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Using group learning strategies to enhance students' understanding of selected chemical concepts in science: Evidence from Bagabaga College of Education, Tamale

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ABSTRACT

The pre-test, post-test small group control experiment with an element of descriptive survey study was used to examine the effects of group learning on college students' understanding of chemical concepts in science. The study was conducted at Bagabaga College of Education, Tamale. A total of 102 first-year students were used for the study. Test and survey questionnaire were the main instruments used for the study. Data obtained were analysed using a t-test to determine if there were statistically significant differences between the experimental and control groups in terms of performance and retention at the 0.05 confidence level. The t-test analysis of the results showed that there was no significant difference between the control and experimental groups in terms of performance in the pre-test but, there was a significant difference between the two groups in the post-test in favour of the experimental group after the treatment.

Keywords— *Group learning, Cooperative learning, Collaborative learning, Chemical concepts achievement pre-test, Chemical concepts achievement posttest.*

1. INTRODUCTION

Group learning, as an instructional approach, has been given different names by various researchers, all depending on the style and approach to it. While some call it "collaborative learning' in a broader sense to mean all formal and informal activities which involve peer student interaction, others call it "cooperative learning", referring to a form of student group interaction that fosters positive interdependence, individual accountability, interpersonal and small group skills, and group processing of activities through verification of information accuracy [1].

According to [2], cooperative learning is group learning activity organized in such a way that learning is based on the socially structured change of information between learners in groups in which each learner is held accountable for her or his own learning and is motivated to increase the learning of others. [3] Saw small group cooperative learning as a classroom environment where students interact with one another in small groups while working together on an academic task to attain a common goal. In cooperative groups, goals can be achieved by all or most group members, whilst in competitive groups, goals can be achieved by some but not all [4]. Comparing the two groups, Deutsch observed greater coordination of effort, obligation to participate, attentiveness to group members, diversity of contribution, sub-division of labour, understanding of communication, the pressure to achieve, productivity per unit time, orientation and orderliness in the cooperative group.

David Johnson and Robert Johnson explained that, in competition, there is "a win-lose struggle" to see who is best and reach their goals only if those against whom they are competing do not, whilst in-group cooperation, members help each other master assigned material, and students reach their goals only if the others in their group also reach theirs, and with individualistic learning, students learn independently, and the achievement of goals is unrelated to the success or failure of others [5]. Cooperative learning as "small groups of learners working together as a team to solve a problem, complete a task or accomplish a common goal" [6]. In cooperative situations, individuals seek outcomes that are beneficial to all other group members (ibid).

2. STATEMENT OF THE PROBLEM

Bagabaga College of Education trains science, mathematics, English and social studies teachers, as well as specialized technical and French teachers for the Primary and Junior High School levels. By the academic structure, all students study science, except those studying French. The technical students are selected based on the strength of their mathematics and science grades from the senior high school while the social studies classes are selected including those with simple passes in mathematics and science. As a result, students in the social studies classes are generally weak in science, especially, in chemistry-related areas. For a period of six years, the continuous assessment marks of the students have consistently

not been encouraging and this has reflected in their end of semester examination results. Students generally complain that science, especially chemistry, is difficult to learn and this has been an institutional concern which the college authorities have bemoaned over the years.

Chemistry is a highly conceptual discipline which requires an ability to deal with symbolic representations at all levels. However, its core concepts are essential for the understanding of almost every aspect of science [7]. Thus, the aim and professional obligation of a chemistry teacher are to make the subject accessible in such a way that maximum meaningful learning can take place. Therefore, the burning question that seeks empirical investigation to find out whether there is any difference between the pre-test and post-test mean scores of students taught in the group learning method.

This study, therefore, sought to examine the effectiveness of group learning on students' academic performance in colleges of education. The specific objectives of the study were to *1)* determine the effectiveness of group learning on first-year colleges of education students' understanding of some selected chemical concepts in science, and 2) examine the attitudes of students toward learning of chemistry before and after using group learning.

3. LITERATURE REVIEW

There is a growing interest in group learning techniques in college courses, particularly in science and engineering [8]. [9] Reported that group learning had a positive impact on student retention and student performance in general chemistry. Cooperative Learning (CL) in chemistry is feasible and desirable because it increases the time students spend studying and encourages students to help each other to learn [8].

According to [10], group learning helps students build a feeling of community in the classroom and fosters a warmer classroom climate, which promotes learning and achievement. Cooperative learning activities encourage students to engage in the type of discourse about concepts and problem solving that moves them away from rote learning strategies and toward more meaningful learning strategies. Students strive to understand different ways of explaining concepts and different perspectives on solving problems.

There are many factors supporting the use of group learning in higher education [11, 12]. Cooperative learning also provides a sound basis for developing mutual respect, interpersonal communication, conflict resolution, and group decision-making skills required for success in students' future careers and lives [13, 11). Many techniques for cooperative learning have been utilized in teaching chemistry in higher education. [13] Conducted an experimental study to test the effectiveness of a cooperative learning technique termed "Jigsaw" in a laboratory course. This technique involves a "division of tasks so that each student in a group is assigned a particular part of a lesson or unit and acts as a resource, helping the other members of the group learn that section of the material" (P: 413). The results established that students in the experimental group engaged in cooperative learning had significantly higher grades than students in the control group.

[14] Used cooperative learning in problem-solving focused on concepts in chemistry. They found that students who engaged in conceptual tasks in cooperative learning had a lower proportion of misconceptions than students in the control group. Deeply examining students' verbal behaviours when they were studying in small groups, Basili and Sanford indicated that students in the group with more interaction and mutual help made more conceptual changes than students in groups with less interaction. Also,

[15] Applied team learning (group learning) to cover the course content in an organic chemistry course. Their finding showed that students who studied within a team learning environment had significantly higher mean scores in the final exam than students who had been taught by the lecture method in three prior years. They noticed that in the team learning method, the course content was covered much more than in the lecture method. Students in the study reported that team learning was an effective way to learn organic chemistry; team learning built better relationships among students than the lecture method, and they felt responsible for their learning and team tasks.

In contrast with Wright's work, [16] devoted time for small group discussions and presentations in a graduate physical chemistry course and found out that cooperative learning moved students from rote learning strategies towards more meaningful learning strategies involving active learning and integrated thinking. Students in the study reported that they spent more time studying and studied more frequently and that they had opportunities to develop their communication skills and build better relationships with peers through cooperative learning.

Generally, the effectiveness of cooperative learning in higher education in chemistry was found to be similar to applications of cooperative learning techniques in elementary and secondary schools. However, cooperative learning in higher education has appeared differently from the strategies used in elementary and secondary schools. While group scores or group rewards based on individual performances were emphasized in cooperative learning in elementary and secondary schools, group work in higher education required more individual accountability. In the five reports concerning chemistry education cited above, [17] used group projects in which each group handed in a single report and was scored as a group, while [13] used the average score of the group members to build interdependence among members in the group. The others either did not give a grade for group learning [16] or used peer grading processes [14, 15] in which members in the group scored each other on preparation tasks and helpful behaviors to stimulate students learning and mutual help among group members.

4. MATERIALS AND METHOD

An experimental descriptive survey design was adopted for this study. The experimental design was considered because it was the best design to establish the true effect of group learning on students' understanding and retention of chemical concepts in science since its central aim is to establish cause and effect. The population for the study was first year students at Bagabaga College of Education studying integrated science. Two first year classes, C (experimental group) and D (control group) containing 50 and 52 students, respectively were selected through purposive sampling method for the study. The purposive sampling method was used because of the fact that the students in those classes generally performed below their counterparts in the other classes.

Two main instruments were used for data collection. These included test and survey questionnaire. The test instrument consisted of Chemical Concepts Achievement Pre-test and

Chemical Concepts Achievement Posttest. The test items for the pre- and post-tests consisted of 40 selected chemical concept-oriented questions drawn from the Foundation Development Course (FDC 114) examinations past papers set by the Institute of Education, the University of Cape Coast for the past three years. The test items were closed multiple-choice test items and short-answered subjective type items. A 5-point Likert-scale style survey questionnaire, consisting of 24 items ranging from strongly agree to strongly disagree was used to examine the views and attitudes of the students before and after using group learning. These were called Chemical Concepts Pre-Attitude Test and Chemical Concepts Post-Attitude Test, respectively.

4.1 The Intervention

The author was the teacher in this exercise. The normal class session was used. Each class had four credit hours in a week for science, two for biology and two for chemistry. To have enough time, there was a negotiation with colleagues in the department to use three credit hours out of the four, which they agreed. To establish the bases of the students, the teacher taught both the control and experimental groups some selected topics, namely elements; atomic structure; electronic configuration and isotopes, during the first and second weeks without any group work. The two groups were then made to write a test which consisted of 25 multiple-choice and 15 fill-in type items. These were scored and used as the pre-test scores for the study.

4.2 Treatment

The author used the Student Team Achievement Division model which was developed by [18] in Formal Cooperative Learning Groups, which last from one class period to several weeks [19]. Group learning using STAD consists of a regular circle of instructional activities such as presentation of the lesson, students work on worksheets in their groups to master assigned materials, students take individual quizzes, team scores are computed based on group members' improvement scores and high scoring groups are recognized in class. The experimental group was assigned to 10 heterogeneous groups of 5 by the teacher. The groups were formed randomly by assigning numbers 1-10 to each roll. The ones, twos, threes, etc. were allowed to form groups. This was done to satisfy the heterogeneity principle of the groups. The lesson then proceeded in the following steps:

- The teacher presented the lesson using a direct teaching approach
- The teacher provided the students with copies of the worksheet which was previously developed by the teacher as guided discovery
- The students started working on the worksheets while the teacher moved round and watched the social skills, level of cooperation, level of interaction and participation.
- The teacher guided the students throughout the exercise
- The students were given the assignment to do individually
- The individual scores were computed and the average scores taken as group scores. Performing groups were acknowledged in class.

In each of these lessons, at least 2hour 20minutes of the three credit hours was used for small group discussion, sharing and solving of problems in the experimental class. Also, some group assignments were given to students to do after classes. These were, however, excluded in the control class. The researcher monitored the students' involvement in the group activities and asked them to encourage and help one another to understand what the group was doing. The students were made to understand that both their individual and groups scores were to contribute to their Continuous Assessment marks and this made them serious with whatever they were doing. Also, for every group activity, the average of individual scores in a group was computed and used as a single score for all. After the last lesson in the 5th week, an achievement test (post-test), consisting of 25 multiple-choice items and 15 fill-in questions covering the treated topics was conducted for the two groups. After 4 weeks of the intervention, the same post-test was administered to the two groups to measure the level of retention of learnt chemical concepts.

4.3 Data collection procedure

A pre-test was administered to both the control and experimental groups before treatment. The rationale was to find out the level of students' understanding of the chemical concepts before the intervention. The experimental group was taught for a period of five weeks using group learning approach, while their control group counterparts were taught without group learning. After the treatment, a post-test was administered to the two groups. The purpose of this test was to determine the achievement of the two groups. The test consisted of 25 multiple choice test items and 15 fill-in type items. All the items were based on the selected first year, first semester chemistry topics that were taught. The same post-test was administered after four weeks as a surprise test to measure the retention of both the control and experimental groups. To minimize the "Hawthorne effect" (pretense and self-adjustment) as much as possible, a tutor from the English Department of Bagabaga College of Education was made to administer the questionnaires. The questionnaires were meant to assess the students' attitude toward teamwork, understanding of the course, perception about chemistry after been taught using group learning as an instructional method and their level of co-operation.

4.4 Data analysis procedure

Mean scores and standard deviations were determined from the pre-test, post-test, and retention-test. Paired t-test for dependent samples was used to investigate any differences that existed between the experimental and control groups in performance and retention at a confidence level of 0.05. Most behavioural scientists agree that alpha significant level of 0.05 is reasonable to be used in research [20].

5. RESULTS AND DISCUSSION

Table 1 shows the paired t-test for dependent samples analysis. The mean score for the control group pre-test was 55.21 (SD = 9.81) while the mean score for the experimental group was 55.10(SD = 10.03). The mean score of the pre-test in the control group was slightly higher than that of the experimental group before the intervention. However, the post-test results showed that the mean score for the control group was 59.40 (SD = 12.06), while the mean score in the experimental group was 75.40 (SD = 12.06). Clearly, the experimental group did better than the control group after the intervention.

The t-test for independent samples was used to determine whether differences between the two groups were significant. The t-test analysis of the pre-test means scores of both groups showed no significant difference between the two groups at t = 0.08($t_{0.05}$ =1.984) and p=0.938 (p> 0.05) (Table 1). This showed that there was no significant difference in performance between the two groups before the study and that the two groups were comparable on their initial level of understanding of chemical concepts. However, there was a significant

difference between the mean scores of both groups in the post-test. The t-test analysis of the mean scores gave t = -9.48 ($t_{0.05}$ =1.984) and p=7.359×10^{-18}(p < 0.05) at 0.05 significant level (Table 1).This indicates that the experimental group, after the intervention, had improved upon their understanding of chemical concepts better than the control group. The statistical significance of the differences in performance between the two groups was attributed to the use of group learning. This means that the two groups were comparable on their initial level of understanding of chemical concepts. However, the analysis of the post-test mean scores for both groups showed a significant difference in favour of the experimental group. This indicates that the experimental group, after the intervention, had improved upon their understanding of chemical concepts better than the control group. This agreed with an experimental study conducted by [13] to test the effectiveness of a cooperative learning technique termed "Jigsaw" in a laboratory course. The results established that students in the experimental group engaged in cooperative learning had significantly higher grades than students in the control group. Also, [14] used cooperative learning in problem solving with a focus on concepts in chemistry, found that students who engaged in conceptual tasks in cooperative learning had a lower proportion of misconceptions than the students in the control group.[15] conducted similar study by applying team learning (group learning) to cover the course content in an organic chemistry course and their finding showed that students who studied within team learning environment had significantly higher mean scores in the final exam than students who had been taught by the lecture method in three prior years.

Table 1: Paired t-test for dependent samples analysis according to pre- and post-tests scores of both control and experimental groups

Groups Compared	Test	Mean Test Scores	Standard Deviation	t-Value	p-Value
Control	Pre-test	55.21	9.81	0.08	0.938
Experimental	Pre-test	55.10	10.03		*
Control	Post-test	59.40	12.06	-9.48	7.359×10^{-18}∞
Experimental	Post-test	75.40	12.06		

** = p > 0.05. ∞ = p < 0.05*

Table 2 presents t-test for dependent samples analysis according to pre-and post-attitude tests scores of the experimental group. The analysis showed that there was a statistically significant difference between the two test scores at t= -16.71($t_{0.05}$= 1.984) and p =2.33788×10^{-14} (p<0.05). This implies that the use of the group learning to teach the chemical concepts showed positive change with regard to the attitude of the students towards the learning of chemical concepts after the intervention. It was therefore concluded that the use of group learning resulted in the positive change of the students' attitudes towards the learning of chemical concepts.

[21] Defined "student involvement" as "the amount of physical and psychological energy that the student devotes to the academic experience". He said the amount that a student learns and develops as a result of an academic program is directly related to the quality and quantity of involvement that the student has invested in the program. According to him, the effectiveness of any educational policy or program lies in its ability to increase the level of student involvement in the learning process. Astin, therefore, recommended that students be given more opportunity for group learning activities that would increase their involvement with faculty and peers inside and outside the classroom [22]. Thus, his recommendation agrees with the results obtained above.

Table 2: Paired t-test for dependent samples analysis according to pre- and post-attitude tests scores of the experimental group

Groups Compared	Test	Mean Test Scores	Standard Deviation	t-Value	p-Value
Exp.	Pre-Att. test	92.08	20.10	-	$2.337\,88\times10^{-14}$∞
Exp.	Post-Att. test	136.54	16.93	16.71	

∞ = significant at 0.05 (p<0.05); $t_{0.05}$*=2.07*

6. CONCLUSION

Overall, the findings of the research showed that the effects of group learning on students' understanding of chemical concepts were positive. The findings showed that group work is effective in improving students' understanding of chemical concepts in science, promotes better retention of chemical concepts and develops positive attitudes of students towards the learning of chemistry. Difficult materials and concepts can be taught and learned effectively in groups. Group work helped the students to learn and care about others. Teamwork helped the students to feel less stressful and motivated them to work harder to score points for themselves and for their teammates. There was mutual liking, better communication, high acceptance, and support, as well as demonstrated increase in a variety of thinking strategies among individuals in the group. Within groups, there was a negotiation of meaning, which resulted in the superior product. Based on the outcome of the study and conclusion drew, it is appropriate to organize some in-service training for tutors on how to use group learning in the classroom.

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