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Possibility of Enhancing Students' Academic Performance in Electrolysis Using Collaborative-Predict-Observe-Explain-Write (CPOEW) and 3E's Learning Models

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Abstract

This research investigated the possibility of enhancing senior secondary school students' academic performance in electrolysis using Collaborative-Predict-Observe-Explain-Write (CPOEW) and Exploration, Explanation and Evaluation (3E's) learning models. The study adopted a quasi-experimental research design. Electrolysis Performance Test (EPT) was the instrument used for data collection. Kuder-Richardson (KR-21) formula was used to test the internal consistency of EPT which yielded a reliability value of 0.91. The population was 7,152 SS2 students offering chemistry in Makurdi, Benue State, Nigeria. A sample of 143 students drawn from 3 schools in Makurdi Local Government Area of Benue State, Nigeria was selected using multi-stage sampling techniques. Two research questions and two null hypotheses guided the study. The research questions were answered using Mean and Standard Deviation scores while the null hypotheses were tested at 0.05 level of significance using results from Analysis of Covariance (ANCOVA). The study revealed that there was significant difference in the mean academic performance of students taught Electrolysis using CPOEW, 3E's model and discussion method [$F_{2, 140}$=1943.116, P<0.05]. The study revealed that there was no significant interaction effect of treatments and gender on the mean academic performance scores of students in electrolysis [$F_{2, 140}$=114.340, P<0.05]. It was recommended among others that to enhance students' academic performance in electrolysis, serving teachers should be encouraged to use CPOEW and 3E's learning models in teaching electrolysis.

Keywords: CPOEW model, 3E's model, academic performance and electrolysis

1. Introduction

Science Education is aimed at inculcating in the learner appropriate skills to live in and contribute to the development of the society. Chemistry as a science subject is an important tool for industrial and technological advancement as its concepts have been useful in the interpretation of biological, physical and

chemical phenomena in science. Chemistry as a core science subjects deals with scientific study of the composition, structure, properties, and reactions of matter in different forms (Ajayi, V.O., & Angura, M.T, 2017). Electrolysis which is the main focus of this study is a process of decomposing ionic compounds into their elements by passing a direct electric current through the compound in a fluid form. Electrolysis is a process that helped in the study of chemical reactions in obtaining pure elements. Electrolysis is a technique that uses direct electric current to drive an otherwise non-spontaneous chemical reaction.

Electrolysis is commercially important as a stage in the separation of elements from naturally occurring sources such as ores using an electrolytic cell. In both experimental and industrial products, electrolysis finds many applications such as in electroplating for corrosion resistance, ornaments and in manufacture of pure gases and compounds like sodium hydroxide, sodium carbonate, potassium chlorate and so on. Despite the importance of chemistry and specifically, electrolysis and the efforts of researchers such as Haruna, M. A. (2018) and Ajayi, V.O. & Audu, C.T. (2023) to improve on its teaching and learning, academic performance of students in the chemistry remains poor in Nigeria. The issue of poor academic performance in chemistry at the SSCE in Nigeria has been widely documented. For instance, Ozcan, G.E., & Uyanik, G. (2022) revealed that all the senior secondary candidates that registered for the Senior Secondary Education Certificate Examination in Makurdi in 2019 only 39.09% passed chemistry at credit level and in the subsequent years the percentage passes at credit level dropped to 36.68% in 2020 and only 37.75% in 2021.

This poor academic performance is attested to by Chief Examiner report of WAEC (2020/2021) that students' performance in chemistry is relatively poor especially in some aspect of chemistry such as electrolysis, thermodynamics and so on. Some of the identified problems according to Olorundare, A.S. (2017) and Atsuwe, B.A., & Nyinya, M. (2022) include passive teaching methods, teacher quality, work environment, inadequacy of laboratory and workshop facilities, low morale and poor preparation of teachers, poor funding of science research among others. Furthermore, Akpghol, T.V., Samba, R.M.O. & Asemave, K. (2020) stated poor teaching method is a major cause of students' poor academic performance in chemistry. Hence, the implication of the persistent poor academic performance in chemistry is that the much-needed educational development will remain a wishful thinking until the inherent problems are identified and remedied. Therefore, if chemistry especially electrolysis is properly taught using effective and appropriate strategies, students' academic performance could be enhanced and therefore provide the nation with valuable technological development, which are required for the achievement of both personal and national goals.

Ajayi, V.O. & Audu, C.T. (2023) opine that teachers should not focus on only conventional method of teaching. This is because it is only when a student has good mastery of the subject that he can do well in examination. Teachers have used a number of teaching methods in the past. Such methods are demonstration, field trip, project method, lecture, expository, question and discussion methods. Studies have shown that these methods have not yielded expected result (Ajiboye, H, 2015), Ajayi, V.O. (2021) and Atsuwe, B.A., & Vaava, A.T. (2022). Ajayi, V.O. (2021) noted that discussion method is popular in teaching/learning of chemistry in senior secondary schools in Nigeria. Discussion method has received a lot of criticisms from different scholars such as Archibong, A.U. (2016) and Obonamu, B.J., & Nbina, J.B. (2021). 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 have led to teachers not exposing the students to meaningful learning.

Consequently, chemistry teaching can only be result oriented when students are willing and the teachers are favourably disposed to using appropriate strategies. This assertion calls for the need to find innovative strategies such as Collaborative-Predict-Explain-Observe-Write (CPOEW) instructional model and Exploration, Explanation and Evaluation (3E's) instructional model that may have the potentials to equip learners to think about their cognition, monitor their learning activities and evaluate the results of these activities and thereby enhancing their conceptual understanding. Collaborative-Predict-Explain-Observe-Write (CPOEW) model

is a five-step conceptual change instructional model and it is from this step the acronym "CPOEW" is derived. CPOEW is an instructional model where learners collaboratively construct their own knowledge by testing ideas based on prediction, observation, explanation and writing. CPOEW is a learning model where four or more students in a small group setting make predictions for an event, conduct and observe a laboratory experiment and are required to explain and write down their observations, thereby enhancing conceptual understanding of scientific knowledge.

Collaborative connote sharing ideas. Collaborative learning engages learners in active learning where they work and learn together in small groups to accomplish shared goals. In collaborative learning students explore their ideas, clarify them for themselves and to one another, expand and modify them and finally make them their own. The CPOEW learning model is developed from the learning model of Predict, Observe, and Explain (POE). The POE learning model is a learning model with the knowledge development process, which begins with predicting solution over a problem, and then it goes with conducting experiment to prove the prediction, and finally it ends with explaining the result of experiment (White, R.T. & Gunstone, R.F, 2006). CPOEW allow learners to compare their new knowledge gained with their prediction and applying these ideas to a new situation, thereby enhancing conceptual understanding (Brown, F, 2014). CPOEW model focuses on linking students existing ideas and beliefs relevant to a situation and exploring the appropriateness of these ideas and beliefs. CPOEW learning model can be used to recognize the initial ideas of students, to give information to the teacher about the students' thinking, to generate discussion, and to motivate them to investigate concepts. The learning phases of CPOEW strategy is explained as follows:

Phase 1: Collaborative (C)

Before presenting students with all the relevant background information, divide learners into groups of 3-6 depending on the class size to collaboratively learn and more specifically as joint problem solving group(s).

Phase 2: Predict (P)

After presenting students with all the relevant background information, students predict what they think will happen next. At this stage, students make a prediction toward a problem given by the teacher. In making the prediction, the students have thoughts the reasons why they make such a prediction. In this process, they are given an extensive freedom to arrange their prediction including its reasons. At this stage, the group or whoever is assigned, write down their prediction(s) as agreed upon by the group on CPOEW worksheet. In this prediction process, the teacher can also understand the misconceptions made by the students. This is important for the teacher to help the students to develop right concepts

Phase 3: Observe (O)

In this stage, students investigate and observe what happens next. In other words, the students are asked to do experiments to examine the prediction righteousness that they deliver and the most importantly, it is a measure of the confirmation on their prediction.

Phase 4: Explain (E)

Explanation comes after observation, and it is here that students who have predicted wrongly need to wrestle with their internal assumptions that led them astray (these may be unconscious, and hence need drawing out first). For those who predicted correctly, they may still have had incorrect assumptions, so this is important to keep in mind (watch out for students with correct answers but low confidence). In this regard, they can learn from the mistake, and learning things from mistake will not be easily vanished or forgettable.

Phase 5: Write (W)

Write phase is to do written communication, reflecting student knowledge and ideas. Writing can help students to express their knowledge and ideas. Students write discussion results and answer questions in CPOEW Worksheet. Besides, they make the conclusion and report from the experiment result. In other words, students write conclusions in their own language about the learning material that they understand.

Exploration, Explanation and Evaluation (3E's) model is a three-step constructivist instructional model and it is from this step the abbreviation "3E's" is derived. 3E's is a constructivist instructional model where students are engaged

actively in constructing knowledge through exploration of activities, explanation and evaluation of the results of these activities thereby enhancing conceptual understanding. In other words, this model arranges learning experiences through exploration, explanation of the exploration outcome and evaluation of the knowledge gain so that students have the opportunity to construct their understanding of a concept. 3E's is a model adopted by a teacher to teach through activity in which the students participate thoroughly and bring about efficient learning experience. It is a model in which the child is actively involved both mentally (mind-on) and physically (hands-on). 3E's model is a form of learning model that encourages thoughtful reflection on activity explored. Academic performance is an individual's characteristic which enables the learner to have positive or realistic views of learner or the situations that the learner is in Ajayi, V.O. & Audu, C.T. (2023). The learning phase of 3E's learning model is explained as follows:

Phase 1: Exploration (E)

In this stage, students' carryout laboratory activities in order to provide answer(s) to a phenomenon. Students are in search for answers, lead students to be active participants. In this stage students learn through curiosity and inquiry. Students develop hands-on and minds-on skills. The teacher should make effort to include interesting and expressive activities. Learning achieved through exploration builds a strong foundation of skills and it leads to fulfilling learning experiences.

Phase 2: Explanation (E)

At this stage, each member of the group writes down the explanation for their exploration outcome. Explanation involves when one arrives at the solution, and then information would be communicated to others. That is, the explanation stage. In this phase, the plan devised or constructed in the preceding phases is carried out.

Phase 3: Evaluation (E)

This stage is where new knowledge is used or transferred to develop products in order to produce ideas. This is the application stage where new knowledge is transferred. In this phase, students reflect back on the problem solving process which should not involve mere checking an answer.

According to Tunçel, H. (2015), academic performance generally plays an important role not only in personal and social aspect of life but in school life as well, and at every stage of life towards success and this can have effect on their academic performance. According to Ajayi, V.O. (2021), students' poor academic performance that, they don't have the ability needed to complete the cognitive-ability test or task has also been attributed to the ineffective teaching methods such as discussion method adopted by teachers. Hence, developing lessons using innovative strategies that involve students' active participation when engaging in electrolysis activities are anticipated to uplift academic performance. Thus, the study investigated if there any possibility of enhancing students' academic performance in electrolysis using Collaborative-Predict-Explain-Observe-Write (CPOEW) and Exploration, Explanation and Evaluation (3E's) instructional models.

1.1 Purpose of the Study

The purpose of this study was to investigate the possibility of enhancing students' academic performance in electrolysis using Collaborative-Collaborative-Predict-Observe-Explain-Write (CPOEW) and Exploration, Explanation and Evaluation (3E's) learning models. Specifically, the study was set out to:

Determine the effects of CPOEW, 3E's learning model and discussion method on students' academic performance in electrolysis.

Ascertain the interaction effect of treatments and gender on students' academic performance in electrolysis

1.2 Research Question

The following research question guided this study:

What are the mean academic performance differences among students taught electrolysis using Collaborative-Collaborative-Predict-Observe-Explain-Write (CPOEW), Exploration, Explanation and Evaluation (3E's) learning model and discussion method?

1.3 Hypotheses

The following null hypotheses guided the study:

1) There is no significant difference in the academic performance of students taught electrolysis using CPOEW model, 3E's model and discussion method.

2) The interaction effect of treatments and gender on academic performance scores of students taught electrolysis is not statistically significant.

2. Research Design and Procedure

The study adopted a quasi-experimental non-randomized pre-test, post-test control group design. The study area is Makurdi, Benue State, Nigeria. Makurdi is the capital of Benue State, located in central Nigeria, and part of the middle belt region of central Nigeria. Makurdi is situated on the south bank of the Benue River. Makurdi and the surrounding areas had an estimated population of 365,000. The major ethnic groups in Makurdi are Tiv, Idoma, Igede and so on. The population for this study comprises all the students offering chemistry in senior secondary school two in Makurdi, numbering 7,152 students from all the 78 approved senior secondary schools in Makurdi Local Government Areas of Benue State, Nigeria (BSTSB, 2021). The sample of this study was made up of 143 SS2 students that were drawn from 3 schools using purposive sampling technique. An instrument known as Electrolysis Performance Test (EPT) was used in this study.

Electrolysis Performance Test (EPT) was adapted from Senior Secondary Certificate Examination (SSCE) past examination question papers of 2017-2022. EPT items were based on SSCE, which is standardized, since the target of the study is to improve the students' academic performance, at this level. The test instrument consists two sections. Section A consists bio-data information of the respondents, while section B consisted 30 multiple choice objective items with four options (A, B, C, D) drawn from the concepts of electrolysis to which respondents are expected to provide the correct answers by selecting the correct option.

Electrolysis Performance Test (EPT) and the instructional packages (lesson notes) were face validated by presenting them to two experts in science education and one expert in Test and Measurement. The items were scrutinized by these expects. Corrections and suggestions arising from these experts were used to review the instrument and the instructional packages. EPT upon validation were trial-tested to establish the reliability of the instruments by administering EPT to a randomly selected 53 SS2 students of a senior secondary school which is not part of the schools selected for this study. After 1 week of 9 periods of teaching, the EPT was administered with the help of the research assistants. Kuder-Richardson (KR-21) formula was used to test internal consistency of EPT. The instrument (EPT) gave reliability value of 0.91. According to Kaser, T., Hallinen, N., & Schwartz, D.L. (2017), the coefficients of 0.50-0.99 indicate that the instruments are reliable.

During the main study, intact classes were assigned to experimental and control groups. Thereafter, Electrolysis Performance Test (EPT) was administered as pre-test by the teachers that served as research assistants. This lasted for one week before actual teaching commences. During lessons, the teachers taught the experimental group I Electrolysis topics using Collaborative-Predict-Explain-Observe-Write (CPOEW) learning model in line with lessons procedure prepared by the researcher and the experimental group II were taught using Exploration, Explanation and Evaluation (3E's) learning model in line with lessons procedure prepared by the researcher. The control group was also taught the same Electrolysis topics using the discussion lesson plans. This lasted for three weeks. At the end of these actual teaching periods, the pre-EPT was reshuffled and administered as post-test which lasted for one week. Descriptive statistics of mean and standard deviation scores were used to answer the research question, while the inferential statistic of Analysis of Covariance (ANCOVA) were used to test the null hypotheses at 0.05 level of significance.

3. Results

Presentations in this section are based on research question and null hypotheses.

3.1 Research Question

What are the mean academic performance differences among students taught electrolysis using Collaborative-Predict-Observe-Explain-Write (CPOEW), Exploration, Explanation and Evaluation (3E's) learning model and discussion method? The answer to research question one is presented on Table 1.

Table 1. Mean Performance and Standard Deviation Scores of Students Taught Electrolysis using CPOEW Model, 3E's Model and Discussion Method

Group	N	PRE- EPT		POST- EPT		Mean Gain within Group
		$\tilde{x}$	δ	$\tilde{x}$	δ	
CPOEW model	49	9.37	0.13	28.56	0.27	19.19
Discussion	48	9.35	0.12	16.33	0.22	6.98
Mean diff. between Groups		0.02		12.23		12.21
3E's model	46	9.36	0.15	26.17	0.25	16.81
Discussion	48	9.35	0.12	16.33	0.22	6.98
Mean diff. between Groups		0.01		7.84		9.83
CPOEW model	49	9.37	0.13	28.56	0.27	19.19
3E's model	46	9.36	0.15	26.17	0.25	16.81
Mean diff. between Groups		0.01		4.39		2.38

Source: Field Survey, 2023.

Table 1 reveals the mean academic performance scores and standard deviation scores difference among students taught Electrolysis using CPOEW model, 3E's model and discussion method (DM) on a paired comparative basis. The data in Table 1 show that the overall mean difference between students in CPOEW and DM groups was 12.21 in favour of CPOEW. This implies that students in CPOEW group had higher academic performance than students in DM group. Similarly, the overall mean difference between students in 3E's and DM groups was 9.83 in favour of 3E's model. This implies that students in 3E's group had higher academic performance than those in DM group. In the same vein, the overall mean difference between students in CPOEW and 3E's groups was 2.38. This difference is in favour of CPOEW model. This implies that students in CPOEW group had slightly higher academic performance than their counterparts in 3E's group. Meanwhile, students taught using 3E's model had higher academic performance than those taught using discussion method.

3.2 Hypothesis One

There is no significant difference in the academic performance of students taught electrolysis using CPOEW model, 3E's model and discussion method. The answer to hypothesis one is presented on Table 2.

Table 2. Two-Way ANCOVA for Mean Academic Performance Scores of Students Taught Electrolysis using CPOEW Model, 3E's Model and Discussion Method

Source	Type III sum of squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	160.931[a]	6	26.822	723.106	.000	.939
Intercept	33.392	1	33.392	1332.790	.000	.845
TprEPT	.001	1	.001	.016	.801	.000
Group	189.102	2	73.301	1439.006	.000	.919
Gender	.091	1	.091	2.670	.117	.003
Group*Gender	.011	2	.005	.122	.168	.001
Error	10.423	136	.037			
Total	3283.959	143				
Corrected Total	159.004	142				

R squared = .429 (Adjusted R Squared= .428), Source: Field Survey, 2023.

Table 2 presents the two-way ANCOVA result for mean academic performance scores of students taught Electrolysis using CPOEW model, 3E's model and discussion method (DM). The data in Table 2 reveal that the observed mean difference in the academic performance scores among the groups was significant [$F_{2, 136}$=1439.006, P<0.05]. Hence, the null hypothesis that there is no significant difference in the mean academic performance scores of students taught Electrolysis using CPOEW model, 3E's model and DM was rejected. This implies that there is a significant difference in the mean academic performance scores among the groups. Meanwhile, the effect size was 0.919 as indicated by the corresponding partial eta squared value is considered as large effect size. This implies that, 91.9% of the difference or variance in the academic performance scores among the groups was explained by the treatments. Hence, the difference in the academic performance scores among the groups has a large statistical effect size.

Table 3. Bonferroni Post Hoc Comparison for Mean Academic Performance Scores of Students' Taught Electrolysis using CPOEW, 3E's and DM

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sign.
CPOEW	DM	1.728*	.021	.000
3E's	DM	1.440*	.021	.000
3E's	CPOEW	-.288	.021	.115

Source: Field Survey, 2023.

Table 3 shows Bonferroni post-hoc comparison for mean academic performance scores of students taught Electrolysis using CPOEW model, 3E's model and discussion method (DM). The results reveal that the mean difference (I-J) between CPOEW and DM is 1.728* and this is significant at p<0.05. This implies that there is a significant difference in the mean academic performance scores between the students taught Electrolysis using CPOEW and those taught using DM in favour of students in CPOEW class. Likewise, the results reveal that the mean difference (I-J) between 3E's and DM is 1.440* and this is significant at p<0.05. This implies that there is a significant difference in the mean academic performance rating between the students taught Electrolysis using 3E's and those taught using DM in favour of students in 3E's model class. However, the paired comparison of 3E's and CPOEW showed a mean difference of -.288 and this is not significant at p>0.05. This indicates no significant difference in the mean academic performance scores between students taught using CPOEW and 3E's models.

3.3 Hypothesis Two

The interaction effect of treatments and gender on academic performance scores of students taught electrolysis is not statistically significant. The data analysis of Table 2 is used to explain hypothesis 2. The table presents a two-way ANCOVA for academic performance scores of students taught electrolysis using CPOEW model, 3E's model and discussion method (DM). The table also presents the interaction effect of instructional learning models and gender. The data in Table 2 reveals that there is no significant interaction effect of treatments and gender on the mean performance scores of students in electrolysis [$F_{2, 136}$=.122, P<0.05]. The null hypothesis is therefore not rejected. Meanwhile, the effect size was 0.001 which is considered as small effect size. By implication, only 0.1% of the interaction in the performance scores among groups was described by treatments and gender.

4. Discussion of Findings

Finding of this study revealed that the difference in the academic performance scores among students taught Electrolysis using Collaborative-Predict-Observe-Explain-Write (CPOEW) learning model, Exploration, Explanation and Evaluation (3E's) learning model and discussion method was statistically significant. The post-hoc comparison for the academic performance scores among the groups revealed that students taught Electrolysis using CPOEW had significantly higher academic performance than their counterparts taught

using discussion method. However, there was scarcity of studies on effect of CPOEW model on students' academic performance in science subjects before. This finding is in line with Arslan, M., & Emre, I. (2021), Ozcan, G.E., & Uyanik, G. (2022) findings that Predict-Observe-Explain (POE) is an effective strategy in improving students' academic achievement, scientific process skills and attitude towards science than conventional teaching method. Thus, the likely reason for this outcome may also be connected to the fact that the use of POE model provides a format for students to see how knowledge is developed through the process of reflecting on what they know and the investigation they undertake thereby enhancing conceptual understanding compared to discussion method that only promotes passive learning.

The post-hoc comparison for the academic performance scores among the groups also revealed that students exposed to Exploration, Explanation and Evaluation (3E's) learning model had significantly higher academic performance than those taught using discussion method. Though, there was scarcity of studies on effect of 3E's model on students' academic performance in science subjects before. This finding is in line with Kaser, T., Hallinen, N., & Schwartz, D.L. (2017) and Ajayi, V.O., & Ogbeba, J. (2017) findings that students improved significantly in their performance within a learning environment and in stoichiometry respectively when exposed to exploration and hands on activities strategies compared to those taught using conventional teaching method. Thus, the likely explanation for this outcome may be attributed to the fact that, in an 3E's instruction, student's active participation are emphasizes in the learning process through exploration, problem solving and evaluation compared to discussion method that the problem may not be clear to all members of the class.

It was revealed that students exposed to Collaborative-Predict-Explain-Observe-Write (CPOEW) had slightly higher academic performance than their counterparts using Exploration, Explanation and Evaluation (3E's) model but the post-hoc comparison for the academic performance scores among the groups further revealed that the difference in the academic performance scores between students taught Electrolysis using Collaborative-Predict-Explain-Observe-Write (CPOEW) and those taught using Exploration, Explanation and Evaluation (3E's) model was not statistically significant. There was scarcity of studies on comparison between CPOEW and 3E's learning models on students' academic performance in electrolysis before. However, the likely explanation for this outcome may be attributed to the fact that both CPOEW and 3E's strategies are used to help students develop a cognitive structure that enable students to understand the structure of knowledge and process of knowledge construction, thereby enhancing students' academic performance.

5. Conclusion

It is evident from the findings of this study that the use of Collaborative-Predict-Explain-Observe-Write (CPOEW) model and Exploration, Explanation and Evaluation (3E's) model enhanced students' academic performance in Electrolysis than the use of discussion method. The results of the study also provide empirical evidence that the use of CPOEW model enhanced students' academic performance in Electrolysis than 3E's model and discussion method. It was also found that 3E's learning model enhanced students' academic performance in Electrolysis than discussion method. The following recommendations were made:

1) To enhance students' academic performance in electrolysis, teachers should be encouraged to use of Collaborative-Predict-Explain-Observe-Write (CPOEW) model and Exploration, Explanation and Evaluation (3E's) model in teaching electrolysis irrespective of gender differences.
2) The curriculum developers should use CPOEW and 3E's learning models to develop and refine the Electrolysis curriculum.

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