Effects of Cooperative Instructional Strategy on Senior School Students' Achievement in Electrochemistry

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The poor performance of Nigerian students in School Certificate Chemistry over the years necessitates the search for alternative instructional strategies that could ensure better students' achievement. This study investigated the effects of cooperative instructional strategy on senior secondary school students' achievement in electrochemistry using gender and scoring levels as moderating variables. The study employed a 2 x 2 x 3 non-randomized and non-equivalent, pre-test and post-test quasi-experimental factorial design. Two intact classes in two secondary schools in Ilorin, Nigeria were involved in the study, with one class serving as the experimental class, and the other serving as control. A Chemistry Achievement Test (CAT) with reliability Coefficient of 0.75 was used for the study. Data analysis was carried out using t-test and Analysis of Covariance (ANCOVA). The findings of this study revealed no significant difference in the achievement of students taught using cooperative instructional strategy and those taught using the traditional lecture-based instructional method ($t=7.26$, $p>0.05$), although students taught using cooperative instructional strategy performed better than their counterparts in the control group. However, a statistically significant difference was observed in the achievement of students based on their scoring level when taught using the cooperative instructional strategy ($F=4.850$, $p<0.05$), with the low scorers benefitting most. Hence it is recommended that chemistry teachers should consider using cooperative instructional strategy for teaching Chemistry as a way of enhancing better understanding of the subject.

Keywords: cooperative instructional strategy, achievement, electrochemistry, gender, scoring level

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INTRODUCTION

Science and technology have been the dominant factors for initiating and accelerating human progress and development. Chemistry is one of the science subjects taught from the Senior Secondary School (SSS) level through Colleges of Education and Polytechnics to the University level in Nigeria because of the important roles it plays in the intellectual and career development of an individual. Electrochemistry is a topic in the curriculum of the Nigerian Secondary School Chemistry Curriculum. According to Alafara (2006), Electrochemistry is a branch of Chemistry that deals with the chemical transformation produced by the passage of electricity and with the production of electricity by means of a chemical transformation. Electrochemistry also provides an insight into the large numbers of processes such as corrosion of metals, refining of metals and with the interaction of ions in solution with one another and with solvent.

Unfortunately, despite the importance of electrochemistry in nature, technological development and everyday life, many students and teachers of chemistry consider the concept difficult to understand (Doymus, Karacop&Simsek, 2010; Garnett &Treagust, 1992; Thompson &Soyibo, 2002; Obamanu, &Onuoha, 2012; 2006; Oyelekan &Olorundare, 2009).Obamanu and Onuoha (2012)investigated secondary school students' conceptual difficulties in electrochemistry. The sample consisted of two hundred and forty-eight students randomly selected from 29 government secondary schools in Abia state. The results of their analysis showed that the students had difficulty in understanding concepts tested by 84% of the items in electrochemistry. Students performed poorly in this concept area at public examinations at the secondary school level (WAEC, 2003, 2008; Ojokuku&Amadi, 2010).

The overall achievement of Nigerian secondary school students in the Senior School Certification Examinations in chemistry over the years has not been encouraging.Figure 1 shows the performance of Nigerian candidates in chemistry in the West African Senior School Certificate Examinations (WASSCE) between 2008 and 2014.

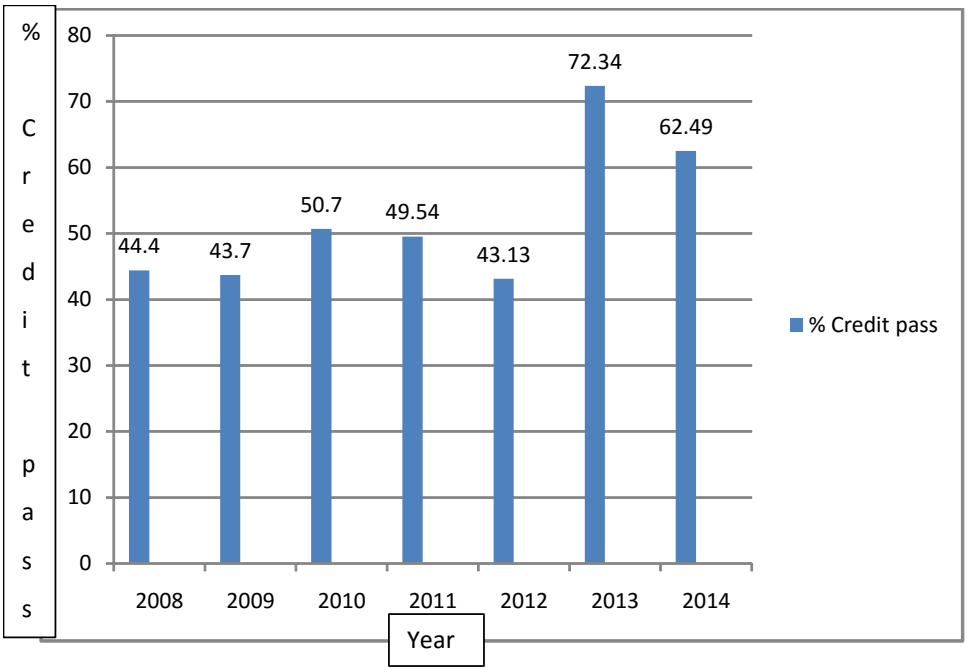

Figure 1. Performance of Nigerian candidates in chemistry in the West African Senior School Certificate Examinations (WASSCE) between 2008 and 2014.

(Source: Statistics Division, West African Examinations Council (WAEC), National Head Office, Yaba, Lagos, Nigeria).

A critical examination of this figure reveals that the highest achievement in chemistry was in the year 2013, when the percentage credit 1-6 was 72.34 after several years of below 50% credit pass, but the percentage credit pass slid back again to 62.49% in 2014. The implication of this for manpower development cannot be overemphasized. This dismal performance has been partly attributed to ineffective and unproductive strategies used by practicing teachers (Oyelekan & Olorundare, 2009).

The instructional strategies employed by the teachers are essential in the implementation of the curriculum contents. A strategy is a predetermined way or manner used by teacher to promote learning among students. The difficulties experienced by some science teachers in putting their lessons across to learners could be traceable to the fact that they are not properly informed of recent development and equipment, nor equipped with relevant skills of new methods that showcase best practices (Olorundare, 2011).

Abimbola (2013) noted that the educational system in Nigeria provides little opportunities for students to engage in self-instruction because they are always being taught by either teacher in school or coaching classes, or parents and siblings at home, without knowing how to study by themselves, with the exception of, perhaps, students in boarding schools.

The dismal performance of students in chemistry over the years necessitates the search for alternative instructional strategies that could ensure better students achievement. The strategy utilised in this study is an adapted version of the popular cooperative learning strategy (Okebukola, 1985; Adigwe, 1999). These researchers have reported the potency of this strategy in enhancing students' performance in science and related subjects. This adapted version is called "Cooperative Instructional Strategy" (CIS) which was specifically aimed at improving problem solving abilities among learners (Aluko, 2008).

Cooperative instructional strategy is a teaching strategy in which small teams, each with students of different levels of ability use a variety of learning activities to improve their understanding of a subject. Each member of a team is expected not only to learn what is taught but also to help teammates learn, thus creating an atmosphere of achievement (Olatoye, Aderogba & Aanu, 2011).Cooperative instructional strategy enables students to have an active control over their own learning and also enhance their academic achievement (Ajaja&Eravwoke, 2010; Aluko, 2004 & 2008). Studies that examined cooperative instructional strategies showed that these strategies, used in both theoretical and laboratory settings, could help students improve their academic and social skills by ensuring their active participation in learning processes (Carpenter, 2003; Johnson & Johnson, 1999).

Gender is a categorization of a person into masculine or feminine based on sex and socially ascribed roles. Several studies have also examined the influence of gender on students' academic achievement. For example, Olatoye, Aderogba and Aanu (2011) found no gender difference in academic achievement of students exposed to different teaching strategies in science. Samuel and John (2004) examined how the cooperative class experiment (CCE) teaching methods affectstudents' achievement in chemistry. They found that there was no significant difference in gender achievement between experimental and control groups, but male students had a slightly higher mean score than the female students.

Scoring level is a form of grouping in which students are categorized as high, medium and low scorers, based on certain criterion which stems from students' achievement in prescribed test items.Scoring level is the range of marks obtainable by the students after being subjected to a test on the basis of which the students are grouped into three, that is high scorers, medium scorers and low scorers. In this

particular study, the high scorers were those students who scored between 70% and 100% in the Chemistry Achievement Test. The medium scorers were students who scored between 50% and 69% while low scorers were students who scored between 0% and 49%.

Students are not the same especially when we find out the rate at which facts and principles in sciences are being assimilated. This implies that there is disparity in student's abilities to perform specific tasks. It is the view of Salami (2000) that problem solving in science depends on student's cognitive ability level. Aluko, (2008) opined that scoring levels which reflects academic ability had influence on the achievement of students. Hence, any innovation in instructional strategy should consider the influence of students' scoring levels with a view to establishing how well the gaps between students in the three identified levels are bridged. For instance, an efficient instructional strategy should bridge the scoring gaps between low and high scorers. Hence, scoring level was chosen as one of the variables of interest in this study.

THEORETICAL FRAMEWORK

Cooperative learning is mainly based on the theories of cognitive development, behavioral learning, and social interdependence (Morgan, 2003). Cognitive development is an outcome of cooperative learning, wherein constructivist knowledge development and transformation result from collaborative attempts to discover, comprehend, and decipher (Piaget, 1965; Vygotsky, 1978). Behavioral learning theory suggests that students will commit to participation in team efforts if they are rewarded for that participation, and are likely not to commit if no rewards are evident (Morgan, 2003). Therefore, both individual and team rewards should be evident in cooperative learning environments, wherein rewards for participation in team productivity is purposeful.

According to Slavin (1987) there are two major theoretical perspectives related to cooperative learning; motivational and cognitive. The motivational theories of cooperative learning emphasize on the incentives that encourage students to engage in academic work, while the cognitive theories emphasize the effects of working together. Motivational theories related to cooperative learning focus on reward and goal structures. One of the elements of cooperative learning is positive interdependence, where students perceive that their success or failure lies within their working together as a group (Johnson, Johnson, &Holubec, 1994). Hence, from a motivational perspective, cooperative goal structure creates a situation in which the only way group members can attain their personal goals is if the group is successful. Therefore, in order to attain their personal goals, students are likely to encourage members within the group to do whatever helps the group to succeed and to help one another with a group task.

There are two cognitive theories that are directly applied to cooperative learning, the developmental and the elaboration theories (Slavin, 1987). The developmental theories assume that interaction among students around appropriate tasks increases their mastery of critical concepts (Damon, 1984). When students interact with their peers, they have to explain and discuss each other's perspectives and this leads to greater understanding of the material to be learned. Attempts to resolve potential conflicts during collaborative activity could result in the development of higher levels of understanding. The elaboration theory suggests that one of the most effective means of learning is to explain the material to someone else. Cooperative learning activities enhance elaborative thinking and more frequent giving and receiving of explanations, which has the potential to increase depth of understanding, the quality of reasoning, and the accuracy of long term retention (Johnson, Johnson, &Holubec, 1994). Expectedly therefore, the use of cooperative learning methods should lead to

improved students' learning and retention from both the developmental and cognitive theoretical bases.

Purpose of the Study

The purpose of this study was to determine the effects of cooperative instructional strategy on senior secondary school students' achievement in electrochemistry. Specifically, the study determined:

1. The effect of cooperative instructional strategy on senior school students' achievement in electrochemistry;
2. The influence of gender on senior school students' achievement in electrochemistry when taught using cooperative instructional strategy;
3. The influence of scoring levels on students' achievement in electrochemistry when taught using cooperative instructional strategy.

Research Questions

For the purpose of this study, the following research questions were raised and answered;

1. Is there any difference in the achievements of chemistry students exposed to cooperative instructional strategy and the traditional lecture-based method of instruction?
2. Is there any difference between the achievements of male and female students taught electrochemistry using cooperative instructional strategy?
3. Is there any difference in the achievements of low medium and high scoring students taught electrochemistry using cooperative instructional strategy?

Research Hypotheses

The following null hypotheses were formulated and tested in this research work:

HO_1:There is no significant difference in the achievement of students taught electrochemistry using cooperative instructional strategy and those taught using the traditional lecture-based method of instruction.

HO_2:There is no significant difference in the achievement of male and female students taught electrochemistry using cooperative instructional strategy.

HO_3: There is no significant difference in the achievement of low, medium and high scoring students taught electrochemistry using cooperative instructional strategy.

Research Methodology

The study employed 2 x 2 x 3 non-randomized and non-equivalent, pre-test and post-test quasi-experimental factorial design.The experimental group was exposed to cooperative instructional strategy and control group was exposed to the traditional lecture-based method of instruction.

The target population for this study comprised of all the public senior secondary school II (SS2) students who offering Chemistry in Ilorin, Kwara State at the time of this study. Two schools were purposively selected based on the fact that they were co-educational, had functional and separate chemistry laboratory and had graduate Chemistry teachers with at least B.Sc.(Ed.) degree in Chemistry education. One hundred (100) students were involved in the study. The experimental group consisted of 48 students while the control group consisted of 52 students.

The CAT consisted of forty (40) multiple-choice items drawn from past West African Senior School Certificate (WASSCE) question papers. The CAT was validated

by giving it to two lecturers in the Department of Science Education, University of Ilorin and four experienced secondary school teachers who were examiners the West African Examinations Council (WAEC) and the National Examinations Council (NECO) for thorough scrutiny. Using Pearson Products Moment Correlation Coefficient formula, the reliability coefficient of the CAT was found to be 0.75 through a test-retest method.

A letter of request for permission was taken to the Principals of the schools to be involved in the study. After obtaining the permission from the Principals, the researchers interacted with the chemistry teachers. The pretest was administered to determine the students' level of understanding of the selected topics before teaching them. The cooperative learning instructional strategy was used to teach the experimental group while the control group was exposed to the traditional lecture-based method of instruction. After four weeks of teaching, both the experimental and control groups were post-tested.

The treatment for the experimental group was conducted using a specially designed cooperative learning instructional guide for chemistry. The instructional guide involved the following phases:

1. Introduction: Identification of topics, concepts, subtopics and instructional objectives. Introducing the cooperative learning instructional strategy as well as making brief remarks on them.
2. Presentation of theoretical base involving lectures and discussions.
3. Implementation of strategy: Carrying out of specific treatment (cooperative instruction).
4. Evaluation of learning and consolidation of knowledge gain.

Treatment for the Groups:

i. Experimental Group

This was the cooperative learning instructional strategy group. The class was divided into 10 sub-groups with five members per sub-group. However, since there were 50 members in this experimental group, two of the 10 sub-groups had 4 members. The materials to be learnt were arranged and presented in small sequence units that led the learners from body of known concepts to unknown, from simple to complex within the same area with learners working at their pace, making frequent responses as they proceeded through the materials and receiving immediate information (feedback) about the adequacy of their responses to attain mastery. Each group was requested to choose a leader that could help the group to achieve a given goal.

The teacher went round to guide them and ensure that they followed the guidelines. The students were taught the rules guiding the principles of cooperation and they were encouraged and motivated to interact among themselves.

The instructional guidelines provided for the cooperative group are as follows:

1. Members should cooperate and work in group.
2. A group leader and assistant should be appointed by each group
3. There must be division of labour in the group. That is, each person in the group must make contribution to the solution to any electrochemistry problem being solved.
4. Each group member must be able to explain any part of the solution to the electrochemistry problem at hand.

ii. Control Group

This group was exposed to the traditional lecture-based instructional method. This method was teacher-centred. The teacher taught electrochemistry concepts by explanation, writing key points on the board for the learners while the students listened. It also involved intermittent question and answer sessions with occasional

demonstration by the teacher. All the students were seated on their individual seats and their verbal participation in the lesson was limited.

The following precautions were taken during the treatment and control sessions:

1. The same set of teachers and research packages were used throughout the study in order to eliminate variations that may have arisen due to instrumentation.
2. Attendance of the students was taken by the teachers throughout the teaching sessions.
3. The experimental and control group subjects were given equal time of treatment and observations.
4. To prevent the students from being familiar with the questions of the pre-test and post-test, the test items in the pre-test were scrambled in the post-test.

Data obtained in respect of hypotheses 1 and 2 were analyzed using t-test and those obtained in respect of hypothesis 3 were analyzed using Analysis of Covariance (ANCOVA). All hypotheses were tested at 0.05 level of significance.

DATA ANALYSIS AND RESULTS

The data collected were analyzed and the findings presented were based on the research questions and the hypotheses formulated. All hypotheses were tested at 0.05 level of significance.

Research Question 1: Is there any difference in the achievements of chemistry students exposed to cooperative instructional strategy and the traditional lecture-based method of instruction?

The corresponding hypothesis to this research question is hypothesis 1:

HO_1: There is no significant difference in the achievement of students taught electrochemistry using cooperative instructional strategy and those taught using the traditional lecture-based method of instruction.

The result obtained in respect of research question1 and hypothesis 1 is showed on Table 1.

Table 1: t-test analysis of significant difference between mean scores of the experimental group and the control group.

Group	N	Mean	Std. Dev	df	t	p-value
Experimental	48	66.60	8.332	98	7.269	.754
Control	52	54.17	8.732			

In response to research question 1, the result in table 1 shows the mean score of students' achievement in the experimental group as 66.60 and standard deviation of 8.332, while that of students in the control group is 54.17 with standard deviation of 8.732. The experimental group had a higher mean score than the control group. This mean there was a difference in the achievements of chemistry students exposed to cooperative instructional strategy and the traditional lecture-based method of instruction in favour of the group taught using cooperative learning strategy. However, the t-test analysis shows that there was no statistically significant difference in the mean achievement scores in electrochemistry between the experimental group and the control group ($t=7.26, p>0.05$); therefore, hypothesis 1 is retained. This means there was no significant difference in the achievement of students taught electrochemistry using cooperative instructional strategy and those taught using the traditional lecture-based method of instruction.

Research Question 2: Is there any difference between the achievements of male and female students taught electrochemistry using cooperative instructional strategy?

HO_2: There is no significant difference in the achievement of male and female students taught electrochemistry using cooperative instructional strategy.

The result obtained in respect of research question 2 and hypothesis 2 is showed on table 2.

Table 2: t-test analysis of significant difference between mean scores of the studentsexposed to cooperative instructional strategy based on gender.

Group	N	Mean	Std. Dev	df	t	p-value
Male	22	67.40	7.53	46	0.612	0.586
Female	26	65.92	9.04			

In response to research question 2, table 2 shows the mean score of students achievement based on gender. The mean score of male students exposed to cooperative instructional strategy was 67.4 with a standard deviation of 7.53, while that of female students was 65.92 at standard deviation of 9.04. The male students had a slightly higher mean score than the female students, so there was a difference between the achievements of male and female students taught electrochemistry using cooperative instructional strategy. The t-test analysis shows that there was no statistically significant difference in the mean achievement scores in electrochemistry between male and female students exposed to cooperative instructional strategy (*t=0.612, p>0.05*); therefore, hypothesis 2 is retained. Hence, there was no significant difference in the achievement of male and female students taught electrochemistry using cooperative instructional strategy.

Research Question 3: Is there any difference in the achievements of low medium and high scoring students taught electrochemistry using cooperative instructional strategy?

The corresponding hypothesis to this research question is hypothesis 3.

HO_3: There is no significant difference in the achievement of low, medium and high scoring students taught electrochemistry using cooperative instructional strategy.

The result obtained in respect of research question 3 and hypothesis 3 is presented on table 3.

Table 3:ANCOVA output of students' achievement on cooperative instructional strategy based on scoring levels

Source	Type III sumof square	df	Mean	F	P-value
Corrected Model	1215.528	13	93.502	4.878	.000
Intercept	1867.133	1	1867.113	97.406	.000
Scoring level	92.967	1	92.967	4.850	.035
Post-test exp	1195.558	12	99.60	5.198	.000
Error	651.722	34	19.168		
Total	43994.000	48			
Corrected total	1867.250	47			

In response to research question 3, table 3 shows the result of Analysis of Covariance (ANCOVA) test that was conducted to find out if there existed any difference in achievement scores in electrochemistry among high, medium and low scoring students taught using cooperative instructional strategy. The ANCOVA analysis (Scoring level group) yielded F (1, 34) =4.850, and p<0.05. This was deemed

to be statistically significant since $p<0.05$. Therefore, there was significant difference in the achievements of low, medium, and high scoring students taught electrochemistry using cooperative instructional strategy. This implies that significant difference existed among the three scoring levels; hence hypothesis 3 was rejected. The difference in the performance of students based on the three scoring levels could be further observed using a post hoc test as presented in Table 4.

Table 4: Duncan's Post-hoc test on students' performance based on scoring levels

Group	N	Mean score	
High scorers	9	28.11	A
Medium scorers	20	29.85	B
Low scorers	19	30.11	C

From table 4, it can be observed that the low scoring students had the highest performance mean score of 30.11 followed by medium scorers with the performance mean score of 29.85 and the high scorers had the least performance score of 28.11. This means that students in low scoring level performed relatively better with cooperative learning instructional strategy than students in the medium scoring level and high scoring level.

DISCUSSION

This study investigated the effect of cooperative instructional strategy on senior secondary school students' achievement in electrochemistry in Ilorin, Kwara State. The results of the findings showed that there was no significant difference in the achievement of students taught using cooperative instructional strategy and those taught using the traditional lecture-based method of instruction.

However, the students who were exposed to the use of cooperative instructional strategy had a better achievement than their counterparts taught using the traditional lecture-based method. This may have been achieved by the high level of students' participation in learning activities. All the students in the cooperative group performed specific roles in solving problems which were presented in the classroom to the benefit of all members of the group. This finding agrees with the findings of Ajaja and Eravwoke (2010), Aluko (2004) and Aluko (2008). The cooperative instructional strategy was found to be more effective in enhancing better performance of the learners. It is believed that when properly and carefully used, cooperative learning activities engage the students in the learning process and seek to improve the critical thinking, reasoning and problem solving skill of learners.

In classes where cooperative instructional approach is used for teaching, students gradually take responsibility for each other's learning. The better attitude exhibited by students in the cooperative learning classroom may have been achieved because feedback, reinforcement, and support come from students' peers in the group (Ajaja&Eravwoke, 2010).

It was found out that gender had no significant effect in the achievement of students taught using cooperative instructional strategy. All students irrespective of their sexes benefited in about the same margin from the use of cooperative learning instructional strategy. This finding corroborates the work of Ajaja and Eravwoke (2010), Aluko (2008), Olatoye, Aderogba&Aanu (2011) and Samuel and John (2004). Olatoye, Aderogba and Aanu (2011) carried out research on the effects of cooperative instructional strategy on students' achievement and found out that gender had no influence on the performance of students.

Findings further revealed that there was a statistically significant difference in the achievement of students taught using cooperative instructional strategy on the basis

of their scoring levels. Students of low scoring level were found to have performed relatively better with cooperative learning instructional strategy than students in the medium scoring level and high scoring level. This supports an earlier finding of Aluko (2008) who found that academic ability influenced students' achievement in science.

CONCLUSION

It appears that cooperative instructional strategy, as described in this study, is a viable option for teaching electrochemistry in secondary schools. This study has shown that teachers' use of cooperative instructional strategy could enhance students' achievement in Chemistry and possibly other school subjects, especially with low and medium scoring students. Gender had no significant role when cooperative instructional strategy was used to teach the students electrochemistry, hence the strategy could be used for both males and females.

RECOMMENDATIONS

Based on the findings from this study, the following recommendations were made:

1. In order to solve the problem of poor achievement, chemistry teachers should consider using cooperative instructional strategy for teaching Chemistry; as such strategies like cooperative instructional strategy could enhance better understanding of difficult topics.
2. Male and female students should be given equal consideration as far as the use of cooperative instructional strategy is concerned since gender has no influence on the academic achievement of students.
3. Science educators should consider scoring levels of the students in the use of cooperative instructional strategy since the scoring levels had influence on the achievements of students.
4. The Federal and State Ministries of Education and other educational bodies like Nigeria Educational Research and Development Council (NERDC), Teaching Service Commission and Science Teachers Association of Nigeria (STAN) should organize training/ workshops for teachers so as to update their knowledge on the use of instructional approaches such as cooperative instructional strategy to improve teaching and learning.

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