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Comparative Effect of Polya and Target-task Problem-solving Teaching Strategies on Students' Achievement in Electrolysis

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Abstract

The study investigated the comparative effect of Polya and Target-task Problem-solving teaching strategies on students' achievement in electrolysis in Uruan Local Education Authority of Akwa Ibom State, Nigeria. The design was a quasi-experimental research employing pre-test, post-test design with a population of 2,950 Senior Secondary II Chemistry students of which 100 students were selected from two intact classes by criterion sampling technique. The instrument used for the study was Achievement Test on Electrolysis (ATE). The reliability coefficient of ATE was determined to be .82 using Kuder-Richardson Formulae-21. Two research questions were answered using descriptive statistics of mean and standard deviation while two hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). The findings showed that those in Target-Task Problem-Solving Teaching Strategy (TPTS) performed better than those in Polya Problem-Solving Teaching Strategy (PPTS). There was a significant difference in the achievement mean scores of students. But there was no significant difference in the mean academic achievement scores of male and female students. Based on the findings, it was recommended that Chemistry teachers should adopt the use of Target-Task Problem-

solving Teaching Strategy (TPTS) in teaching concepts in chemistry to enhance improved academic achievement.

Keywords: problem-solving, electrolysis, polya, target-task, achievement

Introduction

Chemistry is a core science subject. It is a subject in the Nigerian senior secondary school curriculum and has a critical role to play in the socio- economic and technological development of the nation. Chemistry teaches that everything that is seen, touched and felt is made up of elements and combination of elements. According to Adewunmi (2016), Chemistry is a veritable tool for solving socio-economic problems. Knowledge gain in Chemistry is very relevant to the society. It provides a vital link to other science subjects and serves as life-blood in pursuing careers in fields like Biochemistry, Nutrition, Industrial Chemistry, Medicine and Agricultural based disciplines. It facilitates understanding of other core science domains and enables individuals to solve their daily problems.

One of the topics in the Chemistry curriculum is electrolysis. Electrolysis is the process by which ionic substances are decomposed (broken down) into simpler substances when an electric current is passed through them. Functionally, it can be used to separate a substance into its original components/elements. Electrolysis also provides an appreciative and applicable number of chemical phenomena and processes such as electrolyte solutions, electro refining, electroplating and electro winning of metals, the corrosion and passivation of metals, batteries, bio electrochemistry and photo electrochemistry. Regardless of the importance of this concept in everyday life, electrolysis has been regarded as one of the difficult topics to study in Chemistry (Obamanu & Onuoha, 2012).

The abstract presentation of the concept makes it difficult for students to understand. The fact that movement of electrons is invisible creates difficulty for students to visualize the movement of electrons. Consequently, if students cannot visualize the movement of electrons and ions during electrolysis processes, it becomes difficult for them to translate the processes into chemical formulae and equations (Lee & Kamisah, 2014). Other challenges noted as difficulties students have in electrolysis transcend from lack of conceptual understanding of oxidation and reduction as they occur simultaneously (Sen *et al*., 2016), use of poor instructional approaches (Harkirat & David, 2014). This has contributed in one way or the other to poor academic achievement of students in the concept. There is, therefore, need for Chemistry teachers to devise alternative teaching strategies that can address students' difficulties and misconceptions resulting in overall

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improvement in students' academic achievement. One of the ways by which this could be done is adopting teaching methods which encourage problem-solving such as problem-solving teaching strategies.

Problem-solving Teaching Strategy is a student-centred teaching approach where the student is given the opportunity to identify the problem and find answers. Tofi *et al.* (2017a) define Problem-Solving Teaching Strategy as a process which focuses on knowing the issues, considering all possible factors that lead to finding a solution. It is a means by which an individual uses previously acquired knowledge, skill and understanding to satisfy the demand of an unfamiliar situation (Tofi *et al.,* 2017a). The approach makes students to inquire into a problem with a view to finding some answers to existing problems; it also provides the learner the opportunity of identifying and clarifying data, drawing conclusion, applying the conclusion in new situations to new data and developing meaningful generalizations (Tofi *et al.,* 2017b).

Problem solving strategy are of many types. Adeniran (2013) enumerated the types of problem solving strategy as follows: means-end-analysis, trial-and-error, brainstorming, morphological box, research, Minnesota Model (Physics problem solving approach), Polya, target-task and seven steps (Tofi *et al.,* 2017b). However, two problem-solving strategies are of interest in this study: Polya and Target-task Problem-solving Teaching Strategies.

Polya's model (1957) is one of the earliest problem-solving models. It is a method of solving problems, in which students encounter a problem for which students are not ready to proffer immediate solution (Jabeen & Mehmood, 2014). Polya's prescription for solving problems consists of four steps:

i. Understanding the problem (recognizing what is asked for) by asking oneself, 'What am I looking for?" or "What information is given in the problem?"
ii. Devising a plan for solving the problem (responding to what is asked for), asking oneself, "Do I know a similar problem?", "Can I restate the problem?"
iii. Carrying out the problem (developing the result of the response)
iv. Looking back (checking, what does the result tell me?).

Studies by Olatide et al. (2015) on effect of polya problem-solving model on senior secondary school students' performance in current electricity findings showed that students exposed to Polya problem-solving model performed better than those exposed to lecture method. Jabeen and Mehmood (2014) investigagted effect of Polya's problem-

solving method of teaching on achievement of revised Bloom's Taxonomy in Mathematics at elementary level, and reported that problem-solving method works better than conventional method for teaching of mathematics.

The Target-Task Model on the other hand is an adaptation of the guided discovery method for teaching science. It involves presentation of a major problem, the solution of which requires the application of rules and principles, with which the students may not be familiar (Hassan *et al.,* 2019). It is expected that the teacher presents some solutions similar to the target task and guides the students to solve the problem. This model is noted by Olaniyan and Omosewo (2015) in Mandina and Dube (2018) as a step-by-step approach comprising of six key stages which are described as follows:

i. Pre-task: This stage involves the introduction and a detailed explanation of the topic by teacher to make sure that the learners have an adequate understanding of what they are to accomplish at the task stage.
ii. Task: The students are engaged in addressing the given task either in pairs or in groups; at the same time, the teacher will be monitoring the students and offering encouragement.
iii. Planning: At the end of the activity, the students prepare a written report on what they experienced during the task in their groups.
iv. Report: The students submit their reports to the teacher for assessment. The teacher then returns the report back to the students after having made necessary corrections.
v. Analysis: The teacher will highlight the relevant parts of the learning on the board.
vi. Practice: The teacher then gives more problems for practice by the students.

Studies conducted by Olaniyan and Omosewo (2015) on the effects of the Target-Task Problem-Solving Model on Senior Secondary School Students' Performance in Physics found that students taught with the Target-Task Problem-Solving Model significantly did well in a current electricity achievement test than those exposed to the lecture method. In another study by Mandina and Dube (2018) on implementing a Target-Task Problem-Solving Approach in teaching electrochemistry to advanced level chemistry learners, findings showed that the difference in performance between the experimental and control group was statistically significant. Hassan *et al*. (2019) conducted a study on effect of target-task problem-solving model on students' achievement and interest in geometry in Bosso Local Government Area of Niger State, Nigeria. Their results showed that target-task problem-solving model instructional method was superior to conventional instructional method in facilitating students' achievement and interest in geometry.

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Gender is a moderating variable considered in this study. It is one of the factors affecting achievement of students in science. Eden and Mbuk (2019) sees gender as a term used to describe a person either as a man/boy or a woman/girl, adding that gender is an important factor that contributes to academic achievement in Chemistry. It is socially constructed characteristics and roles ascribed to both males and females, in any society (Tofi *et al.,* 2021). Researchers have demonstrated in favour of male or female students; some others have stated that neither males nor females do better in the subject areas investigated (Eden & Mbuk, 2019; Akinsola, 2017; Rusillo & Arias, 2014).

A study by Olaniyan and Omosewo (2015) showed that the target-task problem-solving model enhanced performance of low scoring level male students. Eden and Mbuk (2019) however observed that female students performed significantly better than their male counterparts in chemistry. On the contrary, Nnorom (2019) found that both males and females achieve equally in science when given equal opportunity and facilities. The need to provide solution to secondary school students' poor achievement in Chemistry especially in the concept of electrolysis is what prompted the researchers to develop, validate and determine the comparative effect of Polya and Target-task Problem-solving Teaching Strategies on students' achievement in electrolysis in Akwa-Ibom State, Nigeria.

Statement of problem

Despite the fact of poor achievement and the efforts made by Chemistry educators such as the use of small class size and extra lessons to enhance students' academic achievement in Chemistry, results have continued to show poor content knowledge and understanding of electrolysis concept, leading to poor achievements in external Chemistry examinations. Unfortunately, the number of candidates with a minimum of credit pass in Chemistry has not been encouraging. This has denied many Nigerian students the opportunity of getting admission into higher institutions.

The consistent poor achievement has been attributed to inappropriate teaching methods adopted by Chemistry teachers during instruction delivery and inefficient use of instructional materials in Chemistry lessons and most likely lack of appropriate definition of task. The use of didactic approaches to teach the concept of electrolysis is so teacher-centred. The students consequently become passive recipients of knowledge with no ample cognitive involvement in the learning process. This has necessitated the study.

Research questions

The following research questions guided this study:

1. What is the mean academic achievement scores of students taught electrolysis using Polya Problem-solving Teaching Strategy (PPTS) and those taught using Target-task Problem-solving Teaching Strategy (TPTS)?
2. What is the mean academic achievement scores of male and female students taught electrolysis using Polya Problem-solving Teaching Strategy and those taught using Target-task problem-solving Teaching Strategy?

Hypotheses

The following null hypotheses guided this study and were tested at .05 level of significance:

Ho1: There is no significant difference in the mean academic achievement scores of students taught electrolysis using Polya Problem-solving Teaching Strategy and those taught using Target-task Problem-solving Teaching Strategy.

Ho2: There is no significant difference in the mean academic achievement scores of male and female student's taught electrolysis using Polya Problem-solving Teaching Strategy (PPTS) and those taught using Target-task Problem-solving Teaching Strategy.

Methodology

The design adopted for this study was non-randomized pretest–posttest experimental design in two intact classes involving two (2) experimental groups. The population of the study comprised all the two thousand, nine hundred and fifty (2, 950) senior secondary II science students in all the 13 public secondary schools in Uruan Local Education Authority of Akwa Ibom State. The sample of the study was one hundred and four (104) Senior Secondary II (SS2) science students in their intact classes in two (2) selected public schools in the study area using criterion sampling technique. Experimental group 1 was taught electrolysis using Polya Problem-solving Teaching Strategy (PPTS) while experimental group 2 was taught electrolysis using Target-task Problem-solving Teaching Strategy (TPTS).

Achievement Test on Electrolysis (ATE) was the instrument used for data collection developed by the researchers with two sections; Section A obtained personal information from the students, while section B contained twenty- five multiple-choice question items on electrolysis. Each correct answer had 1 point while zero (0) was awarded for an incorrect answer. Twenty-five marks (25) was the maximum score and zero (0) was the minimum score. Instrument validation was done by two lecturers from the Department of

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Science Education and one lecturer from Test and Measurement unit of Akwa Ibom State University. Based on the comments and suggestions of the validators, corrections and modifications were made on the instrument. The reliability of the instrument was .82 determined by Kuder-Richardson Formulae-21. Achievement Test on Electrolysis (ATE) was administered as pretest and posttest to both Experimental Group 1 and Experimental Group 2. Data collected were analysed using descriptive statistics of mean and standard deviation while the null hypotheses were tested at .05 alpha level of significance using Analysis of Covariance (ANCOVA).

Presentation of results

The results are presented in tables as follows:

Research question 1: What is the mean academic achievement scores of students taught electrolysis using PPTS and those taught using TPTS?

Table 1: Mean and standard deviation of achievement scores of students' taught electrolysis using PPTS and those taught using TPTS

Groups	N	Mean	SD	Mean	SD	Mean Gain	Group diff.
Polya	50	8.18	2.41	13.10	2.96	4.92	
							1.32
Target Task	50	8.76	2.56	15.00	3.00	6.24	

Results in table 1 show the mean achievement scores of students taught electrolysis using PPTS and those taught using TPTS. The table shows that 50 students each were taught electrolysis using PPTS and TPTS. The results revealed that the mean achievement scores of students taught electrolysis using PPTS is 8.18 with a standard deviation of 2.41 during pretest and 13.10 with a standard deviation of 2.96 in posttest. The mean achievement scores of students taught using TPTS is 8.76 with a standard deviation of 2.56 during pretest and 15.00 with a standard deviation of 3.00 in posttest. The mean gain for PPTS and TPTS is 4.92 and 6.24 respectively. The mean difference between the mean achievement scores of students taught electrolysis using PPTS and those taught using TPTS is 1.32. This result indicates that students taught electrolysis using TPTS performed better than those taught using the PPTS.

Ho1: There is no significant difference in the mean academic achievement scores of students taught electrolysis using PPTS and those taught using TPTS.

Table 2: Analysis of Covariance (ANCOVA) of students' posttest achievement classified by treatment groups (PPTS and TPTS) with pretest as covariate

Source of Variance	Sum of squares	Df	Mean	F_{cal}	F_{cri}	Decision at .05 alpha
Corrected model	430.41	4	107.60	19.27	2.53	Significant
Pretest (Covarite)	152.90	1	152.90	27.39	4.00	Significant
Main effect:						
Treatment	50.28	1	50.28	9.06	4.00	Significant
Error	530.35	95	5.58			
Correction total	960.75	99				

In table 2, the calculated F-value for the difference in the achievement mean scores of treatment groups (Fcal) of students' achievement is 9.06 while its corresponding Critical value at df 1, 99 and 0.05 alpha level of significance is 4.00. As seen, the Fcal (9.06) is greater than Fcrit (4.00). This implies that at 0.05 level of significance, the difference in teaching using PPTS and TPTS on students' achievement is statistically significant. That is, there is a significant difference in the achievement mean scores of students taught electrolysis using PPTS and TPTS. Hence, the null hypothesis was rejected.

Research question 2: What is the mean academic achievement scores of male and female students taught electrolysis using PPTS and those taught using TPTS?

Table 3: Mean and standard deviation of achievement scores of male and female students taught electrolysis using PPTS and those taught using TPTS

	Groups	N	Mean	SD	Mean	SD	Mean Gain
Polya	Male	23	6.48	1.59	11.57	2.50	5.09
	Female	27	9.63	2.00	14.41	2.71	4.78
Target Task	Male	19	7.11	1.66	13.32	1.60	6.21
	Female	31	9.77	2.50	16.03	3.21	6.26

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Results in table 3 shows the mean achievement scores of male and female students taught electrolysis using PPTS and TPTS. The table shows that 23 male and 27 female students were taught electrolysis using PPTS while 19 male and 31 female students were taught using TPTS. The results revealed that the mean achievement scores of male and female students taught electrolysis using PPTS is 6.48 and 9.63 respectively with a standard deviation of 1.59 and 2.00 for male and female students respectively during pretest and 11.57 for male and 14. 41 for female students with a standard deviation of 2.50 and 2.71 for male and female students respectively in posttest. The results futher revealed that the mean achievement scores of male and female students taught electrolysis using TPTS is 7.11 and 9.77 respectively with a standard deviation of 1.66 and 2.50 for male and female students respectively during pretest and 13.32 for male and 16. 03 for female students with a standard deviation of 1.60 and 3.21 for male and female students respectively in posttest. The mean gain for PPTS male and female students is 5.09 and 4.78 respectively while mean gain for TPTS for male and female students is 6.21 and 6.24 respectively. This result indicates that male students performed better than female students when taught electrolysis using PPTS while female students performed better than male students when taught electrolysis using TPTS.

Hypothesis two: There is no significant difference in the mean academic achievement scores of male and female student's taught electrolysis using PPTS and those taught using TPTS.

Table 4: Analysis of Covariance (ANCOVA) of students' posttest achievement classified by treatment groups (PPTS and TPTS) and gender with pretest as covariate

Source of variance	**Sum of squares**	**Df**	**Mean**	**F_{cal}**	**F_{cri}**	**Decision at .05 alpha**
Corrected model	430.41	4	107.60	19.27	2.53	Significant
Pretest (Covarite)	152.90	1	152.90	27.39	4.00	Significant
Main effect:						
Treatment	50.28	1	50.28	9.06	4.00	Significant
Gender	15.13	1	15.13	2.71	4.00	Significant
Error	530.35	95	5.58			
	960.75	99				

As shown in table 4, the calculated F-value (F-cal) for difference in the achievement mean scores of male and female students considering the treatment groups (Polya and Target

Task) is 2.71, while its corresponding critical value (Fcrit) at df 1, 99 and 0.05 alpha is 4.00. The F-cal is less the Fcrit. This implies that the difference in the achievement mean scores of male and female students is not statistically significant. That is, there is no significant difference in the mean academic achievement scores of male and female students taught electrolysis using PPTS and those taught using TPTS. With this observation, the null hypothesis 2 is retained.

Discussion of the findings

Finding on the mean academic achievement scores of students taught electrolysis using PPTS and TPTS showed that students taught electrolysis using TPTS performed better than those taught using the PPTS. The findings of this study showed that there is a significant difference in the achievement mean scores of students taught electrolysis using PPTS and TPTS. This might have been due to the fact that Target-task Problem-solving strategy allowed students to engage in given tasks in groups and are opportune to report same. This finding is in line with Olaniyan and Omosewo (2015) who studied the effects of the Target-task Problem-solving Model on senior secondary school students' performance in Physics, and found that students taught with the Target-task Problem-solving Model significantly did well in a current electricity achievement test than those exposed to the lecture method. The finding of this study further concurs with the findings of the study by Mandina and Dube (2018) on implementing a Target-task Problem-solving Approach in teaching electrochemistry to advanced level Chemistry learners. They reported that the difference in performance between the experimental and control group was statistically significant. Results of this study show that there is merit in using TPTS to enhance students' achievement.

Findings showed that there is no significant difference in the mean academic achievement scores of male and female students taught electrolysis using PPTS and those taught using TPTS. The findings of the present study are in line with those of Nnorom (2019) who found that both males and females achieve equally in STEM education when given equal opportunity and facilities. This implies that the achievement of both boys and girls were comparable.

Conclusion

The result of this study highlighted the effect of PPTS and TPTS. The TPTS had merit in enhancing students' achievement. Based on the findings of this study, it was concluded that TPTS was more effective in enhancing students' achievement in electrolysis. Gender did not significantly influence students' achievements.

Recommendations

Based on the findings, it was recommended that:

i. Chemistry teachers and educators should adopt the use of TPTS in teaching concepts in Chemistry.

ii. Education stakeholders should organize conferences, seminars and workshops for Chemistry teachers to acquaint them with the use of TPTS to improve students' academic performance.

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