

Effects Of Cooperative Learning Strategy And Inquiry Based Learning On Secondary School Students' Academic Achievement In Chemistry In Nnewi Education Zone

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Abstract: *The study investigated the effect of cooperative learning strategy and inquiry based learning on the academic achievement of secondary school students in chemistry. Three research questions guided the study and four null hypotheses were tested at 0.05 alpha level. The design was quasi-experimental. The population of the study was 2,092 senior secondary school year one (SS1) students offering chemistry in Nnewi North local government area of Anambra State out of which 123 students was sampled using multi-staged sampling procedure. The instrument for data collection was Chemistry Achievement Test (CAT) validated by three experts and one experienced secondary school chemistry teacher. The reliability of the CAT was established using Kuder-Richardson Formula 20 to be 0.60. The experimental groups were taught chemistry concepts using cooperative learning strategy and inquiry based learning respectively while the control group was taught using conventional method. Data were collected by administering the instruments as pretest and posttest before and after treatment. The data obtained were analyzed using mean, standard deviation and analysis of covariance. The findings of the study revealed that there was a significant difference between the mean achievement scores of students taught chemistry using cooperative learning strategy and inquiry based learning in favour of cooperative learning strategy, followed by inquiry based learning. The study recommended that chemistry teachers should adopt the use of cooperative learning strategy in the teaching and learning process of chemistry in secondary schools.*

Keywords: *cooperative, inquiry learning, achievement, chemistry, secondary school*

I. INTRODUCTION

The study of chemistry and its related fields is important for so many reasons. It gives scientists understanding into how the human body works amidst so many metabolites and enzyme. Such understanding has advanced the production of effective drugs that cure ailments and also prevent them. Chemistry has also found application with engineers. Today, petrochemical products are used in storing water, foods, clothes, and for preservations. Electronic components like diodes, condensers, and resistors are produced with the knowledge of chemistry. These applications of chemistry among others depict the idea that chemistry education is an indispensable part of science education.

The teaching and learning of chemistry in science education has its peculiar challenges. One of the major problems is the experimental verification of what is taught. The students are not often exposed to laboratory experiments owing to the cost of acquiring the consumable chemicals which may not be stored on the shelves. Students of chemistry find some of the concept very abstract and difficult to understand. Others have phobia for chemicals and are scared that it could harm them given their corrosive, basic or poisonous nature. It is made up of concepts which require complex mental process that involves vitalizing, manipulating, analyzing, abstracting, and associating with idea (Oluchukwu, 2015). This implies that the study of chemistry requires effective and efficient teaching for the students to learn meaningfully.

In spite of the importance of chemistry in national development, researchers have observed low achievement in chemistry among students in senior secondary school certificate examinations (Giginna & Nweze, 2014). The percentage analysis of students' performance in West African Senior School Certificate Examination (WASSCE) also revealed that those who passed chemistry at credit level over the years has not been consistently increasing as compared to the percentage of students who enrolled for the examination. From 2007-2012, the percentage of those who passed at credit level was below 50% except in 2011. From 2013 to 2016, although, the percentage of those who passed at credit level was above 50%, there has been consistently decline in the percentage of those who made credit passes; from 72.34% in 2013, to 62.49% in 2014, 60.60% in 2015 and 57.74% in 2016. The poor achievement of students in chemistry has been blamed on teacher-related factors by Giginna and Nweze (2014). Some of the factors implicated include: the teaching methods adopted by the chemistry teachers, lack of activities and assignment that will involve the students' active engagement and teacher demonstrations with little or no practice on the part of the students. The chemistry teachers play a vital role in ensuring success in the delivery of subject matter.

Ofoefuna (2008) observed that chemistry teaching needs a lot of activities on the part of the students for them to benefit maximally from the learning experiences. Okoye (2013) asserted that teaching and learning have gone beyond the teacher standing in front of the learners to disseminate information to them without learners actively participating. Literature however, is replete with evidence that chemistry classrooms are dominated with conventional methods of teaching which makes students passive recipients in the teaching/learning process. For example, Giginna and Nweze (2014) blamed the poor teaching methods adopted by chemistry teachers over the years. Uzoechi (2014) opined that science education (chemistry inclusive) programmes must focus attention on innovative teaching methods that can promote creative thinking in science problem-solving. Science educators also advocate a shift from teacher-centered methods to learner-centered methods that engage students actively in the process of learning. These efforts in assisting the learners to learn, have led to the development of cooperative learning and inquiry based learning which could enhance meaningful learning.

Cooperative learning is the deliberate instructional use of heterogeneous small groups of students who work together to maximize each other's learning (Igboegwu, 2012). Ifamuyiwa and Onakoya (2013) viewed cooperative learning as an instructional method in which learners work together in small groups in such a manner that each member of the group can participate in a clearly collective task and engage in discussion with one another while participation in authentic learning activities relevant to real life that encourage them to teach one another. Cooperative learning is an instructional method in which small groups of students work together on a common task to accomplish group, individual and common goals.

In a cooperative learning class, there exist small groups divided out of the whole class with each group having a leader. Each group together with its leader participates in

structured group activities, as they work together on sets of problems and a given common goal. While the groups work together on their tasks in the cooperative learning class, the course tutor moves group to group, observes the interactions, listens to the conversations and intervenes when he feels it is appropriate. The tutor can ask groups to give a brief oral report on their findings or submit a copy of their group – activity materials for his comments. Johnson and Johnson (2008) indicate that cooperative interaction when compared with competitive, individualistic as well as traditional teaching methods provides greater achievements, retention of materials, motivation, and more frequent use of higher level reasoning strategies. It also provides more positive attitude towards classmates, regardless of handicaps, gender, ethnic background or level of ability, great self-esteem, psychological, health and collaborative skills. More learning occurs when students learn together, talk through with each other and support each other's work. Meaningful learning can also be achieved when students discover knowledge for themselves through inquiry based learning.

Inquiry based learning (IBL) on the other hand is originally designed as a classroom- based method of instruction with the intention of improving students' achievement. Inquiry based learning starts by posing questions, problems or scenarios. It is mainly involving the learner and leading him to understand. Inquiry allows you to ask questions about new resolutions and issues while you are gaining new information. IBL according to Sola and Ojo (2007) involves developing questions, making observations, doing research to find out what information is already recorded, developing methods for experiment, developing instruments for data collection, collecting, analyzing and interpreting data, outlining possible explanations and creating predictions for further study. The process is often assisted by a facilitator. Inquirers research issues and questions to develop their knowledge or solutions.

Inquiry – based learning includes problem-based learning and is generally used in small scale investigation and projects, as well as research. The inquiry-based instruction is principally very closely related to the development and practice of thinking skills. Cheval and Hart (2005), classify inquiry based learning into three namely: structured inquiry, guided inquiry and open inquiry. All these types of inquiry can be useful to students to learn science when taught appropriately. In this study, guided inquiry will be used. Students will be given a set of topic and materials to develop method to find answers to the given problem unlike in conventional method where the teacher is at the centre of instruction.

The conventional (lecture) method is used primarily to introduce students to a new subject, but is also a valuable method for summarizing ideas, showing relationships between theory and practice, and re-emphasizing main points. Although lecture method is beneficial for large group of students and for covering large content areas, it has been castigated in many research studies. This study seeks to ascertain the effect of cooperative learning strategy and inquiry-based learning on academic achievement of secondary school students. The study also seeks to establish the influence

of gender on the achievement of students relative to teaching strategies.

The result of studies on the influence of gender on the achievement by students have been inconclusive. Some studies like that of Nwanze (2016) showed that significant difference exists between the achievements of students while other studies (Izuegbunam, 2018; Pius, 2018) found no significant difference in achievement. Such disparity in the achievement of students due to gender has been attributed to gender stereotyping which is becoming common in most schools. It is believed that certain disciplines especially the sciences is reserved for males and others like the social sciences, arts and humanities are more female oriented. This belief drives the attention given to male students who enroll for sciences than females resulting in gender stereotyping.

Purpose of the Study

The purpose of the study was to find out the effects of cooperative learning strategy and inquiry based learning on academic achievements of secondary school students in chemistry. The specific purposes are to find out the:

- ✓ difference in the pretest and posttest mean achievement scores of students taught chemistry using cooperative learning strategy (CLS), inquiry based learning (IBL) and conventional lecture method (CLM)
- ✓ difference between the pretest and posttest mean achievement scores of male and female students taught chemistry using CLS.
- ✓ difference between the mean pretest and posttest achievement scores of male and female students taught chemistry using IBL.

Research Questions

- ✓ What are the difference in the mean pretest and posttest achievement scores of students taught chemistry using cooperative learning strategy (CLS), inquiry based learning (IBL) and conventional lecture method (CLM)?
- ✓ What is the difference between the mean pretest and posttest achievement scores of male and female students taught chemistry using CLS?
- ✓ What is the difference between the mean pretest and posttest achievement scores of male and female students taught chemistry using IBL?

Hypotheses

- ✓ There is no significant difference in the pretest and posttest mean achievement scores of students taught chemistry using cooperative learning strategy (CLS), inquiry based learning (IBL) and conventional lecture method (CLM).
- ✓ There is no significant difference between the mean pretest and posttest achievement scores of male and female students taught chemistry using CLS.
- ✓ There is no significant difference between the posttest mean pretest and posttest achievement scores of male and female students taught chemistry using IBL.

II. METHOD

The design of the study was quasi-experimental, specifically, the pretest posttest non-randomized control group design was adopted. The area of the study is Nnewi Education Zone. The population of the study was 2, 092 senior secondary school year one (SS1) students in eight public senior secondary schools in Nnewi Education Zone (Post Primary Education Board, Nnewi Zone Anambra State, 2019). The sample for the study was 123 SS1 chemistry students. The sample was obtained through a three stage procedure involving simple random and purposive sampling techniques. The instrument for data collection was Chemistry Achievement Test (CAT) validated by three experts from the Department of Science Education and another in the Department of Educational Foundations (Measurement and Evaluation) in Nnamdi Azikiwe University, Awka and one experienced secondary school chemistry teacher. The reliability of the instrument was established using Kuder-Richardson Formula-20 (KR-20) to be 0.60 through simple administration method.

In the first phase of the experiment, the regular classroom teachers were briefed. The briefing session took one week to complete. This briefing was conducted by the researcher in each school according to the type of treatment required for that particular school in three contacts. The treatment commenced with the administration of pretest in the first week. The test was administered by the regular chemistry teachers of the three treatment groups at the appropriate time allotted for the test.

The treatment phase involved giving the two groups different treatments using Cooperative learning strategy (CLS) and Inquiry based learning (IBL). The experiment was conducted using the school time tables and at their normal lesson periods for a duration of four weeks. At the end of the treatment exercise, posttest (CAT) was given to the students, at the same time in three schools and the scripts were collected for marking. What varied was the teaching strategies as well as the lesson plans guiding the teachers. The control group will be taught using the conventional teaching method. The activities during the treatment for the experimental group on cooperative learning group involve the teacher organizing the students into groups of five and appointing leaders for each group.

The teacher instructed the students to make sure they take down points during the lesson as each group shall be called upon to summarize any part of the lesson contents and answer the questions that follows. The teacher gave the students notes on nature of matter and asked them to discuss it among their groups. Students discussed the notes, brought out the major points and summarize them for presentation. The teacher asked the various groups to use different textbooks, discuss and write about the physical and chemical properties of matter. The teacher then asked the various groups to present what they discovered after which she gave them notes on physical and chemical change. Each group then presented what they discovered from their groups. They now compared the teacher's notes with theirs and added the points which they missed. At the end of the class, the teacher invited the various groups to present summaries on different part of the lesson

contents. This was followed by evaluation where the teacher asked the students question on the contents taught. The students were given assignment on the next topic of discussion group by group. The same instructional procedure was followed to teach changes that matter undergo, the differences in chemical and physical changes, and separation techniques.

In the group for inquiry-based learning was taught similar contents but with a set of students activities that sometimes may be carried out in groups. In the first lesson on matter, the teacher introduced the topic and wrote the topic "Nature of matter on the board. The teacher defined matter and led students to identify matter. Teacher asked the students to pick a stone and tell her what they feel and also remove their shoes and place them on their palms, and tell the teacher what they feel. Students payed attention to the lesson. They asked questions to understand the lesson and carry out the tasks following the teacher's directives and answer the teacher's questions. The teacher further divides the students into five groups of seven students each to carry out the activities. She asks the students to carry out the following tasks, and record their observations.

- ✓ Pick a stone and tell me what you feel.
- ✓ Remove your shoe and place it on your palm and describe the weight.
- ✓ Carry your desks up.
- ✓ Mention about 10 things that have mass and occupy space.

The teacher described the properties of matter. The Teacher gave each group a paper and asks the students to identify the colour of the paper. Also a container of air freshener and ask them to spray it in the classroom. The students identified the colour of the paper and the smell of air freshener and wrote their observation in their activity sheet. The teacher asked one of the students in each group to light a match stick and burn up the paper. Then, they related the activities to chemical and physical properties and gave the students some activities to carry out and inquire the properties the substances possess before and after the experiment and to record their observations.

Students also worked in groups as they carry out the activities and inquire the properties of substances possess before and after the experiment, record their observation, state the physical and chemical properties and participate actively in the general class discussion. They asked questions during the discussion. At the end of the class the teacher asked the students to explain what they discovered before summarizing the important points of the lesson and evaluation.

Data relating to the research questions were analyzed using the mean and standard deviation. The hypotheses were tested with Analysis of Covariance (ANCOVA). This is because ANCOVA enables the researcher to handle the error due to problem of non-equivalent groups. For the hypotheses, the decision was that the null hypothesis be rejected whenever the Pvalue is less than or equal to the significant value of 0.05 ($P \leq 0.05$), otherwise ($P > 0.05$), the null hypothesis was not rejected.

III. RESULTS

| Source of Variation | N | Pretest Mean | Pretest SD | Posttest Mean | Posttest SD | Gained Mean |
|---------------------|----|--------------|------------|---------------|-------------|-------------|
| CLS | 42 | 34.88 | 9.721 | 71.07 | 7.53 | 36.19 |
| IBL | 41 | 32.42 | 12.07 | 60.24 | 12.75 | 27.82 |
| Conventional | 40 | 31.50 | 11.99 | 50.63 | 8.93 | 19.13 |

Table 1: Pretest and Posttest Mean Achievement Scores of Students taught Chemistry using Cooperative Learning Strategy (CLS), Inquiry Based Learning (IBL) and Conventional Method

Table 1 reveals that the students taught chemistry using CLS has gained mean achievement score of 36.19, and those taught using IBL has gained mean 27.82 while those taught using conventional method has gained mean of 19.13.

| Gender | N | Pretest Mean | Pretest SD | Posttest Mean | Posttest SD | Gained Mean |
|--------|----|--------------|------------|---------------|-------------|-------------|
| Male | 16 | 36.87 | 10.15 | 68.13 | 7.72 | 31.26 |
| Female | 26 | 33.65 | 9.44 | 72.88 | 6.95 | 39.23 |

Table 2: Pretest and Posttest Mean Achievement Scores of Male and Female Students taught Chemistry using CLS

Table 2 indicates that male students taught chemistry using CLS have gained mean score of 31.26 while female students have gained mean score of 39.23.

| Gender | N | Pretest Mean | Pretest SD | Posttest Mean | Posttest SD | Gained Mean |
|--------|----|--------------|------------|---------------|-------------|-------------|
| Male | 26 | 39.00 | 9.90 | 61.20 | 11.39 | 22.20 |
| Female | 25 | 28.44 | 12.61 | 58.75 | 14.89 | 30.31 |

Table 3: Pretest and Posttest Mean Achievement Scores of Male and Female Students taught Chemistry using IBL

Table 3 reveals that the male students taught chemistry using IBL has gained mean achievement score of 22.20 while the female students had gained mean of 30.31.

| Source of variation | SS | Df | MS | F | P-value | Decision |
|---------------------|-----------------------|-----|-----------|---------|---------|----------|
| Corrected Model | 8864.626 ^a | 3 | 2954.875 | 30.172 | .000 | |
| Intercept | 38103.251 | 1 | 38103.251 | 389.073 | .000 | |
| Pretest | 279.648 | 1 | 279.648 | 2.855 | .094 | |
| Methods | 8103.826 | 2 | 4051.913 | 41.374 | .000 | Sig |
| Error | 11654.073 | 119 | 97.933 | | | |
| Total | 475400.000 | 123 | | | | |
| Corrected Total | 20518.699 | 122 | | | | |

Table 4: ANCOVA on Difference between the Mean Achievement Scores of Students taught Chemistry using CLS, IBL and Conventional Method

Table 4 shows that at 0.05 level of significance, 1df numerator and 122 df denominator, the calculated F is 41.374 with Pvalue of 0.00 which is less than 0.05. Therefore, the null hypothesis is rejected. Thus, there is a significant difference between the mean achievement scores of students taught chemistry using cooperative learning strategy (CLS), inquiry based learning (IBL) and conventional method.

| (I) Method | (J) Method | Mean Difference (I-J) | Std. Error | Sig. ^b | 95% Confidence Interval for Difference ^b | |
|---------------|---------------|-----------------------------|---------------|-------------------|---|----------------|
| | | | | | Lower Bound | Upper Bound |
| CLS | IBL | 10.827* | 2.173 | .000 | 6.525 | 15.129 |
| | CM | 19.989* | 2.203 | .000 | 15.627 | 24.352 |
| IBL | CLS | -10.827* | 2.173 | .000 | -15.129 | -6.525 |
| | CM | 9.162* | 2.216 | .000 | 4.775 | 13.550 |
| CM | CLS | -19.989* | 2.203 | .000 | -24.352 | -15.627 |
| | IBL | -9.162* | 2.216 | .000 | -13.550 | -4.775 |

Table 5: Scheffe PostHoc on Significant Difference Between CLS, IBL and Conventional Method Groups

Table 5 reveals that significant difference exists between the mean achievement scores of students taught chemistry using CLS and IBL in favour of IBL. Table 5 also reveals that a significant difference exists between the mean achievement scores of students taught chemistry using CLS and conventional method in favour of CLS. Table 5 further shows that there is significant difference between the mean achievement scores of students taught using IBL and CM in favour of IBL. This shows that there is a significant difference between the mean achievement of the three groups in favour of CLS first and followed by IBL.

| Source of variation | SS | Df | MS | F | P-value | Decision |
|---------------------|----------------------|----|-----------|---------|---------|----------|
| Corrected Model | 258.213 ^a | 2 | 129.107 | 2.434 | .101 | |
| Intercept | 12708.851 | 1 | 12708.851 | 239.607 | .000 | |
| Pretest | 33.832 | 1 | 33.832 | .638 | .429 | |
| Gender | 247.329 | 1 | 247.329 | 4.663 | .037 | Sig |
| Error | 2068.572 | 39 | 53.040 | | | |
| Total | 214475.000 | 42 | | | | |
| Corrected Total | 2326.786 | 41 | | | | |

Table 6: ANCOVA on Significance of Difference between the Mean Achievement Scores of Male and Female Students taught Chemistry using CLS

Table 6 shows that at 0.05 level of significance, 1df numerator and 41 df denominator, the calculated F is 4.663 with Pvalue of 0.037 which is less than 0.05. Therefore, the null hypothesis is rejected. Thus, there is a significant difference between the mean achievement scores of male and female students taught chemistry using CLS in favour of the females.

| Source of variation | SS | Df | MS | F | P-value | Decision |
|---------------------|----------------------|----|-----------|--------|---------|----------|
| Corrected Model | 122.144 ^a | 2 | 61.072 | .364 | .697 | |
| Intercept | 11831.725 | 1 | 11831.725 | 70.522 | .000 | |
| Pretest | 63.583 | 1 | 63.583 | .379 | .542 | |
| Gender | 11.926 | 1 | 11.926 | .071 | .791 | NS |
| Error | 6375.417 | 38 | 167.774 | | | |
| Total | 155300.000 | 41 | | | | |
| Corrected Total | 6497.561 | 40 | | | | |

Table 7: ANCOVA on Significance of Difference between the Mean Achievement Scores of Male and Female Students taught Chemistry using IBL

Table 7 shows that at 0.05 level of significance, 1df numerator and 40df denominator, the calculated F is 0.071 with Pvalue of 0.791 which is greater than 0.05. Therefore, the null hypothesis is not rejected. Thus, there is no significant difference between the mean achievement scores of male and female students taught chemistry using IBL.

IV. DISCUSSION

The study revealed that students taught chemistry using cooperative learning strategy had significant higher achievement score than those taught using inquiry based learning and those taught using conventional method. This finding of the study could be as a result of the interaction among students and teachers, interaction between students and their class mates and interaction between students and the learning material. Cooperative learning is centered on collaboration between among students and between them and their teacher. Such collaboration results in peer learning, given more students the opportunity of learning what they could not understand on their own from their peers in the same classroom. In cooperative learning, it is the task of the group to ensure that all group members learn and understand the concept. Thus, majority of the students must have gained from such interaction and boosted their achievements.

The finding of the study is in line with the findings of Sahin (2010) that there was significant difference between the mean achievement scores of students in the experimental taught using cooperative learning and control group in favour of the experimental group. The finding of the study also supports the findings of Durukan (2011) that the students in the experimental group taught using cooperative learning produced a higher level of achievement in home economics than those in the control group. The finding of the study confirms the findings of Van (2014) that Cooperative learning was more efficacious than the peer-teaching in enhancing students' achievement and interest in difficult chemistry concepts.

The findings of the study further showed that inquiry based learning is more effective in enhancing students' achievement in chemistry than conventional method. This could be because inquiry based learning give students the opportunity to take responsibility for their own learning. In taking responsibility for their learning, students become active participants in the learning process and discover new knowledge by themselves. The discovery of new knowledge by students provides sufficient motivation to discover more resulting in further inquiry and increased activeness in the learning process. This endeavor could have resulted in the higher achievement scores of students in IBL group than the students in the conventional method group.

The finding of the study is supported by the findings of Longo (2012) that Students in the IBL group scored higher than students in the traditional group on the academic achievement posttest. The findings of Duran and Dokme (2016) that students who were instructed through inquiry-based learning achieved higher than those who were instructed through the traditional method is in line with the findings of the present study.

The findings of the study revealed that male and female students taught with CLS differed significantly in favour of the females, but no significant difference was observed between the mean achievement scores of male and female students taught using IBL. The observation in favour of females could be explained by the fact that female students by nature prefer working in groups. Thus, cooperative learning strategy must have favoured their interaction within groups thereby improving achievement. In addition, no significant interaction effects of teaching methods and gender was observed on the achievement scores of students in chemistry. The finding on CLS supports that of Nwanze (2016) that there are significant differences in the mean achievement of secondary school students in social studies based on gender. The finding of the study on IBL is in line with the findings of Pius (2018) and Izuegbunam (2018) that there was no significant difference in academic achievement of male and female students in basic science at the pre-test, post-test, and delayed post-test levels respectively.

V. CONCLUSION

It can be concluded from the findings of the study that cooperative learning strategy is more effective than inquiry based learning and conventional method in enhancing students' achievement in chemistry. However, inquiry based learning is more effective than conventional method in boosting students' achievement in chemistry.

VI. RECOMMENDATIONS

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

- ✓ Chemistry teachers should adopt the use of cooperative learning strategy and inquiry-based learning in the learning process of chemistry for secondary school students.
- ✓ Seminars and workshops should be organized by state ministry of education for chemistry teachers on how to use cooperative and inquiry based learning strategies in teaching chemistry to secondary school students.

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