

Effect of a Constructivist- Based Instructional Model on Students' Conceptual Change in Chemistry

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Abstract

The general purpose of this study was to empirically examine students' conceptual change in electrochemistry using prior conception, exploration, discussion, dissatisfaction and application (PEDDA) instructional model and conventional method of instruction which is widely used in our secondary schools. The study was guided by two research questions and three null hypotheses. The study adopted the quasi-experimental design, specifically the non-equivalent control group design. The study was conducted in Delta State. The population of the study comprised all the Senior Secondary school two (SS2) chemistry students. The sample of the study consisted of 148 students. Students were assigned to experimental and control groups in their intact classes. The experimental group was taught using PEDDA constructivist model while the control group was taught using the conventional method of instruction. Both groups were given pretest and posttest. The instrument used in this study was the electrochemistry conceptual change test (ECCT). The instrument was validated by five experts in the Department of Science Education, University of Nigeria, Nsukka. Electrochemistry conceptual change test (ECCT) was trial tested and the reliability coefficient of 0.84 was obtained. The internal consistency of ECCT was found to be 0.81 using Cronbach's Alpha. The mean scores and standard deviations of pretest and posttest were used to answer the research questions. Analysis of Covariance (ANCOVA) was used in testing the hypotheses at 0.05 level of significance. Trace analysis of the students' response item by item and by group of level of understanding on pretest to posttest was done to determine the type of change that occurred. The findings of the study showed that PEDDA instructional model enhanced students' conceptual change in electrochemistry compared to the conventional method of instruction. Also, there was no significant influence of gender on students' conceptual change, it was recommended among others that chemistry teachers should be trained and retrained on how to use PEDDA instructional model in teaching chemistry concepts.

Keywords: Constructivism, Chemistry, misconception, conceptual change, strategy, understanding

Introduction

Chemistry is one of the science subjects offered by students at the senior secondary school level in Nigeria. Chemistry is a branch of science that deals principally with the properties of substances, the changes they undergo and the natural laws that describe these changes. One of the objectives of the revised edition of the Nigerian Educational Research and Development Council (2009) includes amongst others to acquire basic theoretical and practical knowledge in the subject. Science learning is an active and constructive process and knowledge construction requires active participation on the part of the learner (Madu, 2004). This suggests that one alternative way of changing the instruction from teacher – centered to student centered is to use the constructivist approach.

Constructivism is a theory which holds the view that scientific knowledge are personally constructed and reconstructed by the learner based on his experience or prior knowledge (Nworgu, 2006). Learners bring new ideas which affect any new information they receive. What a student learns therefore results from the interaction between what is brought to the learning situation and what is experienced while in it and this results in a restructuring of existing conception (Stofflet, 1994). Nwosu

(2010) asserted that constructivist approach to learning is inclusive, interactive and expresses the dynamic conception of human learning. It is problem solving/inquiry oriented and emphasizes the importance of prior knowledge in concept formation, allows for corporative learning, students experimentation and discussion in groups, as they make meaning of and set out to solve challenging problems. According to constructivism, new knowledge builds on the existing knowledge. Unfortunately, the existing knowledge may be in conflict with the scientific concept. These students' preconceptions that are in conflict with the scientific ones are called misconceptions.

Misconceptions are ideas held by students that are considered different from scientific accepted views. Misconceptions originate from prior knowledge of every day experiences or ones gotten from school. One of such content areas in chemistry where students have lots of misconception is electrochemistry.

Electrochemistry is a branch of chemistry that deals with the chemical actions of electricity and the production of electricity by chemical reaction. The misconceptions in electrochemistry that have been noted include: electrons flow in an electrolyte, in an electrolytic cell with identical electrodes connected to the battery, the same reactions occur at each electrode, random assignment of positive and negative signs to electrodes in an electrolytic cell among others (Obomanor & Onuoha, 2012; Echekwube, 2009). This concept if well understood can be applied in tackling societal problem of rusting, purification of metals and extraction among others. The determination of misconceptions is important but elimination of these misconceptions is more important than mere identification of the students' held misconceptions. Considering the importance of electrochemistry to man, there is need to explore instructional strategies capable of eliminating students misconceptions and hence attain meaningful understanding of the concept. The process of changing students' misconceptions and replacing them with scientifically accepted idea is called conceptual change.

Conceptual change is a learning process in which an existing conception (idea or belief) held by a student is restructured. It is a process that changes or replaces an existing conception with a new conception (Madu, 2004). According to Posner, Strike, Hewson and Gertzog (1982) certain conditions must be fulfilled for conceptual change to occur. They are dissatisfaction, intelligible, plausible and fruitfulness (DIPF). This occurs through accommodation by reorganization of existing concepts. Teaching for conceptual change should involve uncovering students' preconceptions about a particular topic and using various techniques to help students change their conceptual framework. The conviction that the learner is central to any instruction (teaching-learning process) led some researchers such as Karplus and Their (1967); Bybee; Buchward; Heil; Kuerbis; matsumoto and McNerney (1989) and Nworgu (1996) to propose different models of instruction as a means of enhancing teaching and learning for conceptual change in order to eliminate students held misconceptions in science. One of such models is the five step conceptual change model (PEDDA) developed by Nworgu (1996) based on adaptations from Stofflet and Stoddarts (1994). The acronym PEDDA was derived from the initial letters of the processes involved. The processes are: determination of Prior knowledge, Exploration of the phenomenon, Discussion of the experiment, Development of dissatisfaction with prior conception and Application. PEDDA emphasizes dissatisfaction with prior knowledge which allows the learner to go back to the exploration stage until learning becomes plausible and fruitful, hence the use of PEDDA. Exploring phenomena before explaining them is critical for conceptual change learning. Several research reports (Ogbonna, 2013; Olodu, 2012; Obiekwe, 2008) indicate that many science teachers prefer the conventional method of teaching and shy away from innovative activity-oriented teaching methods. There is need therefore to investigate the effectiveness of PEDDA instructional model in bringing about conceptual change in electrochemistry as well as the influence of gender on students' conceptual change.

Statement of the Problem

Misconceptions are obstacles to students' sound understanding of concepts which lead to poor performance and hindrance to realization of the national goals of science education that demands male

and female students' to acquire practical knowledge and skills for societal development and use same to meet societal needs. Studies indicate that students have difficulties in understanding electrochemistry due to held misconceptions. The knowledge got by understanding this concept can be used in tackling societal problem of rusting, metal extraction and purification amongst others. It is therefore necessary to remove students' misconceptions in electrochemistry and replace them with scientifically acceptable belief. Hence, there is need to investigate the effect of PEDDA instructional model on students' conceptual change in electrochemistry as well as the influence of gender on students' conceptual change.

Research Questions: The following research questions guided the study.

1. What are the effects of PEDDA instructional model and conventional method of instruction on students' conceptual change in electrochemistry?
2. What is the influence of gender on students' conceptual change in electrochemistry?

Hypotheses

The following research hypotheses (H_0) were formulated to guide the study and were tested at 0.05 level of significance.

H₀₁: There is no significant difference in the mean conceptual change scores of students taught electrochemistry with PEDDA instructional model and those taught conventional method of instruction.

H₀₂: There is no significant difference in the mean conceptual change scores of male and female students.

H₀₃: There is no significant interaction effect of strategy and gender on the mean conceptual change scores of students in electrochemistry.

Methodology

The study adopted the quasi-experimental design. Specifically, the pre-test post-test non-equivalent control group design. The population of this study comprised of all the senior secondary school year two (SS2) chemistry students in all the co-educational secondary schools located in three Senatorial Districts of Delta State. The sample of the study consists of 148 students (93 males and 55 females). The instrument used for data collection was the electrochemistry conceptual change test (ECCT) developed by the researcher. Table of specification was used in preparing the test. The electrochemistry conceptual change test (ECCT) consisted of thirty (30) test items. The test was in form of written test (Short essay form) to enable the students express their opinion on the topic. The ECCT was used to assess student's conceptual change in electrochemistry. The ECCT was face-validated by five experts in the Department of Science Education, University of Nigeria, Nsukka. The reliability of the instrument was determined by administering the instrument to 40 SS2 chemistry students in a school outside the study area but shares the same characteristics with the students used for the study. The data obtained from the student's scores were used to measure the co-efficient of stability of the ECCT using test-retest reliability method. The scores awarded were correlated using Pearson co-efficient of correlation (r , 0.84). The subjects were randomly assigned to two groups, the experimental group that was taught using PEDDA instructional model and control group that was taught using the conventional method of instruction. The ECCT was administered to the subjects prior to the commencement of the experiment. After the treatment, the posttest was administered. Mean and standard deviation were used in answering the research questions while analysis of covariance (ANCOVA) was used in testing the hypotheses at 0.05 level of significance.

Research Question 1:

What is the effect of PEDDA instructional model and conventional method of instruction on the mean conceptual change score of students' in electrochemistry?

Table 1.0: Mean and Standard Deviation of pretest and posttest after exposure to PEDDA instructional model and Conventional method of instruction

Instructional Approaches	N	Pretest		Posttest		Mean Gain
		\bar{x}	SD	\bar{x}	SD	
PEDDA model	81	18.01	9.50	40.35	13.99	22.34
Conventional Method	67	13.63	12.63	32.18	12.23	18.55

Results on Table 1 shows that for each of the groups, the posttest conceptual change mean scores are greater than the pretest conceptual change mean scores with the group taught electrochemistry using PEDDA instructional model having a higher mean gain ($22.34 > 18.55$). This is an indication that PEDDA instructional model improved students' conceptual change in electrochemistry than conventional method of instruction. The result of the trace analysis revealed that the experimental group taught using PEDDA instructional model had higher sound understanding (SU) of the concept after instruction.

Hypothesis 1

H₀₁: There is no significant difference in the mean conceptual change score of students taught electrochemistry using PEDDA instructional model and conventional method of instruction.

Table 2: Analysis of Covariance (ANCOVA) results showing effects of strategies, gender and their interactions on students' conceptual change

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Dec.
Corrected Model	5073.466 ^a	4	1268.367	7.915	.000	
Intercept	43160.398	1	43160.398	269.326	.000	
Pretest	2302.283	1	2302.283	14.366	.000	
Strategies	1254.291	1	1254.291	7.827	.006	S
Gender	121.112	1	121.112	.756	.386	NS
Strategies * Gender	60.665	1	60.665	.379	.539	NS
Error	22916.263	143	160.254			
Total	226772.000	148				
Corrected Total	27989.730	147				

The result on Table 2 shows that with respect to mean conceptual change score of students taught electrochemistry with PEDDA instructional model and conventional method of instruction, an F-ratio of 7.827 was obtained with associated probability value of 0.01. Since the associated probability value of 0.01 is less than 0.05 set as bench mark, the null hypothesis (H_{01}) was rejected. Inference drawn therefore is that, there is a significant difference in the mean conceptual change score of students taught electrochemistry in favour of the PEDDA instructional group.

Research Question 2:

What is the influence of gender on students' conceptual change in electrochemistry?

Table 3: Mean and Standard Deviation of male and female students pretest and posttest conceptual change scores of PEDDA instructional model and Conventional method of instruction

Instructional Approach	Gender	N	Pretest		Posttest		Mean Gain
			\bar{x}	SD	\bar{x}	SD	
PEDDA	Male	51	18.02	8.02	41.55	15.59	23.53
	Female	30	18.00	11.73	38.30	10.69	20.30
Conventional	Male	42	15.95	13.08	33.24	13.23	17.29
	Female	25	9.72	11.02	30.40	10.34	20.68

Result on Table 3 shows the influence of gender on mean students' conceptual change score in electrochemistry using PEDDA instructional model and conventional method. Results show that for the male and female students taught electrochemistry, the posttest conceptual change mean scores were greater than the pretest conceptual change means scores with the males having a higher mean gain when taught using PEDDA instructional model.

Hypothesis 2

H₀₂: There is no significant difference in the mean conceptual change scores of male and female students.

The result on Table 2 shows that with respect to mean conceptual change scores of male and female students taught electrochemistry using PEDDA model and conventional method, an F-ratio of 0.756 was obtained with associated probability value of 0.386. Since the associated probability value of 0.386 is greater than 0.05 set as bench mark, the null hypothesis (H_{02}) which stated that there is no significant difference in the mean conceptual change scores of male and female students taught electrochemistry using PEDDA instructional model and conventional method was upheld.

Hypothesis 3

H₀₃: There is no significant interaction effect of the instructional strategies and gender on the mean conceptual change scores of students taught electrochemistry.

The result on Table 2 shows that with respect to the interaction effect of the instructional strategies and gender on the mean conceptual change scores of students taught electrochemistry, an F-ratio of 0.379 was obtained with associated probability value of 0.539. Since the associated probability value of 0.539 is greater than 0.05 set as bench mark. The null hypothesis (H_{03}) which stated that there is no significant interaction effect of the instructional strategies and gender on the mean conceptual change scores of students taught electrochemistry was upheld.

Discussions of Findings

The result of the study as presented on Table 1 shows that the group taught electrochemistry using PEDDA instructional approach had a higher conceptual change mean gain (22.34 > 18.55). This is an indication that PEDDA instructional approach improved students' conceptual change in electrochemistry than the conventional method. The result of the study from the test of hypothesis one showed that there was a significant difference ($p < 0.05$) in the mean conceptual change score of students taught electrochemistry with PEDDA instructional model and conventional method of instruction with those taught using PEDDA performing better than those taught using conventional method. The findings of this study are consistent with Madu (2004) who investigated the effects of constructivist based instructional model, PEDDA, on students' conceptual change and retention in physics. The result revealed that PEDDA model facilitated conceptual change of physics concepts compared to the control group. The researcher noted that the students' level of understanding (conceptual change) was significantly dependent on the treatment. Also, the result of the study agrees with Ukwueze (2012) who investigated the effect of PEDDA constructivist instructional model on secondary schools students' achievement in biology and found among other things that the experimental group that was taught with PEDDA performed better than the control group that was taught using the traditional method. These results could be connected to the hands-on activities and minds-on activities which PEDDA instructional approach offered the students. The approach gave the students the opportunity to be actively engaged in meaningful learning testing their preconceived ideas that led to deep understanding of the concept under study. Also in PEDDA instructional approach, students had the opportunity to interact and discuss with one another which may have given the students with some misconceptions the opportunity to drop their flawed ideas. This result agrees with Dewey, Brunner, Piaget and Vygotsky who maintained that knowledge is constructed by the individual learners and is embodied in human experience, perceptions, imaginations and mental and social constructions. The elimination of students' misconceptions in electrochemistry and bringing about conceptual change will improve students' deep understanding of the concept and hence its application to meet societal needs.

The result of the study as presented in Table 3 shows that in all cases, the posttest conceptual change mean scores were greater than the pretest conceptual change mean scores with the male students having a higher conceptual change mean gain when taught using PEDDA instructional model. The result from the test of hypothesis 2 however shows that there is no significant difference ($p > 0.05$) in the mean conceptual change scores of male and female students. This means gender is not a significant factor in determining students' conceptual change in electrochemistry. The result of this study disagrees with Agomuoh (2010), who studied the influence of gender on students' conceptual change and noted that there was a significant difference in the conceptual change of males and females students in favour of the male students. This result however agrees with the findings of Miriogu (2012) who discovered that there was no significant difference in the achievement and retention of male and female students. The higher conceptual mean gain exhibited by the male students in PEDDA instructional model tend to support the claim of Yang (2015) that male students perceive more in investigation and involvement. The insignificant difference in the mean conceptual change scores of male and female students taught electrochemistry using PEDDA instructional model may be due to the fact that the treatments male and female students received gave them equal opportunities. PEDDA model ultimately helped male and female students to have sound theoretical and practical knowledge in electrochemistry. Such knowledge will enable them to participate in solving local and national problems. The result in table 2 revealed that there was no significant interaction effect of strategies and gender on students' mean conceptual change in electrochemistry. This means that the PEDDA model did not combine with gender to affect students' conceptual change. Hence, the strategy is gender friendly.

Conclusion

On the basis of the findings of this study, the following conclusions were made:

1. PEDDA instructional model improved students' conceptual change in electrochemistry.
2. There was no significant difference in the conceptual change of male and female students taught electrochemistry with PEDDA instructional model
3. The interaction effect of strategies and gender on conceptual change of students taught electrochemistry was not statistically significant.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. Chemistry teachers should be trained and retrained on how to use PEDDA instructional model in teaching chemistry concepts.
2. PEDDA instructional model should be used in teaching.
3. Curriculum planners should include PEDDA instructional model as one of the strategies for teaching chemistry in secondary schools in Nigeria.

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