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Creation and Utilization of Collaborative-Predict-Explain-Observe-Explain (CPEOE) Instructional Package and Students' Learning Outcomes in Chemistry

Victor Oluwatosin Ajayi[1*]

[1] Department of Science Education, Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria

Abstract

Purpose: This research was on how to create Collaborative-Predict-Explain-Observe-Explain (CPEOE) instructional package and it investigated the effectiveness of utilizing CPEOE to enhance students' learning outcomes in Chemistry in Nigeria. CPEOE was modified from Predict-Explain-Observe-Explain (PEOE) by the author to emphasize that, knowledge is a social construct and as a result, instruction need to involve learners working in teams or groups to easily and successfully accomplish a common goal. **Methodology:** The sample of this study was made up 152 SS2 Students that were drawn from 4 senior secondary schools in Ekiti State, Nigeria using multi-stage sampling technique. Quasi-experimental research design was adopted and the instrument used for data collection was Chemistry Learning Outcome Test (CLOT). Kuder-Richardson was used to ascertain the reliability which gave a reliability value of 0.93. Three research questions and two null hypotheses guided the study. The research questions were answered using Mean and Standard Deviation scores while the hypotheses were tested at 0.05 significance level using Analysis of Covariance. **Findings:** It was found that there is significant difference in the mean learning outcome scores between students taught Chemistry using CPEOE and those taught using discussion method in favour of CPEOE [$F(1,151)=188.100$, $p<0.05$]. It is found that there is no significant difference in the mean learning outcome scores between male and female students taught Chemistry using CPEOE [$F(1,78)=163.100$, $P>0.05$]. **Significance:** It was recommended that chemistry teachers should adopt CPEOE for teaching, since it was found to be an effective instructional package in improving students' learning outcomes in chemistry.

Keywords: Collaborative-Predict-Explain-Observe-Explain (CPEOE), Students' Learning Outcome, Chemistry.

* Corresponding author: *Victor Oluwatosin Ajayi, drvictorajayi@gmail.com*

Introduction

Science and technology are indispensable practice in the world because the political, social and economic power of any nation depends on her achievement in the area of science and technology. Indeed, the progress of any nation is indicated by the overall political, social and economic development which depends upon citizens activities in their natural environment. Therefore, the study of science and technology is a critical instrument for the promotion of the nation economy and should form the foundation for development. the study of science and technology allied courses found base in the study of basic science, chemistry, biology, physics and chemistry at the senior secondary schools. Specifically, chemistry is taught in senior secondary schools to prepare a path for meaningful scientific and technological advancement. Ajayi (2019) explains that chemistry is an experimental science that systematically studies the composition, chemical and physical properties and activities of substances or elementary forms of matter.

Despite the usefulness of chemistry to scientific and technological advancement, various challenges plague the learning and teaching of chemistry at the senior secondary schools. The problems include method of instruction adopted by the teachers, teacher's content knowledge, gender gaps, students' poor results in Upper Basic Education School Examination, inadequate instructional facilities and lack of conceptual understanding by students (Ajayi & Ogbeba, 2017; Enemarie et al., 2019; Ajayi, 2019). This is affirmed by Ajayi and Achor (2021) that attributed the deterioration in student's learning outcome to ineffective teaching method used by teachers. Perhaps this is likely the reasons for learners' poor learning outcome in the chemistry at the senior secondary schools. Based on this a lot of researchers recommended some instructional strategies over the years to control the problem of learning outcome of students in the subject. Aliu (2019) recommended that the use of discussion method to enhance learning outcome of students in chemistry. Adesewa (2020) recommended learner autonomy strategy to enhance students' chemistry performance. In spite of the supposed effectiveness of these varieties of strategies, students offering chemistry persistently perform poor in external examination.

Chemistry teachers have used a number of teaching strategies in the past. Such methods are demonstration, lecture, expository, question and discussion methods. Studies have shown that these methods have not yielded expected results (Ajayi et al., 2025). Adedayo (2024) noted that discussion method is popular in teaching/learning of Chemistry in secondary schools in Nigeria. Discussion teaching method is the collaborative exchange of ideas among a teacher and students or among students for the purpose of furthering students thinking, problem solving, and understanding (Wilkinson et al., 2016). Adedayo (2024) further added that discussion method has received a lot of criticisms from different scholars such as Ajayi (2019) and Olorundare (2022). The scholars noted that discussion method may degenerate into mere talk and may be monopolized by few individuals. This may consequently lead to a conclusion far from the truth even though such may be accepted by the group as a whole. These has led to teachers not exposing the students to meaningful learning and this at the same time has made students to perceive Chemistry as abstract and difficult concepts to understand. In the long run, learners often resort to memorizing the concepts without meaningful learning taking place.

The researcher observed that students shy away from chemistry because of teacher's dominated style of teaching and students' inability to grasp the concepts in chemistry. This implies that the methods were students indulged in factual memorization of discrete facts limit effective communication of chemistry concepts. It is seen that the use of teacher dominated methods yielded nothing but learning by "rote". It is

against this deplorable trend that the researcher concluded that, chemistry teaching can only be effective when teachers are favorably disposed to using innovative strategies that can equip learners to think collaboratively about their cognition, monitor their learning experiences and evaluate the outcomes of these experiences. Based on this, the author created Collaborative-Predict-Explain-Observe-Explain (CPEOE) package that have the potential to facilitate meaningful learning.

Collaborative-Predict-Explain-Observe-Explain (CPEOE)

Collaborative-Predict-Explain-Observe-Explain (CPEOE) is a conceptual change strategy where learners collaboratively predict answers to challenging questions or event and justify or explain the reasons for their predictions then observe an experiment and are required to compare their observations with their predictions in order to monitor their learning experiences. In other words, CPEOE is an instructional strategy where four or five students in a team make predictions for an event and explain the reasons for their predictions, then conduct and observe a laboratory experiment and are required to compare their observations with their predictions, thereby enhancing conceptual understanding of scientific knowledge. This strategy focuses on concatenating students' previous or prior knowledge relevant to a situation and exploring the appropriateness of these knowledge or experience.

The technique of Collaborative-Predict-Explain-Observe-Explain (CPEOE) was created from Predict-Explain-Observe-Explain (PEOE) by Ajayi (2022) to emphasize that, knowledge is a social construct and as a result, instruction need to involve learners working in teams or groups to easily and successfully accomplish a common goal. Whereas, Predict-Explain-Observe-Explain (PEOE) was developed from Predict-Observe-Explain (POE) by Rickey and Stacey (2015) to emphasize that the students need to explain their predictions to make their beliefs explicit. Meanwhile, POE was originally modified from Demonstrate-Observe-Explain (DOE) by White and Gunstone (1992). Champagne et al. (1979) were the first to create this strategy as DOE to assess the understanding of first year physics students at the University of Pittsburg in 1979. DOE is about real-world situations or real-world experiences. The strategy involves formulating a question for prediction of the results of situation and then observing the effect of the change and explaining results. The advantage of DOE strategies includes a reduction in the quantity of verbal description and a reliance on open-ended questions which provide data to make inferences about students' conceptualizations (Champagne et al., 1979).

White and Gunstone (1992) redesigned the Demonstrate-Observe-Explain (DOE) strategy and developed the first Predict-Observe-Explain (POE) strategy. The scholars used POE strategy to probe children's understanding of science concepts in elementary science. The scholars opine that in POE, the students must first predict the outcome of an event, describe their observation and then reconcile contradictions between what they predicted and what they observed. This was supported by Liew and Treagust (2010), Costu et al. (2012), Mosca (2014), Phanphech and Tanitteerapan (2017), and Ajayi and Audu (2020) who were able to note that POE is a strategy that lets the students explore concepts and generate investigation. Furthermore, the students are given the chance to express their schema and experience the science ideas behind the activity to satisfy their curiosity.

The difference between Collaborative-Predict-Explain-Observe-Explain (CPEOE) and Predict-Explain-Observe-Explain (PEOE) is that, CPEOE emphasizes on collaborative learning. Collaborative learning is an umbrella for a variety of educational strategies involving joint efforts by both teacher and learners. Collaborative connote sharing ideas. Collaborative learning engages learners in active learning where they work and learn together in small groups to accomplish shared goals. CPEOE instructional

package have to the potential to facilitate the exchange of idea in a team and encourage easy and successful accomplishment of teaching/learning goals. The researcher created a seven-step format for Collaborative-Predict-Explain-Observe-Explain (CPEOE) instructional package as follows;

Step One: Introduction

Teacher Activity; Teacher to

- Arouse students' interest by making clear to the students the objectives of the day's study and making clear to them the importance of the subject matter and its relevance to daily life.
- Give the students a resume of what is to be taught, after asking them a few questions to probe into their prior knowledge, teacher then explains what the concept/ topic to be taught is all about.

Students' Activity; students

- Answer the questions orally.
- Students jot down some points as the teacher speaks. They are also allowed to ask questions

Step Two: Grouping (Collaborative settings)/Elicitation of Students' Ideas

Teacher Activity; Teacher to

- Share students out into groups of four to seven depending on the class size
- Ask students to assume different roles
- A full-class discussion will provide the students with the opportunity to recall their prior knowledge.

Students' Activity; Students to

- Move to their respective groups and assume their different roles viz: captain, recorder, timekeeper and so on
- Give responses to the questions based on prior knowledge.
- Jot down some points as the teacher speaks. They are also allowed to ask questions

Step Three: Introducing the Experiment

Teacher Activity; Teacher to

- Introduces the activities or experiments. Concatenating it to earlier discussion will help make the activities meaningful.

Students' Activity; Students to

- Listen to the teacher and also jot down some points as the teacher speaks. They are also allowed to ask questions for clarification.

Step Four: Predict (P)

Teacher Activity;

- Before doing the experiment, ask a challenging question(s) that can be resolved through the experiment that follows.
- Ask each member of the group to write down their prediction to the question(s) asked on a piece of paper.
- Ask the learners to write down their prediction(s) on the CPEOE worksheet as agreed upon by the group.
- Goes around various groups to supervise the activities.

Students' Activity;

- Each member of the group is expected to write out their prediction on a piece of paper.
- All members spread out their papers on a flat surface (desk), where it can easily be read. Have a look at each other's predictions, and make quick comments.

- Then, the recorder for the group or whoever is assigned, write down their prediction(s) as agreed upon by the group and directed by the group captain on the CPEOE worksheet

Step Five: Explaining the Predictions (E)

Teacher Activity; Teacher

- Ask each member of the group to write down the explanation for their prediction to the question(s) asked on a piece of paper.
- Ask the students to write down the explanation for their prediction on the CPEOE worksheet as agreed upon by the group.
- Then, ask each group to present their CPEOE worksheet in full-class discussion, by placing the worksheet on a chalkboard. (At this stage, the CPEOE worksheet only contains highlight of the predictions and explanations for each group). After this has been done, you might invite the class to discuss which predictions and reasons or explanations they now think are best. (When learners reconsider their reasons, some may begin to change their minds and reconstruct their thinking. Immediately prior to the experiment, it's often fun and illuminating to have a straw vote about the outcome).

Students' Activity; Students

- Each member of the group is expected to write out the explanation for their prediction on a piece of paper.
- All members spread out their papers on a flat surface (desk), where it can easily be read. Have a look at each other's explanation for their predictions, and make quick comments.
- Then, the recorder for the group or whoever is assigned, write down the explanation for their prediction(s) as agreed upon by the group on the CPEOE worksheet
- Team leaders or selected group representatives makes their respective presentations in full class discussion
- Students to share their CPEOE worksheet containing both their predictions and the explanation for their predictions in full-class discussion

Step Six: Observe (O)

Teacher Activity; Teacher

- Ask the students to watch a demonstration or carryout a laboratory activity related to the questions asked in step three.
- Ask each member of the group to write down their observation from the activities
- Ask the learners to write down their observations on the CPEOE worksheets as agreed upon by the group.
- Goes around various groups to supervise the activities.

Students' Activity; Students

- Each member of the group is expected to jot down their observation on a piece of paper.
- All members spread out their papers on a flat surface (desk), where it can easily be read. Have a look at each other's observations, and make quick comments.
- Then, the recorder for the group or whoever is assigned, write down their observation(s) as agreed upon by the group and directed by the group captain on the CPEOE worksheet.

Step Seven: Explaining the Observations (E)

Teacher Activity; Teacher

- Ask each member of the group to write down the explanation for their observation(s) on a piece of

paper.

- Ask the learners to write down the explanation for the observation(s) on CPEOE worksheet as agreed upon by the group. Then, ask each group to present their CPEOE worksheet in full-class discussion, by placing the worksheet on a chalkboard. (At this stage, the CPEOE worksheet contains highlight of the predictions, explanations for their predictions, observation, and explanations for their observation for each group)
- Invite the class to discuss which observation and reasons or explanations they now think are best. (At this stage, learners correlate their prediction with their observation and reconstruct their thinking).
- Engage the students in full class discussion in order to reconcile any conflict between their predictions and observations.
- To disengage from their groupings

Students' Activity; Students

- Each member of the group is expected to write out the explanation for their observation on a piece of paper.
- All members spread out their papers on a flat surface (desk), where it can easily be read. Have a look at each other's explanation for their observations, and make quick comments.
- Then, the recorder for the group, write down the explanation for their observation(s) as agreed upon by the group on the CPEOE worksheet
- Team leaders or selected group representatives makes their respective presentations in full class discussion
- At this stage, students are expected to compare their prediction and observation in order to reconcile any conflict between their predictions and observations in a brief full class discussion
- They are allowed to ask questions for clarification. Students move to their respective sits.

Statement of the Problem

The author observed that prominent among the causes of poor students' learning outcomes in chemistry is their inability to attempt various challenging questions in chemistry. The poor learning outcomes of students were traced to the teaching methods adopted by chemistry teachers in senior secondary schools. The conventional teaching methods with it obvious and serious limitations was still observed as a popular teaching method in chemistry classrooms. This necessitated the search for a better innovative teaching strategy that have the potential of enhancing students' learning outcomes in chemistry. Hence, the study created Collaborative-Predict-Explain-Observe-Explain (CPEOE) instructional package and investigated if its utilization could enhance learning outcomes in Chemistry in Nigeria.

Purpose of the Study

The purpose of the study was to investigate if Collaborative-Predict-Explain-Observe-Explain (CPEOE) enhance students' learning outcome in Chemistry. Specifically, the study;

1. Investigated the effect of CPEOE on students' learning outcome in Chemistry.
2. Investigated the difference in effect of CPEOE between male and female students' learning outcomes in Chemistry.
3. Investigated the interaction effect between strategies and gender on students' learning outcome in Chemistry.

Research Questions

The following research questions guided the study:

1. What is the difference in the mean learning outcome scores between students taught Chemistry using CPEOE and those taught using discussion method?
2. What is the difference in the mean learning outcome scores between male and female students taught Chemistry using CPEOE?
3. What is the mean interaction effect of treatments and gender on students' learning outcome in Chemistry?

Hypotheses

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

1. There is no significant difference in the mean learning outcome scores between students taught Chemistry using CPEOE and those taught using discussion method.
2. There is no significant difference in the mean learning outcome scores between male and females' students taught Chemistry using CPEOE.
3. There is no significant interaction effect of treatments and gender on the mean learning outcomes scores of students in Chemistry.

Method

The study employed pre-test, post-test quasi experimental design. The study area was Ado Local Government Area of Ekiti State, Nigeria. The population of the study was made up of 8,637 Senior Secondary 2 students in the 47-government approved secondary schools. The sample of this study was made up 152 SS2 Students that were drawn from 4 senior secondary schools in Ekiti State, Nigeria using multi-stage sampling technique. These schools were selected based on the following conditions: Government grant-aided; Co-educational schools; Chemistry teachers with a minimum qualification of first degree in Chemistry/Education with at least three years of teaching experience; Chemistry Laboratory with at least a laboratory attendant; and where the school authorities permitted the carrying out of the experiment. One instrument known as Chemistry Learning Outcome Test (CLOT) was used to collect data for this study. CLOT is a researcher made instrument that contains two sections. Section A contains bio-data information of the respondents, while section B contains 40 multi-choice objective items questions which respondents are expected to provide the correct answer by ticking the correct options (A-D).

Chemistry Learning Outcome Test (CLOT) was validated by three experts of Science Education and two experts in Measurement and Evaluation all from Benue State University, Makurdi. Corrections and suggestions arising from these experts were used to review the instrument before it was used. Kuder-Richardson (KR-21) was used to obtain the CLOT reliability, which yielded a coefficient value of 0.93. The conduct of the study took place during the normal school lesson periods. The normal time-table of the schools for the study were followed. Before the commencement of the actual treatment, the researcher used one week for the training of the Chemistry teachers who served as research assistants.

The researcher used one week for the training of the Chemistry teachers who served as research The training program covered the following areas: The purpose of the research; the concepts selected for instruction; Procedure to teach the instructional packages; and Procedure for administering the instruments. The training program was to ensure the homogeneity of instructional situation across the two

groups. The training for the experimental group only differs from that of the control group by the use of CPEOE. The sample was divided into two groups namely; experimental and control group.

During lessons, the experimental group was taught Chemistry using CPEOE in line with lessons procedure prepared by the researcher while the control group was taught the same Chemistry topics using the discussion lesson notes which lasted for four weeks. The study covers three sub-topics under Chemistry which includes Alkane, Alkene, and Ethanol and Redox reaction selected from the SS2 scheme of work. The choice of the sub-topics was to help students overcome the difficulties associated with learning outcome in Chemistry as one of the areas that standout as problem areas to Chemistry students in the report by the Chief Examiner's for West African Examination Council (2018/2019). Chemistry Learning Outcome Test (CLOT) was administered as pre-test by the researcher with the assistance of the sampled schools Chemistry teachers. This lasted for one week before actual teaching commences. At the end of these periods, the post-CLOT was administered which lasted for one week. The descriptive statistics of Mean and standard deviation were used to answer to the research questions while the inferential statistics of ANCOVA was used to test the null hypotheses.

Results and Discussions

Research Question 1

What is the difference in the mean learning outcomes scores between students taught Chemistry using CPEOE and those taught using discussion method? The answer to research question one is contained in Table 1.

Table 1

Mean Learning Outcome and Standard Deviation Scores of Students using CPEOE and Discussion

Group	PRE-CLOT		POST-CLOT		
	$\tilde{x}$	δ	$\tilde{x}$	δ	Mean Gain
CPEOE	10.319	1.16	22.24	1.41	11.93
Discussion method	10.303	1.13	13.42	1.24	3.12
Mean difference	0.01		8.82		8.81

The results in Table 1 reveal that, the pre-test mean scores for CPEOE and discussion groups are 10.31 and 10.30 respectively with their standard deviation scores of 1.16 and 1.13 respectively. The post-test mean scores accordingly were 22.24 and 13.42 with their standard deviation scores of 1.41 and 1.24 respectively. The overall difference between the CPEOE and discussion groups was 8.82 in favour of CPEOE group. This implies that the learners in CPEOE had learning outcomes than the discussion group.

Research Question 2

What is the difference in the mean learning outcomes scores between male and female students taught Chemistry using CPEOE? The answer to research question two is presented in Table 2.

Table 2

Mean Learning Outcomes and Standard Deviation Scores of Male and Female Students using CPEOE

Gender	PRE-CLOT		POST-CLOT		
	$\tilde{x}$	δ	$\tilde{x}$	δ	Mean Gain
Male	11.154	1.17	26.76	1.42	15.61
Female	11.135	1.13	26.27	1.39	15.14
Mean difference	0.02		0.49		0.47

Table 2 showed that, male and female students had a mean gain of 15.61 and 15.14 respectively. The mean difference is 0.47. This difference, though small is in favour of the male students. This implies that male learners had slightly higher learning outcomes than the female students using CPEOE.

Research Question 3

What is the interaction effect of treatments and gender on students' learning outcome in Chemistry? The answer to research question three is shown in figure 1.

Figure 1

Plot of treatments and gender on students' learning outcomes

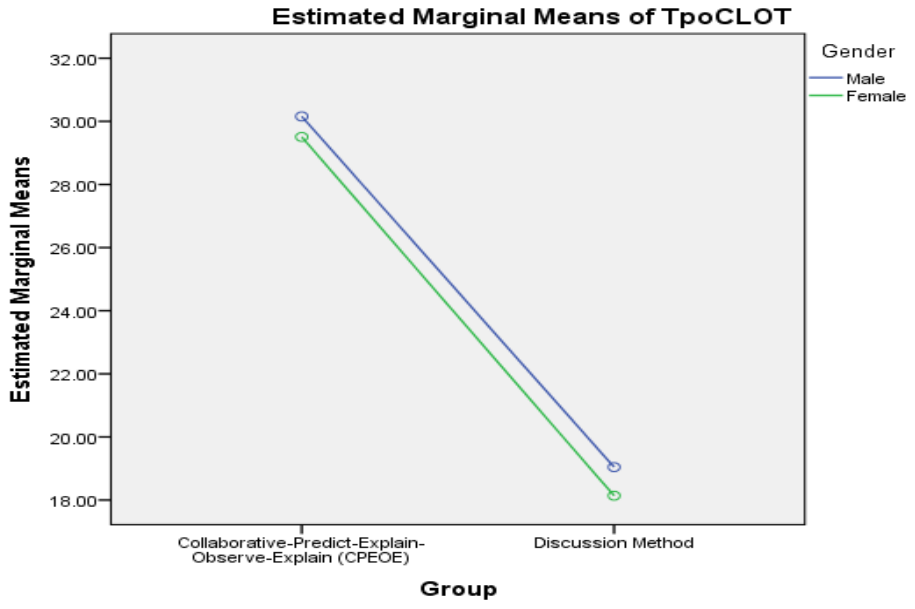

Figure 1 presents a graph of the interaction of treatments and gender on the mean learning outcomes scores of students in Chemistry. The graph lines for gender did not intercept. It is therefore suggested that there was no interactive effect of treatments and gender on students' learning outcomes in Chemistry.

Hypothesis 1

There is no significant difference in the mean learning outcome scores between students taught Chemistry using CPEOE and those taught using discussion method. Hypothesis one is presented in Table 3.

Table 3

Analysis of Covariance for Learning Outcomes Scores of Students taught using CPEOE and Discussion

Source	Type III sum of square	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected model	4663.733[a]	4	1165.933	26.774	.000	.437
Intercept	4136.918	1	4136.918	94.999	.000	.408
TPr^{CLOT}	85.421	1	85.421	1.962	.164	.014
Group	4445.054	1	4445.054	102.05	.000	.725
Gender	21.187	1	21.187	.487	.487	.004
Group * Gender	.573	1	.573	.013	.909	.000
Error	6009.470	149	7.701			
Total	94004.000	152				
Corrected Total	10673.203	151				

a. R squared = .437 (Adjusted R Squared= .421)

ANCOVA Test result in Table 3 reveals that there is a significant difference between CPEOE and discussion method of teaching in favour of CPEOE strategy [F(1,151) =102.075, p<0.05]. The null hypothesis is therefore rejected. This implies that CPEOE strategy was highly effective than discussion method in improving students' learning outcomes in chemistry. Meanwhile, the effect size was 0.725 as shown by the corresponding partial eta squared value is considered as large effect size. This implies that, 72.5% of the variance in the learning outcomes scores between the groups was explained by the treatments. Hence, the difference in the learning outcomes scores between the groups has a large statistical effect size.

Hypothesis 2

There is no significant difference in the mean learning outcome scores between male and female students taught Chemistry using CPEOE. The test to hypothesis two is presented in Table 4.

Table 4

Analysis of Covariance for Learning Outcomes Scores of Students' based on Gender taught using CPEOE

Source	Type III sum of square	df	Mean Square	F	Sig.
Corrected model	3582.001[a]	2	377.101	181.10	.000
Intercept	1971.001	1	1971.001	159.001	.000
TPr^{CPT}	159.001	1	159.001	153.001	.000
Gender	1827.001	1	1827.001	197.100	.221
Error	325.005	76	14.001		
Total	324421.001	79			
Corrected Total	2978.001	78			

a. R squared = .241 (Adjusted R Squared= .239)

ANCOVA Test results in Table 4 reveal that there is no significant difference between the mean learning of male and female students taught chemistry using CPEOE [F(1,78) = 197.100, P>0.050]. The null hypothesis is therefore not rejected. This implies that CPEOE enhanced both male and female students' learning outcomes in Chemistry.

Hypothesis 3

There is no significant interaction effect of treatments and gender on the mean learning outcomes scores of students in Chemistry. The data analysis of Table 3 is used to explain hypothesis 3. The table presents the ANCOVA for learning outcomes of students taught Chemistry using Collaborative-Predict-Explain-Observe-Explain (CPEOE) and discussion method (DM). The table also presents the interaction effect of instructional strategies and gender. The data in Table 3 reveals that there is no significant interaction effect of treatments and gender on the mean learning outcome scores of students in Chemistry [$F_{1,151}$ =.013, P>0.050]. The null hypothesis is therefore not rejected. Meanwhile, the effect size was 0.000 as indicated by the corresponding partial eta squared value which is considered as small effect size. This implies that, only 0.0% of the interaction in the learning outcomes scores among groups was explained by treatments and gender. Hence, the interaction of treatments and gender on students' learning outcome has small statistical effect size.

This research focused on how to create Collaborative-Predict-Explain-Observe-Explain (CPEOE) package and investigated if the utilization of CPEOE can enhance students' learning outcomes in Chemistry in Nigeria. CPEOE is a strategy which focuses on linking students' previous experiences relevant to a situation and exploring the appropriateness of these experiences. Hence, a seven-step format for CPEOE instructional package was created by the researcher and the effectiveness of CPEOE instructional package in enhancing students' learning outcome in Chemistry was also investigated. It was revealed that students taught Chemistry using CPEOE had higher learning outcomes when compared with those taught using conventional method. However, the likely explanation for this outcome may be attributed to the fact that CPEOE used to help students develop a cognitive structure that enable mean-

ingful learning. The instructional strategy enables students to understand the structure of knowledge and process of knowledge construction.

The likely explanation for this outcome may because of the nature of CPEOE such as build on a learner's inherent inquisitiveness and curiosity; encourage a learner to collaborative think about the challenge given by the questions posed by the teacher; undertake the investigation in the classroom to give first-hand exploration; meet the challenge within the parameters set; discuss and plan what to do to reach the target outcome; interpret results, relating one factor to another and draw conclusions made it possible to enhance the learning outcomes of learners taught when compared to the discussion method.

It was revealed that there is no statistically significant difference between male and female students' learning outcomes using CPEOE strategy. It was revealed that there is no significant interaction effect between methods and gender on mean learning outcomes in Chemistry. This implies that, CPEOE is highly better when compared to discussion method regardless of gender. Therefore, there is no need for separation of instructional method.

Conclusions

The use of CPEOE is more effective in facilitating and enhancing students' learning outcomes in Chemistry than conventional discussion strategy. By implication, this affirmed that students' learning outcomes in chemistry depend on the instructional strategies. It is also evident from the findings of this study that CPEOE can foster students' learning outcome regardless of gender. Thus, CPEOE is significantly a very useful package for effective learning and improves learning outcomes of students irrespective of gender. The following recommendations are made:

1. Teachers should adopt CPEOE for teaching, since it was found to be an effective package in improving students' learning outcomes in Chemistry.
2. Workshops should be organized through administrators and professional bodies such as Science Teachers Association of Nigeria (STAN) to sensitize Chemistry teachers with a view to improving their skills and experiences on the usage of CPEOE strategy aimed at developing students' learning outcomes in Chemistry.
3. Teacher should use CPEOE for both male and female students to enhance their learning outcomes in Chemistry since it is not gender sensitive.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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APPENDIX

Sample of Expected Collaborative Predict-Explain-Observe-Explain (CPEOE) worksheet

<table>
<tr><td></td><td>CPEOE WORKSHEET FOR ALKANE</td></tr>
<tr><td></td><td>Group_____ Date_____</td></tr>
<tr><td><u>P</u>redict
(What do you think will happen?
  </td><td>1. If you mix sodium acetate and sodium hydroxide together in a test tube, what do you think will happen? <u>There may be no reaction until it is heated</u>
2. If the solution is heated, what do you think the equation for the reaction would be? $NaOH+CH_3COONa$ heat $CH_4 + Na_2CO_3$ ⟶
3. If you place the mixture on a bunsen burner, what do you think will happen? <u>After a while methane gas will start liberating</u>
4. If the gas is ignited, it would burn with a particular colour and odour, what do you think is the colour and odour? <u>The gas is likely to burn with a blue fire and odourless.</u>
5. What do you think the name of the gas would be? <u>The unknown gas is likely to be methane</u></td></tr>
<tr><td><u>E</u>xplain
(Why do you think that will happen)
  </td><td>1. Because it requires heat for the salts of carbonic acids to melt with alkalis (sodium hydroxide) for it to release alkane (methane)
3. Due to the interaction between sodium acetate and hydroxide
4. Methane undergoes complete combustion and it is an odourless gas. In this regard, a blue gas flame indicates complete combustion while red or yellow gas flame may be a sign of incomplete combustion.</td></tr>
<tr><td><u>O</u>bserve
What actually happened?
  </td><td>
<table>
<tr><td>Test</td><td>Observation</td><td>Inference</td></tr>
<tr><td>$CH_3COONa+$ $NaOH$ + Heat</td><td>After a while unknown gas starts liberating</td><td></td></tr>
<tr><td>Unknown gas + ignition</td><td>The unknown gas burn with a blue fire with colourless and odourless gas</td><td>Methane is produced</td></tr>
</table>
</td></tr>
</table>

Explain (Why did that happen?) 	The unknown gas burns with a blue frame, indicate it undergoes complete combustion and it is an odourless gas. In this regard, the unknown gas is methane.