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The Influence Of Cooperative Learning Approach On Senior High School Students' Understanding Of Ionic Bonding In Integrated Science: The Case At Adeiso Presby Senior High School.

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ABSTRACT
The main purpose of this study was to examine the influence of cooperative learning approach on senior high school students' understanding of ionic bonding in integrated science. The investigation was carried out in Adeiso Presby Senior High School in the Eastern Region of Ghana. The study involved two intact form 2 classes of 85 students and 1 chemistry teacher in the Senior High School. Developmental approach was used in this study. Ionic bonding achievement pretest was administered to the study sample students. The class which obtained higher mean score of 13.52 was designated as control group and the class which obtained lower mean score of 12.35 was designated the experimental group. The prototypes for cooperative learning approach in teaching and learning of ionic bond were developed through four stages before they were implemented in the class of the experimental group. An interactive workshop was organised to discuss the developed prototype materials with the chemistry teacher. The possible advantages and challenges were discussed. During the classroom implementation stage, the teacher taught the experimental group about ionic bonding using the cooperative learning strategy for five weeks. The same teacher taught the control group about ionic bonding using the traditional teaching method. Quantitative data gathering procedures were used to obtain data for the study. The quantitative data involved a pretest and a posttest ionic bonding achievement test items which were reviewed by two chemistry lecturers of the University of Education and one SHS chemistry teacher. The reliability of the pretest and posttest ionic bonding achievement test items was determined after a pilot study, using cronbach alpha. The reliability for the pretest and posttest ionic bonding achievement items was 0.78 and 0.79 respectively. Independent one–tail t-test analysis was performed on both groups. The findings from the study indicated that the experimental group performed better than the control group in the posttest as a result of the cooperative learning strategy applied in teaching the experimental group. Again, the findings showed that the various heterogeneous groupings of mixed ability in the experimental group contributed significantly to the improvement in their performance in the posttest after the implementation of the cooperative learning technique. It is recommended that cooperative learning strategy should be incorporated into the science education curriculum
Keywords: Cooperative learning approach, ionic bonding, developmental approach, prototype.

INTRODUCTION

In the developing world, improvement in the quality of education is increasingly considered a priority, especially in science subjects, because of their perceived potential to provide a foundation for scientific and technological development (Motswiri, 2004). In Ghana, many initiatives have been instituted to boost the teaching and learning of science by successive governments such as building of

more schools, provision of science resource centres in the various districts, training of science teachers by various universities and colleges. However, some of the schools lack material resources such as textbooks, laboratories, and equipment. Combining these challenges with large class sizes, limit the possibilities for group work activities and practical work. These two elements are considered to be central to more learner-centred approaches in science education (Motswiri, 2004). In Ghana, the instructional method of teaching science is teacher-centred which does not encourage critical thinking and problem solving by students (Anamuah-Mensah, 2008). According to Hutchison (2009), the method of instruction for the majority of science teachers in Ghana is the lecture approaches; delivering knowledge, as it were, into "empty, but willing vessels." This situation contributes to the poor understanding of students in scientific concepts like ionic binding. To address this instructional dilemma, teachers need to elicit students' ideas and then allow the students to test their ideas against scientific knowledge and thereby construct their own understanding. Students' personal understandings of chemical concepts must be systematically exposed in a supportive environment so that such a procedure gets students to compare their conceptions with their peers as well as the experts (Ebenezer, 2001). When students make their ideas public and work as a community of inquirers, then they would be aware of and respect each other's thinking (Miller & Hunn, 2001). Students would be able to discuss and resolve opposing views based on their conceptions. Then students would be encouraged to ask further questions, reflect on their beliefs, and assess new information. The questions students ask would reveal more of their understanding. Thus, learning involves knowledge that needs to be restructured, adapted, and rejected and even discarded (Duschl & Osborne, 2002). It is expected that teachers use learner-centred approaches like cooperative learning to enhance better understanding of scientific concepts. In Ghana, one of the foundation principles of the educational reform is emphasis on active learning rather than passive learning by students (Anamuah-Mensah, 2008). Thus, with this idea in view students should be engaged in more learner-centred instructional strategy such as cooperative learning, discovery learning, problem-based learning, and inquiry-based learning.

Research on cooperative learning over the past decades has documented academic and social benefits that students derive when they work together (Gillies & Boyle, 2010). According to Shimazoe and Aldrich (2010),cooperative learning promotes deep learning, improves academic achievement, social skills and higher-order critical thinking skills, and develops positive attitudes toward autonomous learning. The findings can be generalised to affect Ghanaian situation only after a considerable investigation has been carried out. It is therefore desirable to find out the influence of cooperative learning on students understanding of ionic bonding in the Ghanaian Context.

Purpose of the Study

The main purpose of this study was to investigate, at Adeiso Presby Senior High School, the influence of cooperative learning approach on the performance of senior high school students in ionic bonding.

Research Question

The following research question guided the study

To what extent does cooperative learning help to improve understanding of ionic bonding by students at Adeiso Presby Senior High School?

REVIEW OF RELATED LITERATURE

Tarim and Akdeniz (2008) reported that cooperative learning method results in higher achievement than the traditional method of instruction**.** In the view of Slavin (2013) well-structured methods such as cooperative learning produce more positive effect sizes than those evaluating other instructional practices such as the use of innovative curriculum text books or the use of technology in reading and mathematics. Johnson, Johnson, Roseth and Shin (2014) found that situations characterized by positive interdependence as in cooperative learning resulted in greater motivation and achievement than did negative or no interdependence situations.

Evidence from synthesis of elementary science programs by Slavin, Lake, Hanley, and Thurston (2014) indicated that science teaching methods which focused on enhancing teachers classroom instruction throughout the year, such as cooperative learning have significant potential to improve science learning". In short, there is overwhelming evidence that cooperative learning as a pedagogical practice has had a profound effect on student learning and socialisation (Slavin, 2014). According to Gocer (2010), students are to be aware of the fact that they should work so as to maximize the

learning levels of not only themselves but also that of their peers. In cooperative learning, peers assist each other's learning and establish proper communication among them. Students with different culture, experiences, and learning modes get together to achieve success towards a common goal by assuming the responsibility of each other's progress. Odagboyi (2015) noted that classroom groups with supportive friendship patterns enhance academic learning, while interpersonally tense classroom environment in which peer group rejection are strong and frequent, get in the way of learning. Cooperative learning help satisfy many psychological conditions of man. Each individual member of the team works until each member of the team fully understands and completes the assignment (Adams, 2013). In the view of Mills (2003), there is evidence that high achieving students often dislike group work due to their dependence on others to obtain marks.

METHODOLOGY

Research Design

The study adopted a developmental research approach in developing cooperative learning strategy for teaching ionic bonding to SHS form two students. In this design, prototypes were developed through four stages before implementation in the classroom. Overview of the design specifications that was adapted from (Ottevanger, 2001) and (Motswiri, 2004) to develop the prototypes of lesson plans in the cooperative learning study is provided below.

Lesson preparation

- Description of what the lesson looks like to exemplify what change was expected.
- Objectives of the lesson should be specific, time-bound, measurable and achievable learning outcomes expected from students at the end of each lesson.
- Suggestions for possible textbooks and relevant materials for teachers and students to look out for more information on a concept.
- Suggestions for timing lesson to indicate how time could be used efficiently in each stage of the learning process.
- Possible difficulties during the lesson to provide teachers with dynamics of a learner-centred practice.
- Advice on materials required to support learner-centred procedures through problem solving.
- Concrete suggestions for the role of the teacher in supporting investigations.

Subject content

- Short explanation of the key chemical concepts in the lesson.
- Adequate and accurate notes on what students are expected to be taught and learn.
- Suggestions for possible student questions and answers.
- Suggestion to explore students' prior knowledge.

Teaching strategies

- Suggestions for sequencing of activities, including start up and finishing of the lesson.
- Suggestions on how to conduct lessons to fit in a double period.
- Suggestions for grouping students to guide teachers in using groups to promote effective learning.
- Suggestions on how to handle materials.

Monitoring student learning (learning effects)

- Suggestions on how to conduct formative assessment.
- Suggestions for marking and analysing student reports.
- Suggestions for using students feedback class-work and lesson preparation.
- Suggestions for homework.

Design and Formative Evaluation of Prototypes

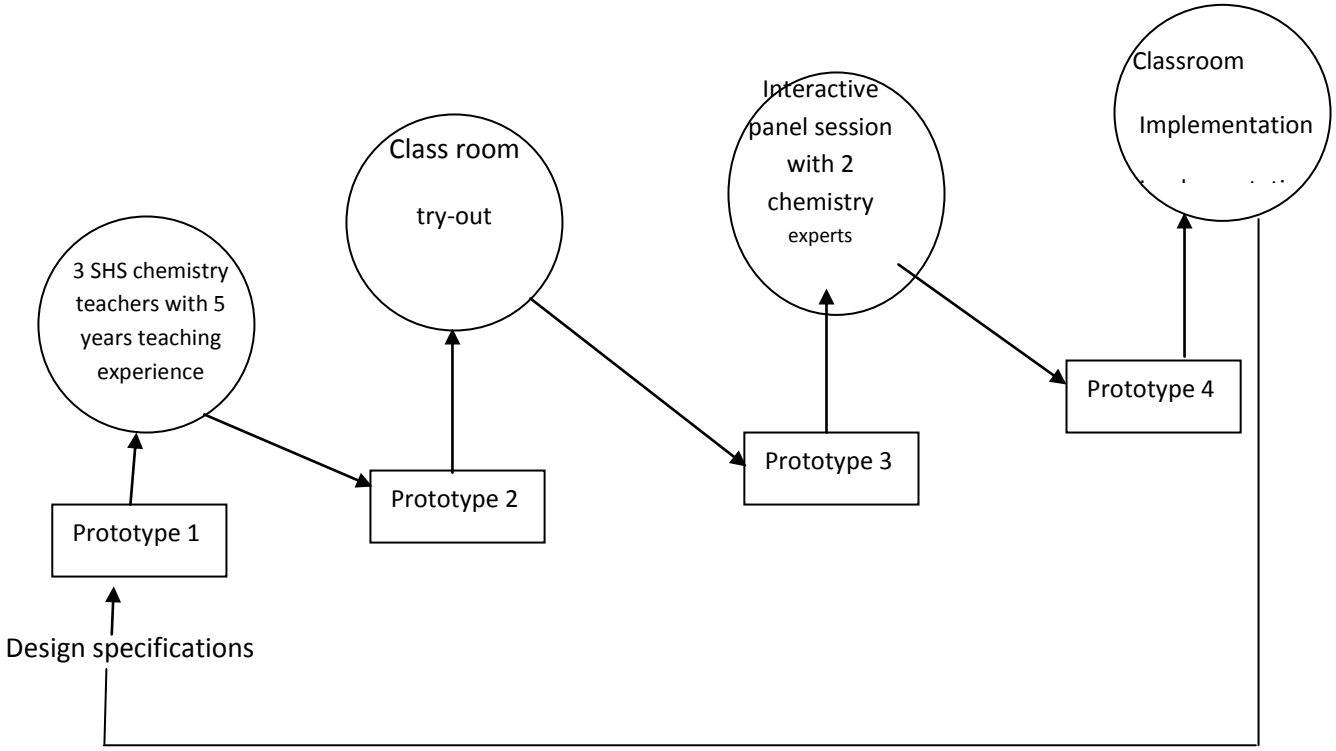

Fig 1: Developmental Design Process of the Prototypes

Research Population

The target population was students and science teachers in Adeiso Presby SHS in the West Akyem Municipality.

Sample and Sampling Technique

Eighty-five second year students and one chemistry teacher were selected from the SHS based on purposive sampling (Cohen, Manion & Morrison, 2007). The sample students were in two intact classes. Second year students were used in the research because the topic was taught in the second year in that school. Ionic Bonding Achievement Pretest was administered to all the students at the same time in their respective classrooms. The class with higher mean score formed the control group and the class with lower mean score formed the experimental group. Forty-two (42) students with a composition of 25 girls and 17boys formed the control group. The experimental group consisted of 43 students (19 boys and 24 girls). The pretest score was used to put students in the experimental group into three performers' strata, namely, high performers' stratum, average performers stratum, and low performers stratum. The criteria used to classify students have been presented in Table 1:

Table 1: Classification of Experimental Students

Pretest Score	Stratum	Number of Students
1-10	low performers	14
11-20	average performers	19
21-30	high performers	10

A stratified random sampling procedure was used to constitute the group of mixed performers' strata, which was heterogeneous in nature. Ten (10) groups, made up of 3 groups of three members, 3 groups of four members, 2 groups of five members and 2 groups of six members were formed in the experimental group. The composition of the each team in the experimental group based on performance levels is showed in Table 2.

Table 2: Composition of Experimental Groups Based on Performance Levels.

Member Group	Number of Low Performed Students	Number of Average Performed Students	Number of High Performed Students
3-member	1	1	1
4-member	1	2	1
5-member	2	2	1
6-member	2	3	1

Research Instrument

Ionic bonding achievement test was used to collect data for this study. The instrument is described below:

Ionic Bonding Achievement Test

A fourteen test item was developed to determine the understanding of ionic bonding concept by both experimental and control group students. The test items were constructed based on the content of the integrated science syllabus, which is used for all senior high schools in Ghana. Also the nature of questions asked relating to ionic bonding in integrated science and detailed instructional objectives in the textbooks were taken into consideration. The content of the test items included basic concepts related to ionic bonds and properties of ionic compounds.

The test consisted of ten multiple choice and four short-answer items. It was assumed that short-answer items would help to differentiate between students scoring well by chance on multiple choice items from those performing well as result of true understanding of the subject matter. Each of the multiple choice items had four options: one correct answer and three plausible distracters. In case of the multiple-choice, one mark was given for each correct answer for a total of 10 points. Also, each part of the short-answer items was given five marks for a total of 20 points.

Validity and Reliability of Research Instruments

The quality of a research instrument or a scientific measurement is determined by both its validity and reliability (Aikenhead, 2005). Validity seeks to determine whether the instrument actually measures what is intended to be measured. Reliability on the other hand, refers to the consistency of data when multiple measurements are gathered (Gott, Duggan & Roberts, 2008).

The ionic bonding achievement test items were reviewed by two chemistry lecturers of the University of Education, Winneba with expertise in chemistry education and one experienced SHS chemistry teacher. After incorporating the recommendations of the reviewers, the ionic bonding achievement test was pilot-tested in St Thomas SHS. The students who have studied the ionic bonding were used to get feedback on the suitability of the test items. Students completed the test in a 50-minute period. Immediately after the test, the researcher held a discussion (a think aloud session) with ten students chosen randomly from the class. The focus of the discussion was on the test's time, clarity, difficulty level of questions, and content. Students' feedbacks were used to revise the test items again.The reliability of the pretest and posttest ionic bonding achievement items was determined after a pilot study, using cronbach alpha. The reliability for the pretest and posttest ionic bonding achievement items was 0.78 and 0.79 respectively.

Ethical Considerations

The consent of the students to be involved in the study was requested. The participants in the study were assured of confidentiality. Also, there was no discrimination against students as a result of the information that was provided.

Treatment of the Experimental and Control Groups

Four days before the beginning of the treatment, the teacher was introduced to the cooperative learning approach in a one-day interactive preparatory workshop. During the workshop, the researcher introduced the teacher to the main aspects of the teacher support materials that were designed to facilitate classroom implementation of the cooperative learning approach in teaching and learning of ionic bond. The researcher and the teacher had open and frank discussions about how effective the support materials could be used to ensure positive outcomes. The potential difficulties that students may encounter as they engaged in cooperative learning activities were examined.

Prior to the beginning of the lessons on ionic bonding, students in the sampled two classes were administered the ionic bonding achievement pretest of the participating classes. The test was

supervised by the subject teacher and the researcher. The class which obtained higher mean score of 13.52 was designated as control group and the class which obtained lower mean score of 12.35 was designated as the experimental group.

The teacher used the developed cooperative learning activities about ionic bonding in teaching the experimental group. The lessons were conducted once a week and covered two periods of 40 minutes each. A possible total of five lessons involving ten periods were conducted for the experimental group and the instructional period lasted for about five weeks.

In the control group, the teacher taught the same content topic as part of the normal curriculum of integrated science using regular 'traditional' teaching approaches. The traditional approach mainly involved lecturing and question and answer methods (teacher led-questions) without activities. Students were taught two periods of 40 minutes each week. The total instructional periods lasted for about five weeks and covered ten periods.

Data Collection Procedures

The sampled students were administered the ionic bonding achievement pretest in their respective classrooms a day before the intervention strategy. The test which lasted for 30minutes was supervised by the chemistry teacher and the researcher. In order to determine students' academic achievement, an ionic bonding achievement posttest was administered at the end of the five weeks intervention strategy to both the experimental and control groups. The researcher and the chemistry teacher supervised the test which lasted for 30minutes.

Data Analysis Procedures

Data from the pretest and the posttest of ionic bonding achievement test were analyzed quantitatively. The t-test was used to investigate whether there was any significant difference between the mean score on the achievement test of the control and experimental groups in the pretest and posttest. Inter group and intra group comparison was made using t-test model for dependent data and t-test model for pooled variance. The level of significance set by the researcher was at 0.05.

RESULTS AND DISCUSSION

The achievement test scores of students in the control group in pretest and posttest are shown in Table 1.

Table 1: Frequency Distribution of the Achievement Test Scores of Students in the Control Group

Scores	1-5	6-10	11-15	16-20	21-25	26-30
Pretest	8	1	19	2	11	1
Posttest	1	5	15	9	8	4

From Table 1, for the control group, out of 42 students who took the ionic bonding achievement pretest, 14 students scored above 15. In comparison to the posttest, students did relatively better as 21 students scored above 15.The achievement test scores of students in the experimental group in pretest and posttest are shown in Table 2.

Table 2: Frequency Distribution of the Achievement Test Scores of Students in the Experimental Group

Scores	1-5	6-10	11-15	16-20	21-25	26-30
Pretest	11	3	19	0	10	0
Posttest	0	5	7	13	7	11

From Table 2, for the experimental group, as many as 33 students scored below 16 with the remaining 10 students scoring between 21 to 25 in the pretest. In the posttest, there was improvement in performance as 31 students scored above 15, 11students scored between6 to 15 and no student scored below 6. The means, standard deviations and t-test for the control and experimental groups in the pretest and posttest are presented in Table 3.

Table 3: The Comparison of Means and Standard Deviations of Pretest and Posttest for Experimental and Control Groups

Group	Test	Mean	Standard Deviations	p-value
Experimental	Pretest	12.35	7.05	
Control	Pretest	13.52	6.80	0.436[a]
Experimental	Posttest	19.67	6.36	
Control	Posttest	16.81	6.12	0.037*

a = Not Significant; p >0.05 * = Significant; p < 0.05

From Table 3, the mean for the control group was relatively higher than the mean for the experimental group in the pretest. However the independent t-test analysis of the pretest mean score showed that there was no significant difference between the mean scores of the two groups in ionic bonding achievement pretest (p > 0.05; p = 0.436). Therefore any difference in the means was by chance. This indicated that the groups were statistically the same before the intervention strategy. However, the mean test score of the experimental group was higher than their control group counterpart in the posttest. The t-test analysis of the posttest scores showed there was a significant difference in the means between the two groups (p < 0.05; p = 0.037). This means that the experimental group performed better than the control group in the posttest.

In order to determine which of the ability groups performed better, the mean score and the t-test for both pretest and posttest were calculated as shown in the Table 4 below:

Table 4: Mean Scores of Students on Pretest and Posttest by Type of Performance Level

Level	Experimental	Control	p-value
Low Performers			
Posttest	9.20	7.83	0.016*
Pretest	4.00	4.22	- 0.003*
Mean Gain	**5.20**	**3.61**	
Average Performers			
Posttest	16.50	15.25	-0.006*
Pretest	12.32	11.95	0.005*
Mean Gain	**4.18**	**3.30**	
High performers			
Posttest	26.11	24.42	0.005*
Pretest	22.20	22.42	-0.015*
Mean Gain	**3.91**	**2.00**	

* = Significant; p < 0.05

In the pretest, the low performer students within the experimental group had a lesser mean score than their counterparts in the control group. But the low performers in the experimental group made better mean score than those in the control group in the posttest. However the t-test analysis of the mean scores of the low performers on both pretest and posttest were significant (p = 0.016 and p = - 0.003).

In the pretest, the average performers in the control group had a higher mean score than their counterparts in the experimental group. The average performers in the experimental group recorded a higher mean score than their counterparts in the control group in the posttest. However the t-test analysis of the mean scores of the average performers on both pretest and posttest were significant (p = -0.006; and p = 0.005).

In the pretest, the high performers within the control group recorded higher mean score than their counterparts in experimental group. However, in the posttest, high performers in the experimental group registered higher mean score than their counterparts in the control group. The t-test analysis of the mean scores of the high performers on both pretest and posttest were significant (p = 0.005 and p = -0.015) indicating that the differences in the means were not by chance.

In the control group, the mean gains of 3.61, 3.30 and 2.00 obtained by the low performers, average performers and high performers respectively in Table 4 indicated that even though the control group

did not benefit from the intervention, there was improvement in their performance. Also, the experimental group obtained 5.20, 4.18 and 3.91 as mean gains for the low performers, average performers and high performers respectively in Table 4. However, the better performance of the experimental group than the control group might be due to the intervention strategy.

In both the experimental and control groups, the low performers made the highest mean gains. This was followed by average performers who made better mean gains than high performers. Comparative analysis of each level of performers revealed that the experimental group made mean gains which was better than that for the control group.

In order to determine whether there was variation in the performance within and between (i.e. intra and inter) groups, the F and p test for both pretest and posttest for the control group were calculated as shown in Table 5 below:

Table 5: AN0VA for Control Group

Test	Source of Variation	Mean Square	F-value	p-value
Pretest	Between groups	882.20	226.78	.000*
	Within groups	3.890		
Posttest	Between groups	618.113	80. 288	.000*
	Within groups	7.699		

* = Significant; $p < 0.05$

From Table 5, the univariate analysis of ANOVA shows there were significant differences in the mean scores of the low performers, average performers, and high performers in both the pretest and posttest of the control group ($F = 226.787$, $p = 0.000$ and $F = 80.288$, $p = 0.000$ respectively). It was realised that students in the three performer levels were statistically not equivalent before and after instruction.

In order to determine whether there was variation in the performance within and between (i.e. intra and inter) groups, the F and p test for both pretest and posttest for the experimental group were calculated as shown in Table 6 below:

Table 6: AN0VA for Experimental Group

Test	Source of Variation	Mean Square	F-value	p-value
Pretest	Between groups	982.031	322.757	.000*
	Within groups	3.043		
Posttest	Between groups	747.932	148.416	.000*
	Within groups	5.039		

* = Significant; $p < 0.05$

From Table 6 the univariate analysis of ANOVA shows there were significant differences in the mean scores of the low performers, average performers, and high performers in both the pretest and posttest of the experimental group ($F = 322.757$; $p = 0.000$ and $F= 148.416$; $p = 0.000$ respectively). It was realized that students in the three performer levels were statistically not equivalent before and after instruction.

DISCUSSION

In order to determine the influence of the intervention strategy, analysis of the data indicated that the control group had performed better than the experimental group in the pretest. However, there was significant improvement in the performance of the experimental group over the control group in the

posttest. The implication was that the experimental group benefited greatly from the intervention strategy which made them to outscore the control group in the post achievement test. The result of the study therefore confirms the findings of the study conducted by some researchers Tarim and Akdeniz (2008) reported that cooperative learning method results in higher achievement than the traditional method of instruction. Through group interactions, students get opportunities to share and exchange the ideas and give feedback to each other, as well as to make use of different perspectives and alternatives in learning (Millis, 2002). In this way, cooperative learning can contribute to an overall increase in motivation and promotion of cognitive development (Jungst, Colleti & Thompson, 2000).
In the view of Gilles (2003), co-operative learning tasks in which students assist other peers to learn through explaining topics to each other, i.e. elaborated help, have been correlated with academic achievement.
The findings therefore seem to suggest that students of the SHS exposed to small-group cooperative learning would retain significantly more scientific concepts taught than those who learnt in the whole-class approach. Students also benefit from alternative ideas which increase their cognitive development. The findings also suggest that small-group learning can be used to assist senior secondary school students to find solutions to problems in science.
In terms of the different performance levels, students in the control group surpassed the experimental group in the pre-achievement test. However, the students in each performance level in the experimental group did better than their counterparts in the control group. Analysis of variance of the scores of the pretest and posttest of students of the three performer levels shows that the control group also made some significant gain on their pretest and posttest scores just as the experimental group. However, the various categories of students based on performance in the experimental group recorded a higher mean gain.
This study confirms the findings of Goor and Schwenn (1993) that cooperative learning helps all students to make progress in the area of academics, social skills, and gives them a higher rate of acceptance in a diverse classroom. This may mean that independent of the potential of a student, there would be improvement in his or her performance when engaged in cooperative learning approach.
The comparative analysis of students in the various performance levels in the experimental group indicated that the low performers made the highest mean gain. This finding is consistent with Eshun and Abledu (1999), which pointed out those low ability students in heterogeneous small-group make the most significant gain. Also, students in the average performer level obtained a greater mean gain than those in the high performer level. This corroborates the research work of Haris and Tarwater (1996), which indicated that students with previously average achievement welcome working in small –groups as their grades improve through group effort.
The high performer students made better scores than the other students but their mean gain was the least. The reason could be that those very good students were assisting their other group members to understand and deal with the given task appropriately.
In the view of Millis (2002), there is evidence that high achieving students often dislike group work due to their dependence on others to obtain marks. On the contrary, there was no sign of resentfulness of very good students in the various groups in the study. There was willingness by the students to come to the classroom with a strong readiness to work. This commitment to work created a bonding among the students which, in turn lead to higher academic self-esteem and positive feelings towards peers and the instructor.

CONCLUSION

Odagboyi (2015) noted that classroom groups with supportive friendship patterns enhance academic learning, while interpersonally tense classroom environment in which peer group rejection are strong and frequent, get in the way of learning. The findings from the study seem to suggest that if students of Senior High Schools are exposed to cooperative learning, they may retain significantly more knowledge about ionic bonding taught in the study than those who learn in the traditional lecture approach.
The study also showed that there was improvement in achievement of the students in the three performer levels. However, students in the low performer level made the highest mean gain. This outcome agrees with the findings of Hampton and Grudnitski (1996), who conducted a study to determine whether using cooperative learning approach mean equal learning for the three ability levels namely, low ability, average ability and high ability. The results of the findings indicated

relative difference in learning for students in the three achievement levels. The low achievers benefited more than high and average achievers. The findings of the study also give credence to the research work of Eshun and Abledu (1999), that low ability students in heterogeneous teams make the most significant gain when engaged in cooperative learning .

Cooperative learning seemed to have made students understand things better. The findings are affirmed by the research outcome of Gilles (2003) that co-operative learning tasks in which students assist other peers to learn through explaining topics to each other, that is elaborated help, have been correlated with academic achievement.

RECOMMENDATIONS

In the light of the above research findings, the following recommendations have been made specifically for Adeiso Presby SHS

1. The authorities of the school should hold workshops to familiarise teachers with the theory and practice of cooperative learning in classrooms. The facilitators of such workshops should be experts in the field of cooperative learning strategy. This may help teachers see the relevance of the approach more clearly.
2. The teachers can incorporate innovative teaching methodologies like cooperative learning into the syllabus.
3. Students should be put in mixed ability groups to practice peer tuition. This is because when students explain concepts to each, they do so at their own cognitive maturity level. Their understanding of scientific concepts may be enhanced as students solve problems together.

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