?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

HO1: There is no significant difference in the mean performance scores of students taught thermal physics using cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy.

HO2: There is no significant difference between the mean performance scores of male and female students taught thermal physics using cognitive conflict instructional strategy.

HO3: There is no significant difference between the mean performance scores of male and female students taught thermal physics using conceptual change pedagogy.

HO4: There is no significant interaction effect of treatments and gender on the mean performance scores of students in thermal physics.

2. Method

2.1. Design, Sample and Instrument

The design of the study was quasi-experimental type. Specifically, pretest, posttest non-equivalent-control group design was used for the study. The design was used for the study because it involves experiment, control groups and the use of intact classes. In this type of design, the researcher cannot randomly sample the research subjects.

The area of the study was Kogi East Education Zone in Nigeria. The population of the study was 7,380 Senior Secondary two Physics students from 153 co-educational secondary schools in Kogi East Education Zone during the 2018/2019 academic session. This population is made up of 4,794 males and 2,586 females [19].

The sample size of the study comprised 294 (males =187, and females = 107) Physics students from six schools in Kogi East Education Zone, Kogi State. Intact classes were used. Multi-stage sampling technique was employed to obtain the sample for the study. This was because it enabled the researcher to sample the students in the nine local government areas in the zone, including co-educational schools and schools with laboratory and qualified Physics teachers. The breakdown includes is that random sampling technique was used for selecting three local government areas out of the nine local government areas in Kogi East Education Zone. From this sampling technique, Ankpa, Idah and Olamaboro local government areas were selected.

Purposive sampling technique was employed in selecting six schools two each out of the three sampled local government areas in Kogi East Education Zone. Stratified random sampling technique was used to assign two schools each to each of the three groups or strata (experimental group 1, experimental group 2 and the control group). One intact class in each of the six schools was used for the study. Therefore, in this study, random sampling, purposive sampling and stratified random sampling techniques were used in the sampling process.

The instrument used in this study is Thermal physics Performance Test (TPPT). The TPPT was used to measure students' performance in thermal physics concepts before and after the treatment. The items were reshuffled and administered as posttest. They were made up of 50 structured objective questions and were drawn from the standardized questions in West African Examinations Council (WAEC) past questions from 2008 - 2018. In each item, the students were expected to choose the correct option from the four options letter A to D. Each correct option chosen attracted two marks while wrong option was scored zero. The scoring guide for the TPPT was drawn by the researcher from the same WAEC questions.

The Thermal physics Performance Test (TPPT and lesson plans were subjected to face while TPPT was further subjected to content validation. Based on the comments of the validators, some of the items in TPPT were restructured and some were removed. The observations of the experts were used for the final modification and selection of the items for the study.

A trial test was conducted in three schools outside the area of study. This was to avoid bias and test-wise effect on the subjects. Twenty copies of the instruments were used for the pilot test. After the trial testing, the reliability of TPPT was determined using Kuder Richardson (KR21) Reliability Test. The choice of this reliability estimate was because the instrument is dichotomously scored. That is, each item of the instrument has right or wrong answer. With this Kuder Richardson (K-R 21), the internal consistency index of the instrument was calculated to be 0.79 which shows that TPPT is reliable.

2.2. Method of Data Collection

Before the commencement of the study proper, the six research assistants (regular Physics teachers) administered the Thermal physics Performance Test (TPPT) as pretest to the students in the three groups (CCIS, CCP and TPIS) in their respective schools. Thereafter, the teachers administered the TPPT as posttest after six weeks of treatment.

In this study, three instructional approaches were used. They were cognitive conflict instructional strategy (CCIS), conceptual change pedagogy (CCP) as experimental group which are the same in content, instructional objectives and evaluation and traditional instructional strategy as control group. Also, the two instructional strategies that were used as experimental group are constructivist teaching approaches and conceptual change approaches. In CCIS, there are three stages, which are: (a) Identifying students' current state of knowledge. This was done through the use of pretest, in this case TPPT will be used to determine students' preconception in thermal physics. (b) Confronting students with contradictory information: it is usually presented through texts and interviewers, who make explicit the contradictions or only guide the debate with the students or among peers or by the teacher and new techniques and; (c) Evaluating the degree of change between students' prior ideas or beliefs and a posttest measure after the instructional intervention. The conflict is induced often by presenting information that is clearly for the experimental or the teacher contradicts children's or students' ideas, beliefs or theories [20]. For clarity, the researchers divided step two into four more steps and makes the steps to be six steps. This modification does not in any way change the original three steps, but rather makes the model more understandable and simple to use. The six steps are:

Step 1: Identifying students' alternative conception;

Step 2: Presentation of anomalous situation;

Step 3: Creation of cognitive conflict with the anomalous situation.

Step 4: Students interaction with peers;

Step 5: Discussion and summary

Step 6: Evaluation of degree of change between students' prior idea and posttest measure.

In this method, students were grouped into two pairs. The teacher demonstrated an anomalous situation experiment to ascertain students' alternative conceptions. After these students were allowed to do the experiment and come up with a result that contradicts with their previous conceptions and set students in cognitive conflict. The students were asked to discuss the result of the experiment and their previous ideas with their peers. Lastly, the teacher collected different ideas about the experiment, summarized them on the board and discussed them with the class through which correct ideas were determined and explained in detail.

Similarly, in CCP, five-step conceptual change pedagogy will be used which includes:

Step 1: Diagnosis of students' misconceptions

Step 2: Exploring the phenomena in question using guided discovery methods

Step 3: Discussion of the results of the experiments

Step 4: Development of dissatisfaction with the pre-existing conceptions.

Step 5: Development of fruitfulness by applying the new concepts to real-world examples.

Here, the instructor asked the students to provide examples of the phenomena occurring in their own lives and to explain the concept in their own context. This model was developed by Stoffleet and Stoddart [21].

In this method, no grouping of the students was done. Preconception test (TPPT) was used to diagnose students' misunderstanding. After this, all the students found misconceived in thermal physics concepts were used for the study. Experiments followed immediately after the pre-testing. The teacher's role was to guide the students during practical sections. During discussions, the teacher moderated the sections and put students on tract. Students were led to dissatisfy with their naive beliefs or misunderstandings. The teacher once again asked students to draw an example (s) from their immediate environment on the uses of their newly acquired concepts. Finally, posttest was administered using the same thermal physics performance test instruments that have been reshuffled.

For the Traditional Instructional Strategy (TIS), the teacher used discussion method of teaching. The steps include:

Step 1: Diagnosing students' misunderstanding

Step 2: Exploring the phenomena using lecture and discussion method.

Step 3: Discussion of what the students read from the Physics text

Step 4: Development of dissatisfaction with the pre-existing conceptions

Step 5: Development of fruitfulness based on what they have read from the text, the teachers' explanation and their pre-existing conceptions.

Here the teacher uses examples to explain the concept to the students. All the teaching was done by following the detailed lesson notes prepared for the three groups. In the new Physics curriculum, the thermal physics topics last for six weeks, hence the teaching in the study was spread across six weeks in order to follow the stipulated duration in the curriculum [22] but a total of eight weeks was used for the study.

3. Results and Discussion

3.1. Results

The results from the data analysis and interpretation are presented according to the research questions and hypotheses formulated for the study. Data related to each research question and hypotheses are presented on a separate table to aid comprehension of the analysis and interpretation of results. The data presented were analyzed using means, bar graphs and standard deviations to answer the research questions. The hypotheses for the study were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The decision rule was that null hypotheses were rejected if the P-value was less than 0.05 and not rejected if otherwise.

Research Question One

What are the mean academic performance scores of SSII students taught thermal physics using cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy?

Table 1. Mean Performance Scores of SSII Students taught Thermal physics using Cognitive Conflict Instructional Strategy, Conceptual Change Pedagogy and Traditional Instructional Strategy

Method		PreTPPT	PostTPPT	Mean Gain
Cognitive Conflict Instructional Strategy	Mean	42.8700	78.7900	35.92
	N	100	100	
	Std. Deviation	12.67516	12.55879	
Conceptual Change Pedagogy	Mean	42.2708	68.2500	25.98
	N	96	96	
	Std. Deviation	10.28691	13.31165	
Traditional Instructional Strategy	Mean	42.2755	53.4388	11.16
	N	98	98	
	Std. Deviation	10.97023	12.29287	

The analysis of data on Table 1. reveals the mean academic performance scores of SSII students taught thermal physics using cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy. The table shows that the mean performance score of students taught thermal physics using cognitive conflict instructional strategy is 42.87 with a standard deviation of 12.68 during pre-test and 78.79 with a standard deviation of 12.56 in post-test. The mean performance score of students taught thermal physics using conceptual change pedagogy is 42.27 with a standard deviation of 10.29 during pre-test and 68.25 with a standard deviation of 13.31 in posttest. The mean performance score of students taught thermal physics using traditional instructional strategy is 42.28 with a standard deviation of 10.97 during pre-test and 53.44 with a standard deviation of 12.29 in post-test. The table further shows that the mean gain for cognitive conflict instructional strategy is 35.92, while that of conceptual change pedagogy is 25.98 and traditional instructional strategy is 11.16. The summary of the pretest, posttest mean performance score as well as the mean gain in the performance scores of students in cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy is as shown in Fig 1.

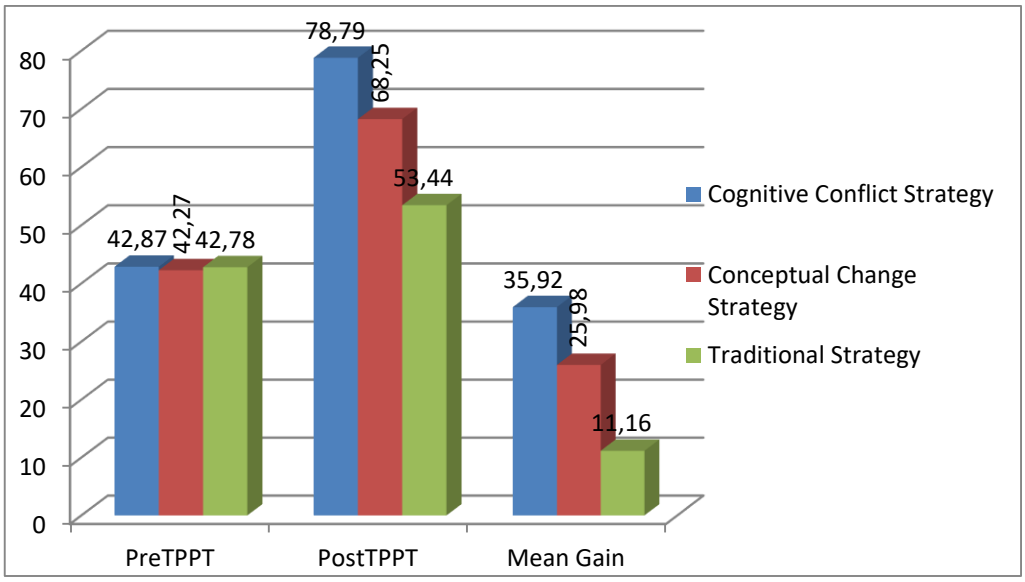

Fig. 1. Pretest, Posttest Mean Performance Scores of Students taught Thermal physics using Cognitive Conflict Instructional Strategy, Conceptual Change Pedagogy and Traditional Instructional Strategy

Research Question Two

What are the mean academic performance scores of male and female students taught thermal physics using cognitive conflict instructional strategy?

Table 2. Mean Academic Performance Scores of Male and Female Students taught Thermal physics using Cognitive Conflict Instructional Strategy

Gender		PreTPPT	PostTPPT	Mean Gain
Male	Mean	47.2373	84.6780	37.40
	N	59	59	
	Std. Deviation	12.36700	9.76701	
Female	Mean	36.5854	70.3171	33.73
	N	41	41	
	Std. Deviation	10.35610	11.28370	
Mean difference				3.67

Table 2. reveals the mean academic performance scores of male and female students taught thermal physics using cognitive conflict instructional strategy. The table shows that the mean performance scores of male students taught thermal physics using cognitive conflict instructional strategy is 47.24 with a standard deviation of 12.37 during pre-test and 84.68 with a standard deviation of 9.77 in posttest. On the other hand, the mean performance scores of female students taught thermal physics using cognitive conflict instructional strategy is 36.59 with a standard deviation of 10.35 during pre-test and 70.32 with a standard deviation of 11.28 in post- test, the table further shows that the mean gain of male students that were taught thermal physics using cognitive conflict instructional strategy is 37.40 and that of female students taught thermal physics using cognitive conflict instructional strategy is 33.73. The difference between the mean gains of male and female students taught thermal physics using cognitive conflict instructional strategy is 3.67 in favour of male students.

Research Question Three

What are the mean academic performance scores of male and female students taught thermal physics using conceptual change pedagogy?

Table 3. Mean Academic Performance Scores of Male and Female Students taught Thermal physics using Conceptual Change Pedagogy

Gender		PreTPPT	PostTPPT	Mean Gain
Male	Mean	41.6066	72.3934	30.78
	N	61	61	
	Std. Deviation	10.41038	12.61650	
Female	Mean	43.4286	61.0286	17.60
	N	35	35	
	Std. Deviation	10.11198	11.39010	
Mean difference				13.18

Table 3. reveals the mean academic performance scores of male and female students taught thermal physics using conceptual change pedagogy. The table shows that the mean performance scores of male students taught thermal physics using conceptual change pedagogy is 41.61 with a standard deviation of 10.41 during pre-test and 72.39 with a standard deviation of 12.62 in post-test, while the mean performance score of female students taught thermal physics using conceptual change pedagogy is 43.43 with a standard deviation of 10.11 during pre-test and 61.03 with a standard deviation of 11.39 in posttest, Table 5 further shows that the mean gain of male students that were taught thermal physics using conceptual change pedagogy is 30.78 and that of female students taught thermal physics using conceptual change pedagogy is 17.60. The difference between the mean gains of male and female students taught thermal physics using conceptual change pedagogy is 13.18 in favour of SSII male Physics students.

Research Question Four

How does interaction effect of treatments and gender affect students' mean academic performance scores in thermal physics?

In Fig 2. the profile plot/graph shows the interaction effect of treatments and gender on students' mean academic performance scores in thermal physics. The interaction pattern shows that the plots for males and females do not intersect though not parallel lines. This indicates that there is likelihood of an interaction effect between strategies and gender in TPPT for traditional Physics instructional strategy. But when the plot is extrapolated the intersection could only be at infinity, which means that the interaction effect between strategies and gender may be tenable only at infinity in this case.

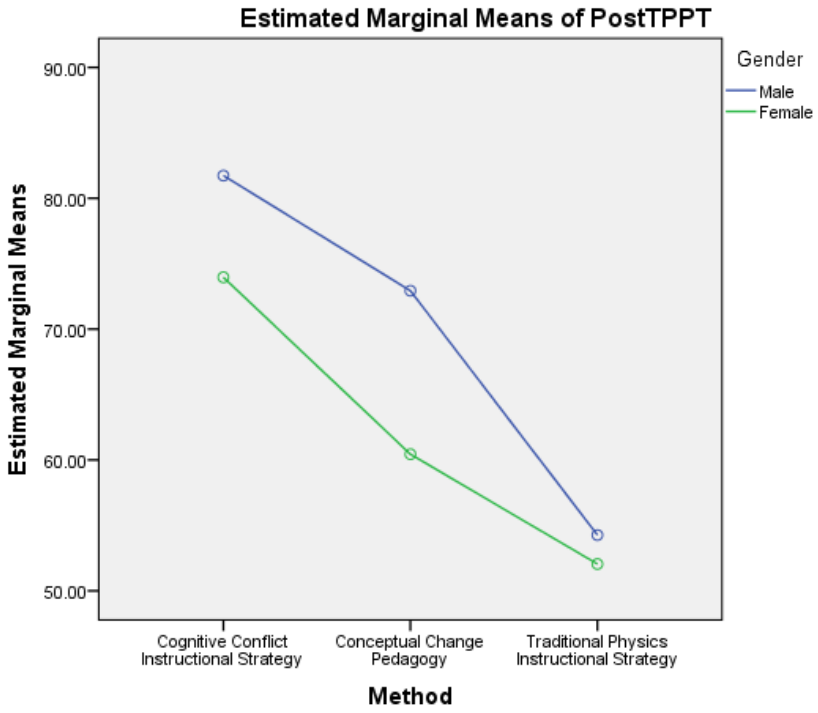

Fig. 2. Interaction Effect of Treatments and Gender on Students' Mean Academic Performance Scores in Thermal physics

Hypothesis One

There is no significant difference in the mean performance scores of students taught thermal physics using cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy

Table 4. ANCOVA of Mean Performance Scores of Students taught Thermal physics using Cognitive Conflict Instructional Strategy, Conceptual Change Pedagogy and Traditional Instructional Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	48138.112[a]	3	16046.037	149.920	.000	.608
Intercept	29739.418	1	29739.418	277.859	.000	.489
PreTPPT	16067.896	1	16067.896	150.125	.000	.341
Method	31144.448	2	15572.224	145.493	.000	.501
Error	31038.827	290	107.030			
Total	1394926.000	294				
Corrected Total	79176.939	293				

[a.] a. R Squared = .608 (Adjusted R Squared = .604)

Table 4. reveals difference in the mean performance scores of students taught thermal physics using cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy, that is, $F(2, 293) = 145.493$; $p = 0.000 < 0.05$. Since the p value is less than 0.05, the null hypothesis is thus rejected. This implies that there is significant difference in the mean performance scores of students taught thermal physics using cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy. Thus, it can be deduced based on evidence from data analysis that there is significant difference in mean performance scores among Physics students in cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy classes. The partial Eta square of 0.501 was obtained for the strategy.

This means that 50.1% of the students' performance in Physics can be accounted for by the strategy employed in the teaching.

Table 5. Comparisons of Mean Performance Scores of Students taught Thermal physics using Cognitive Conflict Instructional Strategy, Conceptual Change Pedagogy and Traditional Instructional Strategy

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.
Cognitive Conflict Instructional Strategy	Conceptual Change Pedagogy	10.148*	1.479	.000
	Traditional Instructional Strategy	24.963*	1.471	.000
Conceptual Change Pedagogy	Traditional Instructional Strategy	14.814*	1.486	.000

[b.] Based on estimated marginal means.

[c.] *. The mean difference is significant at the .05 level.

Table 5. shows the bivariate comparisons of the mean performance scores of students taught thermal physics using cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy. The table shows that methods of teaching thermal physics and its effect on the mean performance scores of students at P = 0.000 < 0.05 for cognitive conflict instructional strategy and conceptual change pedagogy; P = 0.000 < 0.05 for cognitive conflict instructional strategy and traditional instructional strategy; P = 0.000 < 0.05 for conceptual change pedagogy and traditional instructional strategy. Therefore, null hypothesis is rejected in all the three cases. This implies that there is significant difference in the mean performance scores of students taught thermal physics using cognitive conflict instructional strategy and traditional instructional strategy, cognitive conflict instructional strategy and conceptual change pedagogy as well as conceptual change pedagogy and traditional instructional strategy.

Hypothesis Two

There is no significant difference between the mean performance scores of male and female students taught thermal physics using cognitive conflict instructional strategy

Table 6. ANCOVA of Mean Performance Scores of Male and Female Students Taught Thermal physics using Cognitive Conflict Instructional Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6579.157[a]	2	3289.579	35.315	.000	.421
Intercept	27536.971	1	27536.971	295.623	.000	.753
PreTPPT	1590.327	1	1590.327	17.073	.000	.150
Gender	2273.671	1	2273.671	24.409	.000	.201
Error	9035.433	97	93.149			
Total	636401.000	100				
Corrected Total	15614.590	99				

[d.] a. R Squared = .421 (Adjusted R Squared = .409)

Table 6. reveals difference between the mean performance scores of male and female students taught thermal physics using cognitive conflict instructional strategy, F (1,99) = 24.409; p = 0.000 < 0.05. Since p is less than 0.05, the null hypothesis is rejected. This implies that there is significant difference between the mean performance scores of male and female students taught thermal physics using cognitive conflict instructional strategy. Thus, it can be deduced based on evidence from data analysis that there is significant difference between the mean performance scores of male and female students taught thermal physics using cognitive conflict instructional strategy classes. The partial Eta square of 0.201 is obtained for the strategy meaning that 20.1% of the students' performance score in Physics can be attributed to the cognitive conflict instructional strategy employed in the teaching thermal physics.

Hypothesis Three

There is no significant difference between the mean performance scores of male and female students taught thermal physics using conceptual change pedagogy.

Table 7. ACOVA of Mean Performance Scores of Male and Female Students taught Thermal physics using Conceptual Change Pedagogy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7277.373[a]	2	3638.687	35.410	.000	.432
Intercept	7689.394	1	7689.394	74.829	.000	.446
PreTPPT	4404.902	1	4404.902	42.866	.000	.316
Gender	3491.152	1	3491.152	33.974	.000	.268
Error	9556.627	93	102.759			
Total	464008.000	96				
Corrected Total	16834.000	95				

[e.] a. R Squared = .432 (Adjusted R Squared = .420)

Table 7. reveals difference between the mean performance scores of male and female students taught thermal physics using conceptual change pedagogy, F (1,95) = 33.974; p = 0.000 < 0.05. Since p is less than 0.05, the null hypothesis is rejected. This implies that there is significant difference between the mean performance scores of male and female students taught thermal physics using conceptual change pedagogy. Thus, it can be deduced based on evidence from data analysis that there is significant difference between the mean performance scores of male and female students taught thermal physics using conceptual change pedagogy. The partial Eta square of 0.268 is obtained for the strategy meaning that 26.8% of students' performance score in Physics can be accounted for by conceptual change pedagogy employed in the teaching thermal physics.

Hypothesis Four

There is no significant interaction effect of treatments and gender on the mean performance scores of students in thermal physics.

Table 8. Interaction Effect of Treatments and Gender on the Mean Performance Scores of Students in Thermal physics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	53128.144[a]	6	8854.691	97.559	.000	.671
Intercept	28045.354	1	28045.354	308.998	.000	.518
PreTPPT	13196.081	1	13196.081	145.392	.000	.336
Method	27514.826	2	13757.413	151.576	.000	.514
Gender	3765.938	1	3765.938	41.492	.000	.126
Method * Gender	1144.856	2	572.428	6.307	.002	.042
Error	26048.795	287	90.762			
Total	1394926.000	294				
Corrected Total	79176.939	293				

[f.] a. R Squared = .671 (Adjusted R Squared = .664)

Table 8. reveals significant interaction effect of treatments and gender on the mean performance scores of students in thermal physics, F (2, 293) = 6.307; p = 0.002 < 0.05. Since p is less than 0.05, the null hypothesis is rejected. This implies that there is significant interaction effect of treatments and gender on the mean performance scores of students in thermal physics. Thus, it can be deduced based on evidence from data analysis that there is significant interaction effect of treatments and gender on the mean performance scores of students in thermal physics. The partial Eta square of 0.042 is obtained for the strategy. This means that 4.2% of students' performance score in Physics can be accounted for by interaction effect of method and gender in the teaching thermal physics.

4. Discussion of Findings

Findings arrived at in this study are discussed in this section. The study investigated the effects of cognitive conflict instructional strategy and conceptual change pedagogy on students' academic performance in thermal physics concepts in Kogi East Educational Zone of Kogi State. Since the population for the study consisted of both male and female students, gender was incorporated as a moderating variable for comparison.

The finding revealed that there is significant difference in the mean performance scores of students taught thermal physics using cognitive conflict instructional strategy, conceptual change pedagogy and traditional instructional strategy. The bivariate comparisons of the methods of teaching thermal physics and its effect on the mean performance scores of students confirmed the rejected null hypothesis. This means that Physics could be better taught using cognitive conflict instructional strategy and conceptual change pedagogy than traditional instructional strategy. The finding agrees with that of Madu [9] and Agomouh [14] that constructivist based instruction is efficacious in enhancing students' conceptual change. The finding also agrees with Baser [23] that there was a significant difference in SS II students' performance when exposed to lecture method and cognitive conflict instructional approach. The finding also confirms that of Lee and Byun [24] that cognitive conflict initiated the first step in the process of conceptual change for students' better performance in motion concepts in Physics. The finding also agrees with that of Adebisi and Ajayi [25] that constructivist instructional strategy foster conceptual change more than the conceptual change pedagogy. The finding also agrees with Chi [26] that Chemistry students taught using cognitive conflict problem-based on teaching techniques (PBTT) perform better than those taught using conventional methods. The finding also agrees with that of Abiodun and Jonathan [27] that significant differences in mean performance scores in favour of students taught using constructivist teaching strategy than those taught using conventional method.

Conceptual change pedagogy when employed as a strategy of teaching thermal physics had the capacity of removing misconceptions. These are texts that refute commonly held simple concepts, and designed to make readers aware of the inadequacy of their intuitive ideas, directly stating that commonly held intuitive idea do not explain certain phenomena through the use of explanation and examples. Conceptual change pedagogy is an innovative approach that applies constructivist learning theory and responds in various ways to the situations. Cognitive conflict has been that the perception of inconsistency among an individual's cognitions generates psychological discomfort called cognitive dissonance and that this aversive state motivates individuals to attempt to resolve the dissonance. Cognitive dissonance predicted that when an individual holds two or more elements of knowledge that are relevant to each other but inconsistent with one another, a state of discomfort is created. This unpleasant state is referred to as dissonance. The use of cognitive conflict as an instructional strategy has the capacity to reduce this cognitive dissonance and therefore enhance performance. The use of cognitive conflict instructional strategy and conceptual change pedagogy show evidence of the putting the new knowledge to use, applying the knowledge in a new situation by solving a new problem, amplifying differentiated features, graphically reorganizing concepts into more coherent way in which teacher and students could evaluate progress. Evaluating the degree of change between students' prior ideas or beliefs is enhanced after the cognitive conflict instructional strategy and conceptual change pedagogy intervention.

The result further revealed that there is significant difference between the mean performance scores of male and female students taught thermal physics using cognitive conflict instructional strategy. This implies that the use of cognitive conflict instructional strategy is not gender friendly. The finding disagrees with Chi [26] who found that there was no significant different in the academic achievement of male and female Chemistry students taught with cognitive conflict problem based teaching techniques.

Gender stereo-typing permeates the Physics class when cognitive conflict instructional strategy was used to teach thermal physics. The performance of both male and female students was found to be significantly different. Physics has been seen as a masculine subjects just like Chemistry and Mathematics. The use of cognitive conflict instructional strategy is expected to bridge such gap but findings have shown that the instructional strategy is gender bias. Besides, language illustrations used in textbooks, bulletin boards and software-programmes suggest gender bias. Boys are generally portrayed as brave, intelligent, decisive and adventurous. On the other hand, girls are shown as shy,

timid and are assigned only to duties such as cooking meals and fetching water and sweeping. A study by Okeke [27] revealed that gender discrimination in schools and poor teaching method among other things have been identified as one of the causes of poor performance especially among female students in Physics. Notwithstanding, the use of an interactive strategy such as cognitive conflict strategy enhance performance among students in Physics.

The result further showed that there is significant difference between the mean performance scores of students taught thermal physics using conceptual change pedagogy. This implies that the use of conceptual change pedagogy is not gender friendly. The finding agrees with Adebisi and Ajayi [25] that there was a difference in the mean score of students taught constructivist instructional approach and those taught conceptual change pedagogies in favour of the male students in analytical chemistry concepts. The finding also agrees with Fairbanks [28] that there is significant difference in the level of conceptual shift in favour of male students.

The strategy draws attention to the status considerations that influence all learning. On this idea, findings showed that conceptual change strategy is not all about who is right or wrong but a solution package to help students learn and understand the right concept by questioning the already known concept that is in the same cognitive structure. Students' performance can only be enhanced when they are made to acquire the right conceptions that are in line with the scientific conception or idea.

The result revealed that there is significant interaction effect of treatments and gender on the mean performance scores of students in thermal physics. The interaction could come from the gender difference in the group that utilizes the cognitive conflict based instruction. The finding agrees with Ukozor [29], Lee and Byun [24], Ugwuanyi [30] and Tashidire [31] that there is interaction effect of gender and instructional treatment in favour of male respondents. The finding also confirms Madu and Orji [32] who found that there is significant interaction effect of treatment on male students than female. The finding also agrees with Mbajiorgu, Ezechi and Idoko that there is significant effect of gender on students' understanding of genetic concepts. Males were found to benefit more than females.

When two or more independent variables are involved in a research design there is more to consider than simply the main effect of each of the independent variables (also termed factors). That is, the effect of one independent variable on the dependent variable of interest may not be the same at all levels of the other independent variable. This means that the effect of one independent variable (strategy) may depend on the level of the other independent variable (gender). A factorial design was involved, in which the two independent variables (strategy) and gender were "crossed" with one another so that there are observations at every combination of levels of the two independent variables. In this study, they never crossed but very close.

5. Conclusion

Based on the findings it can be concluded in this paper that both cognitive conflict instructional strategy and conceptual change pedagogy are effective and student oriented strategies for teaching thermal physics. However, the two strategies are gender sensitive with male students taught using cognitive conflict instructional strategy and conceptual change pedagogy benefiting more in their performance than female students. Also both the strategies and gender when used together in a 3 x 2 x 1factorial design as in this study interact to affect students' performance in thermal physics. These conclusions have obvious implications for teaching and learning of physics especially thermal concepts. While both cognitive conflict instructional strategy and conceptual change pedagogy are effective and encouraged to be used for teaching thermal physics, they have to be used with caution as both are gender sensitive and therefore will not be appropriate for narrowing gender gap in performance and or in a factorial study involving gender as there will be interaction effect on performance. The following recommendations were made in the light of the findings of this study: (1) to maximize performance of students in thermal physics. Physics teachers are encouraged to use cognitive conflict instructional strategy and conceptual change pedagogy that are learner-centered with hands-on activities as conceptual change teaching strategies; (2) school administrators should adequately provide science learning facilities especially in physics to schools to facilitate teaching and learning of physics and other science subjects. This is important because meaningful learning cannot be advanced by constructivist and cognitive based teaching strategy in physics lessons if learning facilities are not available in secondary schools; (3) physics teaching guide and workshops are

recommended on the use of cognitive conflict instructional strategy and conceptual change pedagogy to teach conceptual change concepts; (4) students' gender should be taken into cognizance during teaching by Physics teachers especially when teaching to remedy misconceptions. This is because finding of the study have revealed that male and female students exist in separate conceptual world.

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Appendix A

Table 9. Analysis of Students' Performance in WASSEC 2008 to 2018

Year	Total No. that Sat.	No. Passing Credit and above (1-6) (%)	7-8 (%)	9 (%)
2008	375824	218199 (58.1)	95506 (25.4)	62119 (16.5)
2009	418593	180797 (43.2)	140172 (33.0)	88480 (21.1)
2010	415113	200345 (48.3)	911167 (22.0)	166772 (8.1)
2011	465636	222722 (47.8)	141595 (30.4)	79919(17.2)
2012	468593	180797 (43.2)	140172 (33.5)	88480 (21.1)
2013	463755	237756 (51.3)	141283 (30.5)	84716 (18.3)
2014	275369	130982 (47.6)	84418 (30.5)	53079 (19.3)
2015	254188	120768 (47.5)	81814 (32.2)	51606 (20.3)
2016	321499	158837 (49.4)	90012 (28.0)	61940(19.5)
2017	334129	142943 (41.5)	102036 (29.6)	89150 (25.9)
2018	344846	144314 (41.8)	103242 (29.9)	97290 (28.2)

[g] **Source:** Federal Ministry of Education, Statistics Office, Lagos, 2018