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EFFECTIVENESS OF PROBLEM-BASED AND THINK-PAIR-SHARE TEACHING METHODS IN ENHANCING SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN ELECTROCHEMISTRY IN ENUGU EDUCATION ZONE

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ABSTRACT

The study investigated the effectiveness of problem-based learning and think-pair-share teaching methods on secondary school students' achievement in electrochemistry in Enugu Education Zone. Three research questions guided the study while three null hypotheses were tested at 0.05 level of significance. Quasi-experimental design was adopted for the study. Specifically, the pretest, post-test, non-randomized experimental groups was used. The population of the study comprised 7,824 Senior Secondary School year two (SS 2) students offering Chemistry in the 31 public secondary schools in Enugu Education Zone. A sample size of 126 SS2 Chemistry students were involved in the study obtained using multi-stage sampling procedure. The instrument used for data collection was Chemistry Achievement Test (CAT). The coefficient of reliability was established through Kuder-Richardson Formula 20 and internal consistencies of 0.84 was obtained, indicating that the instrument was reliable. The experimental group one (E_1) were taught using problem-based method, while the experimental group two (E_2) was taught using think-pair-share method. The treatments lasted for six weeks. Data collected were analyzed using mean, standard deviation and Analysis of Covariance. The results revealed that problem-based and think-pair-share methods are effective in teaching electrochemistry; problem-based method is more effective than think-pair-share method in enhancing achievement in electrochemistry; the use of problem-based learning and think-pair-share as teaching methods were significant factors on the students' overall achievement in electrochemistry and that gender was a significant factor on the overall students' achievement in electrochemistry. Based on the findings of the study, the following recommendations were proffered among others that, chemistry teachers should adopt problem-based and think-pair-share teaching methods when teaching in order to enhance students' achievement in chemistry. Also, students and chemistry teachers should be trained properly on the use of these two methods in teaching by teacher educator tertiary institutions.

Keyword: teaching method, electrochemistry, problem-based, think-pair-share, achievement

Introduction

Science has contributed immensely to the development of the modern world and has been recognized as the bedrock on which modern day technological breakthrough is hanged. Nowadays, countries all over the world, especially the developing nations like Nigeria, are striving hard to develop technologically and scientifically. Since the world is turning scientific, proper functioning of lives depend greatly on science. Science education is needed to dispel ignorance, poor cultural practices and beliefs in the society. The major goal of science education is to develop scientifically literate individuals that are concerned with high competence for rational thoughts and actions. Science comprises the basic subjects such as Physics, Biology, Mathematics, Agriculture and Chemistry.

Chemistry is a branch of pure science, which deals with the composition, properties, reactions and uses of matter (Ababio, 2000). It is often referred to as the central science because its concept link together concepts of Physical, Mathematical, Biological, Medical, and Environmental sciences. Akudo (2020) asserted that, the knowledge of Chemistry helps us to observe some issues consciously and logically, and to check the accuracy of our assumptions about things in our physical and biological world. The major branches of Chemistry are Organic, Inorganic, Analytical, Physical, Biochemistry, Industrial, Polymer, Nuclear and Electrochemistry. This researcher is interested in one of the branches of Chemistry namely electrochemistry.

Electrochemistry is a branch of Chemistry that studies the relationship between electricity and chemical changes. It is concerned with the transfer of electrons from one chemical species to another and the relationship between the electron transfer and the electrical currents that are generated or used during these processes (Okechukwu, 2019). Electrochemistry also deals with chemical changes produced by an electric current and with the production of electricity by chemical reactions

Despite the importance placed on Chemistry, it is very disappointing to note that students' performance in the subject at both internal and external examinations has remained consistently poor (Nkot, 2022; Onwuma, 2017; Rann, 2006). Reports from various researchers show that mass failure in chemistry examination is real and the trend of students' performance has been on the decline (Nwajiuba, 2020, 2017; Nkama, 2019; Omaga, 2017). Therefore, using an alternative teaching method cannot be over-emphasized in redressing this situation and enabling students to perform better in chemistry. It is therefore more pertinent that

we should continue to seek for methods and variables which would improve students' mastery of the subject and consider some strategies especially those that have to do with peer learning. Such student-oriented methods include; problem-based learning (PBL), think-pair-share approach, collaborative learning approach, inquiry-based science education among others. Two activity-oriented and learner-centered approaches to learning that may improve achievement of students in Chemistry learning are Problem-based learning and think-pair-share learning methods.

Problem-based learning is an instructional method that initiates students learning by creating a need to solve an authentic problem rooted in the students' prior knowledge and experiences. During the problem-solving process, students construct content knowledge and develop problem solving skills as well as self-directed learning skills while working towards a solution to the problem (Akcay and Doymus, 2018).

The problem-based learning framework has 6 stepwise components (Sungur, 2006). They are; entry point, framing the problem, knowledge inventory, problem log, problem exit and problem debriefing. In each of these phases, the teacher served as a facilitator and guide. Students are guided to identify ill-structured problems related to the topics specified in the subject syllabus. In line with the framework, the students are engaged in self-directed learning, collect resources for themselves and their respective groups and take the necessary actions to solve the problems they had formulated. The teacher periodically steps in to engage them in brief discussion as and when it became necessary. In the final phase of each exercise, group members met in class to share their learning, exchange ideas, reflect, revisit the problem and go over it one more time. Another student-centered teaching method that could improve the academic achievement of students is the Think-pair-share.

Think-pair-share learning method is an instructional method that hold promises of improving achievement in learning. Think-Pair-Share (TPS) is a cooperative learning strategy that encourages students to work together to solve problems or answer questions on an assigned topic (Andrew and Alexandria, 2015). Think-pair- share as the name goes involves the students in thinking about challenging academic tasks given by the teacher individually, pairing with other students to exchange ideas and sharing the idea with the larger class.

These features of PBLM and TPS bear good and positive prospect for the students' achievement in chemistry. Achievement is the degree of success attained at the end of a general or specific task. Success in the area of academic is what

is referred to as academic achievement. Academic achievement of students especially at the secondary school level is a major determinant of their academic career in future. According to Chris and Enok (2021), academic achievement is measured by students' performance in test and examination. Kambili (2021) is of the opinion that the major aim of the school is to work towards attainment of academic excellence by students.

A student with excellent achievement in a particular subject is rightly assumed to have learnt much in that subject. Excellent achievement in Chemistry which is the paramount expectation of Chemistry students after examination has not been actualized. Surprisingly, the students' poor achievement in Chemistry at WASSCE is persistent for many years as reported by Hazari and Mari (2019); Mkpanaya (2020) and Maikudi (2021). Also, according to Kola and Taiwo (2021), the plethora of researchers on students' academic achievement in Chemistry is a testimony to this concern.

Gender related difference in Chemistry achievement has been an issue of concern to educationist. Researchers like Onwuma (2017); Uche and Maduako (2018) and Okpala and Okigbo (2021a) found that boys achieve higher than girls in Chemistry. Kparogi and Njama (2019) and Kamba and Nosa (2020) found that females achieve higher than males. However, Remireku (2018), Ojediran and Fatoba (2019) observed no gender difference in the achievement of boys and girls while, Neborisa and Anakwenze (2020) found that the mode of instruction is one of the causes of gender related differences in Chemistry achievement. In view of this controversy and inconclusive male/female influence on students' achievement in Chemistry, the present study seeks to determine the relative effectiveness of problem-based learning approach and think-pair-share approach in improving the achievement of students in electrochemistry.

Statement of the Problem

Poor performance of students in chemistry both in internal and external examination is becoming more alarming by the day and this cannot be unconnected with the inability of students to solve problems related to electrochemistry. It is unfortunate that students nowadays cannot walk boldly and confidently into chemistry examination without carrying unwanted materials from which to copy in order to pass the examination. Much of this problem stem from the fact that the method of instructional delivery in a conventional classroom at best leaves the student in confusion and perplexity about chemistry concepts especially solving electrochemistry problems. Without a student friendly and student-centered instructional approach, students will continue to lag

behind in ability to solve electrochemistry problems and consequently perform poorly in chemistry examination. This tends to cripple the nation's pursuit towards the development of science and indigenous technology hence it spells doom for the nation's industrial and technological development. It is on this premise that this study sought to find out the effectiveness of problem-based and think-pair-share teaching methods in enhancing students' academic achievement of senior secondary two (SS2) chemistry students.

Research Questions

1. What are the mean achievement scores of students taught electrochemistry using Problem-based learning method (PBLM) and that of those taught using Think-pair-share method (TPSM)?
2. What are the mean achievement scores of male students taught electrochemistry using PBLM and that of those taught using TPSM?
3. What are the mean achievement scores of female students taught electrochemistry using PBLM and that of those taught using TPSM?

Null Hypotheses

1. There is no significant difference in the mean achievement scores of students taught electrochemistry with Problem-Based Learning Method (PBLM) and that of those taught with Think-Pair-Share Method (TPSM).
2. There is no significant difference in the mean achievement scores of male students taught electrochemistry with PBLM and that of those taught with TPSM.
3. There is no significant difference in the effectiveness of PBLM and TPSM on mean achievement scores of female students in electrochemistry.

Research Method

The adopted a quasi-experimental research design. Specifically, the pretest, post-test, non-randomized experimental groups was used. The students' pretest scores serve as covariates with post-test scores to minimize the error that may occur from using this design.

The design is represented schematically as follows:

Group	Pre-test	Treatment	Post-test
E_1	0_1	X_1	0_1
E_2	0_2	X_2	0_2

Figure 1: Design of the Experiment

Where;

E_1= Experimental group

E_2= Experimental group

0_1= Pre-test

0_2= Post-test

X_1= Treatment with Problem-based learning method (PBLM)

X_2= Treatment with Think-Pair-Share method (TPSM)

----=Non-randomized groups (equality of the groups not assured)

The research was conducted in Enugu Education Zone of Enugu State. Enugu Education Zone is one of the six (6) education zones in Enugu State and it covers three Local Government Areas (LGAs) namely: Enugu East, Enugu North and Isi-uzo. The three LGAs have similar culture, tradition and dialect. The area is at about the center of Enugu State, and shares boarders with the two major towns in the State- Udi and Nsukka. The population of the study consisted of 7,824 senior secondary two (SS2) students offering Chemistry in the 31 government owned secondary schools in the Enugu Education Zone of Enugu State, Nigeria.

The sample for this study comprises of 126 SS2 chemistry students made up of 75 males and 51 females. The Purposive sampling technique was used to select four schools out of the 20 coeducational schools from the area of study. Random sampling using balloting was used to select two (2) schools out of the four. From these two schools, intact classes comprising 66 and 60 students made up of 75 males and 51 females offering chemistry were selected respectively. The two schools were randomly assigned experimental group one (E1) and experimental group two (E2) respectively. The experimental group one was taught using problem-based method (PBLM) while the experimental group two was taught using think-pair-share method (TPSM). The instruments used for the study was Chemistry Achievement Test (CAT). The Chemistry Achievement Test (CAT) was developed by the researcher based on the topics covered in the study and chosen from WASSCE chemistry past question papers from 2013 to 2022 (10 years) that covers topics in Electrochemistry. The Chemistry Achievement Test was used in assessing students' achievement in electrochemistry. The CAT is a 50-items multiple choice objective test based on lessons that were taught in Electrochemistry. Each of these questions in the CAT has four options (A, B, C, and D). The maximum score for CAT is 50 while the minimum score is 1.

The reliability of the instruments was carried out with a trial testing on a sample of forty (40) senior secondary two (SS2) chemistry students in a school outside the study area which were not part of the main study. The

data obtained was analysed using the Kuder-Richardson formula 20, which gave a reliability index of 0.84, indicating a high reliability of the instrument. Instructional packages used for treatment during the problem-based method and the think-pair-share method treatments were designed by the researcher. Before treatment for each group commenced a pretest was administered to each group and at the end of the treatment a posttest was also administered. Data collected were analysed using the mean and standard deviation to answer the research questions while the hypotheses were tested at .05 level of significance using Analysis of Covariance (ANCOVA).

Presentation of Results

The results are presented in tables according to the research questions and hypotheses.

Research question 1: What are the mean achievement scores of students taught electrochemistry using Problem-based learning method (PBLM) and that of those taught using Think-pair-share method (TPSM)?

Table 1: Mean achievement scores of students taught electrochemistry using problem-based learning method (PBLM) and think-pair-share method (TPSM)

Treatment Group	Pre-Achievement		Post Achievement			No of Students
	Mean	Standard Deviation	Mean	Standard Deviation	Mean gain score	
PBLM	22.40	4.40	36.81	5.46	14.77	66
TPSM	21.91	4.36	32.81	3.78	10.90	60

Table 1 shows that students taught using problem-based method had mean achievement score of 22.04 and standard deviation of 4.40 while those taught using think-pair-share method had mean achievement score of 21.91 and standard deviation of 4.36 in the pretest. In the post test, students taught using problem-based method had mean score of 36.81 and standard deviation of 5.46 while those taught using think-pair-share method had mean score of 32.81 and standard deviation of 3.78.

The students mean gain score for the problem-based group was 14.77 while the students mean gain score for the think-pair-share teaching method was 10.90. Therefore, the problem-based method is more effective

in enhancing achievement in electrochemistry.

Table 1 also shows that in the pretest, scores in problem-based method group deviated higher from the mean score with standard deviation of 4.40 while the scores in think-pair-share method group deviated from the mean score with standard deviation of 4.36.

In the post test, scores in problem-based method group deviated higher from the mean score with standard deviation of 5.46 while the think-pair-share method group deviated with standard deviation of 3.78.

The high mean achievement scores in the post test for the problem-based method and think-pair-share method suggests that the two teaching methods are effective in enhancing achievement in electrochemistry.

Research question 2: What are the mean achievement scores of male students taught electrochemistry using PBLM and that of those taught using TPSM?

Table 2: Mean achievement scores of male students taught electrochemistry using problem-based learning method (PBLM) and think-pair-share method (TPSM)

Treatment Group	Gender	Pre-Achievement		Post Achievement			No of Students
		Mean	Standard Deviation	Mean	Standard Deviation	Mean gain score	
PBLM	Male	23.97	3.75	40.61	3.04	16.64	39
TPSM	Male	24.11	3.70	35.05	2.60	10.94	36

Table 2 shows that in the pre achievement, male students taught using problem-based method had mean score of 23.96 and standard deviation of 3.75 while those taught using think-pair-share method had mean score of 24.11 and standard deviation of 3.70. In the post achievement, male students taught using problem-based method had mean score of 40.61 and standard deviation 3.04 while those taught using think-pair-share method had mean score of 35.05 and standard deviation of 2.06. The male students mean gain score for the problem-based method group was 16.64 while the mean gain score for the think-pair-share method group was 10.94. Therefore, after treatment males gained higher mean score in problem-based group than the think-pair-share method group. Therefore, the problem-based method is more effective in enhancing achievement among males in electrochemistry than think-pair-share teaching method.

Research question 3: What are the mean achievement scores of female students taught electrochemistry using PBLM and that of those taught using TPSM?

Table 3: Mean achievement scores of female students taught electrochemistry using problem-based learning method (PBLM) and think-pair-share method (TPSM)

Treatment Group	Gender	Pre-Achievement		Post Achievement			No of Students
		Mean	Standard Deviation	Mean	Standard Deviation	Mean gain score	
PBLM	Female	19.25	3.77	31.33	2.86	12.08	27
TPSM	Female	18.62	3.01	29.45	2.62	10.83	24

Table 3 shows that in the pre achievement, female students taught using problem-based method had mean score of 19.25 and standard deviation of 3.77 while those taught using think-pair-share method had mean score of 18.62 and standard deviation of 3.01. In the post achievement, female students taught using problem-based method had mean score of 31.33 and standard deviation of 2.86 while those taught using think-pair-share method had mean score of 29.45 and standard deviation of 2.62. The female students mean gain score for the problem-based group was 12.08 while the mean gain score for the think-pair-share method was 10.83. Therefore, after treatment females gained higher mean score in problem-based group than the think-pair-share group. Therefore, the problem-based method is more effective in enhancing achievement among females in electrochemistry than think-pair-share teaching method.

Hypotheses 1: There is no significant difference in the mean achievement scores of students taught electrochemistry with Problem-Based Learning Method (PBLM) and that of those taught with Think-Pair-Share Method (TPSM).

Table 4: Two-way Analysis of covariance of students' post Achievement due to Treatment and Gender.

Tests of Between-Subjects Effects

Dependent Variable: Post--test Achievement

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2491.008[a]	4	622.752	94.305	.0001
Intercept	414.065	1	414.065	62.703	.0001
Pre Achievement	162.047	1	162.047	24.539	.0001
Teaching Method	342.707	1	342.707	51.897	.0001
Gender	390.042	1	390.042	59.065	.0001
Teaching Method * Gender	138.530	1	138.530	20.978	.0001
Error	799.031	121	6.604		
Total	156871.000	126			
Corrected Total	3290.040	125			

Table 7 shows that the difference in mean achievement scores between the groups taught using the different teaching methods in the covariates is significant since the worked F ratio of 51.897 is significant at P< 0.001. The difference in the mean achievement scores between the treatment groups is therefore significant at P< 0.05. Therefore, it can be concluded that the research hypothesis 1 is rejected. The difference in the mean achievement scores of students taught electrochemistry using problem-based learning and think-pair-share teaching method is significant and not by chance.

Hypotheses 2: There is no significant difference in the mean achievement scores of male students taught electrochemistry with PBLM and that of those taught with TPSM.

Table 5: One-way Analysis of covariance of students' post Achievement due to Treatment for males only.

Tests of Between-Subjects Effects

Dependent Variable: Post--test Achievement

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	767.359[a]	2	383.680	68.989	.0001
Intercept	1300.653	1	1300.653	233.868	.0001
Pre Achievement	188.692	1	188.692	33.928	.0001
Teaching Method	590.781	1	590.781	106.227	.0001
Error	400.428	72	5.561		
Total	109164.000	75			
Corrected Total	1167.787	74			

a. R Squared = .657 (Adjusted R Squared = .648)

Table 8 shows that the difference in mean achievement scores between the groups taught using the different teaching methods in the covariates is significant since the worked F ratio of 106.227 is significant at P< 0.001. The difference in the mean achievement scores between the treatment groups is therefore significant at P< 0.05. Therefore, it can be concluded that the research hypothesis 2 is rejected. The difference in the mean achievement scores of male students taught electrochemistry using problem-based learning and that of those taught with think-pair-share teaching method is significant and not by chance.

Hypotheses 3: There is no significant difference in the effectiveness of PBLM and TPSM on mean achievement scores of female students in electrochemistry.

Table 6: One-way Analysis of covariance of students' post Achievement due to Treatment for females only.

Tests of Between-Subjects Effects

Dependent Variable: Post--test Achievement

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	171.855[a]	2	85.927	16.850	.0001
Intercept	727.313	1	727.313	142.626	.0001
Pre-Achievement	127.186	1	127.186	24.941	.0001
Teaching Method	31.371	1	31.371	6.152	.017
Error	244.773	48	5.099		
Total	47707.000	51			
Corrected Total	416.627	50			

a. R Squared = .412 (Adjusted R Squared = .388)

Table 9 shows that the difference in mean achievement scores between the groups taught using the different teaching methods in the covariates is significant since the worked F ratio of 8.152 is significant at P< 0.017. The difference in the mean achievement scores between the treatment groups is therefore significant at P< 0.05. Therefore, it can be concluded that the research hypothesis 3 is rejected. The difference in the mean achievement scores of female students taught electrochemistry using problem-based learning and that of those taught with think-pair-share teaching method is significant and not by chance.

Discussion of Findings

Table 4 indicates that teaching methods (PBLM and TPSM) yielded a significant difference on students' achievement in

electrochemistry. The improvement in performance might have been because of the fact that the students were required to find out facts for themselves, thereby imbibing the scientific processes involved in learning science, which enabled them to perform better. When the students generate their own question, analyze and discuss their findings and finally construct their understanding they seemed to understand their own information better than the ones the teachers introduced to them. The implication is that either of the problem-based learning or think-pair-share methods (both being child-centered) teaching methods could be applied to achieve goals of Chemistry education in electrochemistry. This is in line with Obiekwe (2020) who calls for a shift from the conventional methods of teaching to innovative strategies in teaching science, Technology and Mathematics for effectiveness. The two teaching methods are learner-centred and students can learn electrochemistry when they are actively involved. The result is also in line with the National Policy on Education which stresses that the teaching of Chemistry should be centred on the learner for maximum self-development and self-fulfillment (FRN, 2014). It is also consistent with the findings of Aidoo, Boateng, Kissi and Ofori (2016) whose study reveals that teaching methods have statistically significant effects on the achievement of students in chemistry. Also, Owoduni (2018), Dauda and Kaura (2021) and Onyi, Njoku and Nwafor (2022) declared significant effectiveness of the problem-based teaching method on achievement while Eze and Obiekwe (2018), Akuna (2020), Aniefiok (2020) and Umar (2020) reported significant effectiveness of think-pair-share teaching method on achievement. The practical nature of electrochemistry demands active participation of the learner which the conventional (lecture) teaching method does not usually provide. Therefore, the abstract nature of the electrochemistry concepts could be minimized in the process of learning those concepts by using more pragmatic and effective teaching methods such as the problem-based learning and think-pair-share.

On the other hand, the Table 1 indicates that problem-based learning is more effective than think-pair-share teaching method on students' achievement in electrochemistry. The findings revealed that the mean achievement scores in the Chemistry Achievement Test were higher with problem-based learning group (36.81) than think-pair-share group (32.81). The implication is suggestive of the fact that the problem-based learning should be made use of in teaching electrochemistry more frequently than the peer-teaching for better results in realizing Chemistry education goals.

Conclusion

The study shows that teaching methods have significant effects on students' achievement in electrochemistry. Indeed, the result indicates that the two teaching methods were effective but problem-based learning method was outstanding and more effective than the think-pair-share method in engendering the aforementioned criteria measure. This means that in an effort to achieve set objectives of Chemistry education in Senior Secondary Schools, electrochemistry should be taught using more of the problem-based learning than think-pair-share. The influence of gender on achievement was significant and the male students demonstrated higher achievement and based on the mean scores of CAT. Now that it has been proved that the teaching methods adopted in teaching electrochemistry plays an important role in students' achievement. The use of problem-based learning and think-pair-share teaching methods should be recommended in the Chemistry curriculum since both are efficacious and unisex in their effects.

Recommendations

1. Since the use of problem-based learning in teaching has been found more effective on the achievement of students in electrochemistry, chemistry teachers should be encouraged to employ it in the teaching of the subject. By so doing, the achievement of students in electrochemistry could be improved.

2. The fact that higher mean achievement scores were recorded through the use of problem-based learning and think-pair-share calls for teachers to acquaint themselves through training with the distinctive characteristics of the teaching techniques involving problem-based learning and think-pair-share with a view to enhancing students' achievement for effective learning outcomes. This could be done through seminars, conferences and workshops organized by the Science Teachers' Association of Nigeria (STAN), Chemical Society of Nigeria (CSN) and the Curriculum Organization of Nigeria (CON).

3. Teacher training tertiary institutions should incorporate performance based instructional and playwriting techniques which can be learned from the simple to complex or from the known to unknown. This can be presented to the learner of the subject matter or the trainee teachers as the principles of preparing and assisting the learners to prepare quality problem solving ability. By so doing the students will learn willfully and better too.

4. The government and other educational authorities should organize seminars and workshops on regular basis to educate the in-service teachers on these innovative teaching method.

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