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ORIGINAL ARTICLE

# The Use of Collaborative Approaches on Students' Performances in Redox Reactions

**Francis Adjei[1], Ruby Hanson[2], Arkoful Sam[2]*, Samuel Sedegah[3]**

[1]Department of Science, Winneba Senior High School, Winneba, Ghana, [2]Department of Chemistry Education, University of Education, Winneba, Ghana, [3]Presbyterian College of Education, Akropong-Akuapem, Ghana

***Corresponding Author:** arkofuls@yahoo.co.uk

## ABSTRACT

This study investigated the use of collaborative instructional approaches on form two science students' performance in redox reactions. The sample for this study consisted of 106 science students from Winneba Senior High School in Ghana. The sample was selected from two intact classes in the school. After a pre-test organized for both classes, the class with the lower average score was assigned as the experimental group and the other class assigned the control group. Interviews, questionnaires, and tests were used as the main instruments to collect data for the study. The reliability of the questionnaire, pre-test, and post-test items which were determined using Cronbach alpha ranged from 0.76 to 0.80. A collaborative learning text-oriented instruction was applied in teaching the experimental group whereas conventional approach was used in teaching the control group. It was also found that a number of the students who took part in the study had wrong notions about redox reactions. The findings showed that there was a significant difference in performance between the experimental and control groups. The experimental group performed better in the post-test than the control group. It is recommended that chemistry teachers in Ghana should employ the collaborative learning approach in teaching chemistry to enhance the students' learning.

**KEY WORDS:** Collaborative instructional approaches; collaborative learning approach; redox reactions; text-oriented instruction

## INTRODUCTION

Teacher-centered methods such as lecturing, demonstrations, memorizing, reviewing, and questioning are often used by many instructors. According to Chin (2007), these approaches do not stimulate or improve students' understanding of science. Student-centered learning methods such as collaborative learning could be used in shifting the focus of activity from teacher to the learner. Collaborative learning is based on the constructivist model in which students construct rather than receive or assimilate knowledge (Puntambekar, 2006). Constructivist learning models also require intellectual effort by students and aids in the retention of knowledge and generate interest in science. The role of the teacher in the student-centered learning is to facilitate the students' learning by providing a framework of activities for the students to complete. Constructivists believe that for higher level of cognition to occur, students must build on their own knowledge through activities that engage them in active learning (Cooperstein and Kocevar-Weindinger, 2004). Effective learning takes place when students take stock of what they already know and then move beyond it. If students construct their own framework scheme through experimenting, they are more likely to retain the facts they learn, specifically for this study in chemistry. Despite the application of redox reaction in technological development and everyday life, both students and teachers of chemistry consider the concept difficult (Udu, 2018). Studies have shown that the performance of students in redox reaction in most West Africa countries has generally and consistently been poor over the years (WAEC, 2012, 2013; Adu-Gyamfi and Ampiah, 2019).

According to Acker and Armenti (2007), the instructional method which is right for a particular lesson depends on many factors. Among these are the age and developmental levels of the students, what the students already know and what they need to know to succeed in a lesson, the subject matter content, the objective of the lesson, and class size. Other factors are time, space, materials, resources, and the physical setting. A more difficult problem is to select an instructional method that best suits one's particular teaching style and the lesson to be taught. Flores (2016) suggested that resources that assist teachers teach better are typically a lesson plan or practical activity that involves learning and acquisition of skills. Furthermore, students' working in groups is another way the teacher can organize a better constructivist lesson. Many educators seek to apply the strategies that help students collaborating to complete course work (Reigeluth, 2009). Reigeluth (2019) explained that active or participatory learning by the students within the classroom environment has been recognized as an effective, efficient, and superior instructional technique. Yet, only a few teachers in basic and senior high schools in Ghana employ this pedagogical strategy (Akyeampong and Lewin, 2002).

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Collaborative or peer learning is one of the most widely discussed teaching methods according to Marjan and Seyed (2012). According to researchers (e.g., Darling-Hammond, 2006), collaborating in learning allows students in smaller groups to work on the same task; talk among themselves and to the viewpoints of one another during discussions or assignment. Evidence from Puntambekar's (2006) research shows that collaborative learning approaches increase opportunities for learners to practice concepts they have been taught and provide opportunities for learners to be problem solvers rather than information receivers. It also provides opportunities for meaningful interactions between peers and teachers. Hence, there is the need for a study to investigate the use of collaborative instructional approaches on the academic performance of students in chemistry at Winneba Senior High School.

The objectives for this study were to (1) explore the causes of poor performance of students in redox reaction and (2) evaluate the statistical difference in academic performance between students exposed to collaborative instructional approach and those exposed to conventional instructional approach of teaching.

The study was guided by the following research questions:

- What are the main causes of students' poor performance in their study of redox reactions?
- What statistically significant differences would be observed in the performance of students exposed to collaborative instructional approach and those exposed to conventional instructional approach of teaching redox reactions?

## METHODOLOGY

The research design used in this study was quasi-experimental. In this type of design, two groups are used with one as the experimental group and the other as the control group. Both groups were evaluated with the same test item to establish their entry knowledge. The experimental and control groups underwent classroom instruction. Thus, a pre-test for both groups was then assessed again with a post-test to ascertain the impact of the treatment. Hayford (2008) clarified that this research design is potentially useful in that it controls all threats to validity and all sources of bias such as history and maturation.

Agreeing with Lee and Chwen (2017), this research design allows the researcher to compare the final post-test results between the two groups, giving the researcher an idea of the overall effectiveness of the intervention or treatment. Furthermore, it enables the researcher to find out how both groups changed from pre-test to post-test whether one, both, or neither improved over time. If the control group also showed a significant improvement, then it will permit the researcher to attempt to uncover the reasons behind this. Again, this design will enable the researcher to compare the scores in the two pre-test groups and to ensure that the randomization process was effective. These checks evaluate the efficiency of the randomization process and determine whether the group given the treatment showed a significant difference in performance. Students' informed consent and voluntary participation guaranteed their involvement in the study. This was considered by making the student participants be aware of their rights to refuse or withdraw from the study at any point in time. All the students of form two agriculture science class (2AG2) and form two science class (2SC1) in Winneba Senior High School (students age range was 16–18 years) were examined on redox reactions. This served as the pre-test. The intervention was in the form of a collaborative learning approach. Both groups of students were taught by the first author in the course of the study. The students in the experimental group were administered the treatment and those in the control group were taught using the traditional method of teaching. Students in the treatment group were taught using a collaborative learning approach in the teaching and learning process. Each student in the group was assigned a different aspect of a given learning task to perform. The solution to the task allocated to each group was arrived on consensus. Students from each group then presented their findings in turns. The researchers then summarized the major points agreed on by all members in each of the groups in the class on the marker board. This approach was adopted for a period of 3 weeks in the experimental class.

The control groups, however, were taught using the traditional method of teaching which consisted of lecturing and teacher directed discussion. After the end of the 3-week period, all the students in the two classes, 2C1 and 2AG2, were then assessed using the post-test to ascertain the impact of the collaborative learning approach.

The post-test for both the control and experimental was held at the same time in different classrooms under strict supervision. During the implementation of the intervention to the experimental group, the teacher observed the entire teaching and learning process in the class. According to Thorpe and Easterby-Smith (2012), observation offers more information which would not have been done with other methods. It also offers first-hand information without relying on reports of others. Observation is useful to determine whether or not people do what they say they do and behave in a way they claim to perform (Hayford, 2008).

The population for this study consisted of all SHS chemistry students in Winneba Senior High School in the Winneba municipality. The sample involved in the study comprised all form two (2SCI, 2AG2) chemistry students in Winneba Senior High School. Winneba Senior High School was chosen for the study because the first author teaches at the school, and he is more familiar with the school with respect to science education delivery in that school. Furthermore, for the lack of inadequate time, logistics, and funds, Winneba Senior High school was chosen for the study. It was also chosen so as to enable the researchers to benefit from teachers and students for the cooperation of the headmistress, teachers, and students for

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the research work. Finally, the researchers chose the school in question because of the willingness of the students to partake in the study during the pre-study visits to the school.

Purposive sampling technique was used to select the sample for the study. The sample for the study was selected from two 2nd year complete classes at Winneba Senior High School. One of the two classes, 2AG2 (Form Two Agriculture 2 class) was chosen as the experimental group and the other class, 2SC1 (Form Two Science 1) the control group. The total sample size was 106 students. Out of this, 50 were in the experimental group while the control group contained 56 students. The control group was made up of 23 females and 33 males, while the experimental group was made up of 20 females and 30 males. After the pre-test, which was administered to all the students at the same time in their respective classrooms, the class that obtained the lower mean mark (that is, low ability class) was chosen as the experimental group while the class that obtained the higher mean mark (that is, high ability class) was chosen as the control group. This was done to find out whether the performance of the low ability class would improve from the collaborative learning approach than the high ability class.

The instruments used for data collection in this study were observation, interview, questionnaires, and performance tests. The tests used were pre-test and post-test. Observations and tests were meant to provide reliable and inform measure, without disparities (Hayford, 2008). Observation is a collection of data to provide information when other methods are not effective. It also offers straight information without relying on the reports of others and it is relatively inexpensive to run. Observation is again appreciated in particular to discover whether people do what they claim to behave. Throughout the entire 3 weeks when the treatment was being administered, the other researchers apart from the first author, observed the behavior, responses, and contributions of students in both the control and experimental groups. This was to ascertain if there were any changes in behavior of students and also to find out the differences in attitude of students from each of the two groups. A treatment variation on the collaborative learning approach industrialized by Pinar (2012) was also accepted in the course of the treatment being administered. This was used to help determine the effectiveness of collaborative learning approach on students' behavior in class and attitude toward chemistry. The pre-test named "Base Line Survey" test was used to undertake the pre-test. It consisted of five items covering redox reactions (Appendix A). The instrument was designed by the researchers and consisted of five multiple-choice questions and one subjective answer type question. These items were critically reviewed by a subject area expert (that is, the third author). The instrument was pilot tested, and the reliability coefficient of the pre-test and post-test was calculated to be 0.78 and 0.77, respectively, using the Cronbach's alpha reliability test. All assessments were made using these items. The tests were administered twice during the study, once before the administration of the interventions and after the interventions. The purpose of the pre-test was to assess the students' prior knowledge level in the subject matter and to find out if there were any significant differences between the control and experimental groups. The post-test was aimed at assessing if a significant difference in terms of subject matter knowledge between the groups has emerged. The same questions were administered in both tests, however, the questions used for the pre-test were altered slightly in terms of arrangement and construction for the post-test (Appendix B).

The questionnaire also consisted of five items which sought the views and perceptions of students on chemistry. It was designed by the researchers and consisted of five responses ranging from strongly disagree to strongly agree. Positive worded items in the questionnaire were scored on a scale of 1–5. Negative worded questionnaire items were scored in the reverse manner. This was to ensure that all of the individual item scores lie on the same scale with regard to direction. For positive items, strongly agree was scored 5, agree was scored as 4, not certain 3, disagree 2, and strongly disagree 1. However, for negative statements, strongly agree was scored 1, agree 2, not certain 3, disagree 4, and strongly disagree 5. The mean value for each subscale was obtained.

## Validity and Reliability

The content validity of the interview schedules and questionnaire for students was ascertained by senior science educators (that is, the second and third authors) in the Department of Science Education of University of Education, Winneba, with extensive knowledge and research experience in designing instructional strategies and curriculum materials for suggestions and comments for the improvement of the items. These experts vigorously analyzed various questions items in both the interview schedule and questionnaire. This led to the correction of incorrect items.

Reliability is clarified by Cohen et al. (2017) as the extent to which a procedure produces similar results under constant conditions on all occasions. To ensure the reliability and effectiveness of the instruments used, they were pilot tested with Form Two Science students in Apam Senior High School in elective chemistry. This school is chosen because it offers the elective science program just as students at the Winneba Senior High School. Proximity was another reason why Apam Senior High School was chosen for the exercise. The internal consistency of the study was determined using the Statistical Package for the Social Sciences (SPSS), version 20 for Windows. The Cronbach's alpha coefficient of reliability was measured. The reliability coefficient of the questionnaire and tests are summarized and presented in Table 1. According

**Table 1: The reliability coefficients of the various instruments**

| Instrument | Reliability coefficient |
|---|---|
| Questionnaire | 0.80 |
| Pre-test | 0.78 |
| Post-test | 0.77 |

to Berg and Lune (2017), coefficient of reliability values above 0.75 is considered reliable. Therefore, the above reliability indices gave an indication that the instruments were substantially reliable.

The interview protocol was also piloted with the same sample used in piloting the survey. The reliability of the interview was then assessed using inter-rater reliability. The transcriptions of the audio recordings of the interviews were given to different experts to determine the inter-rater reliability of the data. These experts agreed that the interview protocol could be used to undertake the substantive study. The reliability of the interview protocol was also enhanced by the fact that the interviewer held one-no-one interview sessions with the various respondents using almost the same questions. Agreeing to Guion (2011), one-on-one interviews with standardized questions appear to have the highest reliability.

## Treatment of the Groups

### *The control group*

The control group received the conventional teaching instruction which involved lessons using lecture/discussion methods to teach redox reaction. Teaching strategies relied on teacher explanation and textbooks, with no direct consideration of the students' alternative conceptions. The students studied their handouts on their own before the class hour. The teacher structured the entire class as a unit, wrote notes on the marker board about the definition of concepts, and key points. The primary underlying principle was that knowledge resides with the teacher and that it is the teacher's responsibility to transfer that knowledge as a fact to students. The teacher described and defined the concepts and after teacher's explanation, some concepts were discussed, motivated by teacher-directed questions. The majority of instruction time (70–80%) was devoted to instruction and engaging in discussion stemming from the teacher's explanation and questions. The remaining time was spent on a worksheet study. Worksheets developed specifically for each lesson were used as practice activities; they required written responses and reinforced the concepts presented in the classroom sessions. While the students were studying worksheet exercises, the teacher circulated and provided assistance if needed. The students had the opportunity to ask questions, and the teacher was available both to answer questions and make suggestions. The worksheets were collected and corrected by the teacher, and the students received their sheets after correction. This classroom typically consisted of the teacher presenting the right way to solve problems.

### *The experimental group*

To promote change in the study of chemistry, collaborative learning model was prepared by the first and the third researchers and used with the experimental group lasting 3 teaching weeks.

### *Data collection procedure*

The first author obtained an introductory letter from the Head of Science Education Department of the University of Education, Winneba, and used it to obtain permission from the Municipal and Directors of Education to administer the instruments in the selected schools. The researchers sought permission from the headmistress to undertake the study. Permission was also sought from the teachers of the selected classes. The first visit was used to establish rapport with the students and to solicit their participation in the study and to select a date for administering of the instruments. In the 1$^{st}$ week, the questionnaire and the pre-test were administered to the students in their respective classrooms by the first author. This was done during their chemistry periods and the responses were collected immediately to ensure 100% collection.

The redox reaction pre-test was administered by the first author to both intact classes during the chemistry period of each class which lasted for 20 min to determine each student's level of performance in the topic before the start of intervention. Based on the mean performance of students out of a maximum score of 30 marks, the experimental and control groups were designated. The class which obtained higher mean mark was designated the control group and one with the lower mean mark was designated experimental group. This was done to find out whether the performance of the class of lower ability might improve much more from collaborative learning approach instructions than the class of high ability.

After the administration of the pre-test, a collaborative learning model was prepared, and the experimental group was taught the redox reaction by the researcher using the collaborative learning model whilst the control group was taught the same topic using the conventional (traditional) method of teaching. Each class was taught for 3 weeks. Each classroom instruction was four periods of 60 min each per week (that is, 240 min of contact per week in each class). After 3 weeks of instruction, post-tests of comparable standards as the pre-tests were administered to the entire students in their respective classrooms. The test lasted for 20 min. This was done to compare the performance of the students in the two groups after the instructional period. After the administration of the post-test in the last week, a 15 min interview was also conducted with 10 students from the treatment group to find out their views and perceptions about the collaborative learning model. The interviewees were assured of confidentiality and given code names to prevent the exposure of their identities. Before each interview session, the interviewees and the researcher agreed on the time and venue of interview. The permission of each interview was also sought before the interview sessions were recorded.

### *Data analysis procedure*

Both qualitative and quantitative methods of data analysis were employed by the researchers for analysis of data collected. Data from the interview sessions were analyzed qualitatively while the data from students' questionnaire and the test was analyzed quantitatively. Analyses of the results obtained from the study were carried out in three phases. The statistical analyses of the tests (that is, pre-test and post-test) and the students' scale questionnaire were carried out first. The mean, standard

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deviation, and the t-test of the experimental and control groups were computed. The t-tests were used for the computations. The t-tests were used to investigate whether any differences existed between the experimental and control groups' mean scores on the tests and the questionnaires. Furthermore, the t-test was used to investigate whether there were any significant differences between the groups' mean scores before and after the administration of the interventions. The inferential statistics were used by the researcher to determine the effectiveness of the collaborative learning approach in solving the learning needs of students. The second phase of the analysis was done to find out the views of students about the collaborative learning method developed as provided on the interview schedule.

In the third phase, qualitative analysis was done on the data gathered through the interviews. The recorded conversations were transcribed, analyzed, and summarized thematically after the interview sessions. Using the constant comparative method of analysis, the researchers read through the transcript for each interview to get a sense of the uniqueness of that story. Each transcript was carefully reviewed, sentence by sentence, to identify words and phrases that were descriptive and represented a particular concept. Central themes were extracted as the transcript was read and reread several times by the researchers to come into agreement.

## FINDINGS AND DISCUSSION

### Research Question One: What are the Main Causes of Students' Poor Performance in Redox Reaction?

This question was answered using data from items in the questionnaire designed for the study as well as the interview data of random selections of students from both the experimental and control groups. Table 2 gives a summary of the responses provided by the students to the questionnaire items designed to answer the research question. A vast majority of the students agreed that the conditions in school inhibited the smooth study of chemistry. Only 29 out of the 106 students disagreed with the above assertion as shown in Table 2.

The students gave diverse responses to item two which sought to ascertain the impact of a chemistry teacher on the students' attitude and achievement in the subject. Whereas 56 of the students said that they were discouraged from studying chemistry by the attitude of their chemistry teacher, 48 of them disagreed with the students. From Table 2, it is evident that the peer influence had an impact on the students' attitude toward the study of chemistry. A total of 63 students admitted to being discouraged from studying the subject due to the influence from peers. Only 35 students disagreed with the statement that there were no relevant reagents for studying redox experiments at school. The total number of students who admitted to being influenced adversely by the conditions at home as far as the study of chemistry is concerned was 30. Seventy of the students stated that their study of chemistry was not adversely influenced by the attitudes of their parents' and conditions at home.

**Table 2: Views of students on the causes of their poor performance in redox reaction**

| Item | SA | A | NC | D | SD |
|---|---|---|---|---|---|
| 1. Conditions in the school are not conducive for the study of chemistry | 52 | 21 | 5 | 22 | 6 |
| 2. The attitude of my chemistry teacher discourages me from studying chemistry | 29 | 27 | 2 | 26 | 22 |
| 3. I am discouraged from studying chemistry by my peers | 33 | 30 | 0 | 28 | 15 |
| 4. There are no relevant reagents and laboratory apparatus in the school to help me study redox experiments | 40 | 37 | 4 | 18 | 17 |
| 5. I am not motivated to study chemistry because of conditions at home and the attitude of my parents toward chemistry | 15 | 15 | 6 | 36 | 34 |

In the complimentary data collected through interviews in this question, students indicated that the factors responsible for their poor performance include: *Congestion in the chemistry laboratory*, *absence of logistics*, *lack of comprehension of concepts*, *outdated nature of equipment and logistics*, *teaching method of the teacher, and improper supervision by teachers and technicians.*

### Research Question 2: What Statistically Significant Differences would be observed in the Performance of Students Exposed to Collaborative Instructional Approach and those Exposed to Traditional Approach of Teaching Redox Reaction?

This research question sought to establish the impact of collaborative learning approach on students' understanding of various concepts in redox reaction as compared to the conventional method of teaching. The scores attained by both groups of (control and experimental) in both the pre-test and post-test were tabulated, compared, and analyzed to come out with inferences and conclusions. Twenty-five students scored below 50 marks for the post-test for the control group while only three students scored below 50 marks for the post-test for the experimental group. Only six students scored above 60 in the post-test for the control group. After the post-test, 41 students scored above 60 marks for the experimental group. Hence, there is a significance difference in the performance between students exposed to the collaborative learning approach and those exposed to the traditional learning approach.

The frequency distribution of both pre-test and post-test scores of students in the control group is shown in Table 3.

The frequency distribution of pre-test and post-test of scores of students in the experimental group is shown in Table 4.

To find out whether there were significance differences in the performance between those exposed to collaborative learning approach (experimental group) and those exposed to the traditional approach (control group) of teaching, the means, standard deviations, and t-tests for both pre-test and post-test scores were calculated, as shown in Table 5.

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**Table 3: Frequency distribution of pre-test and post-test scores of students in the control group**

| Scores | 10–20 | 21–30 | 31–40 | 41–50 | 51–60 | 61–70 | 71–80 | 81–90 | 91–100 |
|---|---|---|---|---|---|---|---|---|---|
| Pre-test | 4 | 16 | 15 | 15 | 6 | 0 | 0 | 0 | 0 |
| Post-test | 0 | 13 | 12 | 13 | 11 | 5 | 2 | 0 | 0 |

**Table 4: Frequency distribution of pre-test and post-test of the experimental group**

| Scores | 10–20 | 21–30 | 31–40 | 41–50 | 51–60 | 61–70 | 71–80 | 81–90 | 91–100 |
|---|---|---|---|---|---|---|---|---|---|
| Pre-test | 8 | 17 | 20 | 5 | 0 | 0 | 0 | 0 | 0 |
| Post-test | 0 | 0 | 0 | 3 | 6 | 8 | 12 | 11 | 10 |

**Table 5: Means, standard deviations, and t-test of pre-test and post-test scores of the experimental and control groups**

| Groups compared | Test | Mean test scores | Standard deviation | t-value | ρ-value |
|---|---|---|---|---|---|
| Experimental | Pre-test | 35.73 | 4.33 | 0.134 | 0.254 |
| Control | Pre-test | 41.22 | 5.64 | | |
| Experimental | Post-test | 79.43 | 11.21 | 5.465 | 0.004 |
| Control | Post-test | 57.17 | 8.61 | | |

*ρ<0.05

From Table 5, the mean test score of the experimental group (35.73) in the pre-test was smaller than for the control group (41.22) counterparts. The t-test analysis of the pre-test mean score of the two groups shows no significant difference ($t = 0.134$; $\rho > 0.05$). This showed that there was no significant difference in the performance between the two groups at the beginning of the study. This indicates that the two groups were comparable on the initial understanding of redox reaction.

As shown in Table 5, the mean test score of the experimental group (79.43) was higher than their control group (57.17) counterparts in the post-test. The t-test analysis of the mean score on the post-test shows a significant difference between the two groups ($t = 5.465$; $\rho < 0.05$). There was a statistically significant difference between the performance of students exposed to the collaborative learning approach and their counterparts exposed to the conventional teaching approach. The experimental group performed better than the control group in the post-test. This indicates that the experimental group had better conceptual understanding of redox reaction than the control group after the treatment.

This study has exposed some of the reasons why students might lose interest in chemistry, and particularly redox reaction, in the course of their secondary schooling. It thereby highlights ways in which we might attempt to enhance students' interest in the topic. In terms of the content of the chemistry curriculum, some topics appear to attract some students but deter others. As such, emphasis or reduction of such subjects might, overall, prove ineffective. This suggests that science should be taught using topic study instead. Another major effect on whether students find a subject interesting appears to reside in whether they perceive it as "relevant" (Osborne et al., 2010). Interviews with students in the present study revealed that "relevance" was a reason for finding redox reaction interesting and "lack of relevance" as a reason for finding it boring. This idea was reinforced by the specific curriculum areas that students raised in the context of finding the subject interesting. However, a few also raised the notion of degree of relevance of the topic to other parts of the formal school curriculum.

Science teachers must place more emphasis on interdisciplinary links, perhaps by raising, for example, in physics lessons, circumstances in which chemistry is relevant to popular areas in physics. For example, applications in electrolysis might be preferable. Perhaps, the most obvious factor raised by students was the link between the poor teaching methods employed by the teacher and perceiving a topic as being abstract. Indeed, there is evidence that the method of teaching adopted in teaching a particular topic tends to result in the development of a general negativity to that topic. In addition, students tended to choose for further study those subjects in which they anticipate they will be able to perform well (Krapp and Prenzel, 2011). The challenge here, then, is to make redox reaction less daunting to school students while retaining its essential nature. The issue of which subject areas are of inherent interest to students, especially girls, is worth exploring further if such information has the potential to contribute to increasing an overall interest in chemistry, and science in general. The superiority of the collaborative learning method over the traditional method can be explained on the basis of several mechanisms. In traditional classrooms, individual competition exists where failure of an individual plays an important role in the success of another. Hence, instead of helping others, students try to take advantage of their peers, so as to enhance their own chances of success. Competition also exists in collaborative learning set-up but unlike the traditional set-up, there is intergroup competition. In collaborative learning, an individual is not the winner. It is the group which loses or wins. The members of a particular group help each other to promote the success of their group members. In addition, collaborative learning emphasizes rewards. The rewards are given on the basis of the sum-total of the performances of individual members in the group. Thus, individual accountability is ensured. Individual accountability ensures that each member puts his/her maximum effort for the group rewards. For this, members try to make sure that all have understood the assigned material. Collaborative

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learning structures produce a situation in which the only way group members can get their personal goals is if the group is successful (Johnson et al., 2007; Laurillard, 2012). Students in collaborative learning situations value the success of the group so they encourage and help one another to achieve. This factor is absent in conventional (traditional) classrooms. This might have been the reason for the significantly greater achievement for the knowledge level and the total achievement in chemistry in the collaborative learning group.

A significant difference in the attainment of scores by students in chemistry was found in the study. This result is in partial agreement with the findings of Muijs and Reynolds (2018) who found that cooperative learning resulted in significantly higher achievement in students at the knowledge and comprehension levels of Bloom's taxonomy. The main challenge faced in cooperative and collaborative learning is group conflict. Students need to learn to work together. It is not always something that comes naturally. Furthermore, teachers who have previously not used cooperative or collaborative learning might also need to get used to the increased noise level in the classroom, during class activities. Some teachers may also feel that cooperative learning takes too much time for planning and might also take longer to cover the required portion of the curriculum. With all these challenges studies have shown that once teachers start to use this tool, they continue to use it and make it the foundation for teaching. One fear many instructors have about collaborative learning is that when students' grades are affected by the achievement of their group mates, students will believe that the grading practices are unfair (Chin-min, 2013). When positive outcome interdependence is structured within learning groups, achievement is greater than when students work individually. Again, collaborative experiences resulted in more positive attitudes toward classical music and own musical skills and no change in desire to teach music to elementary school students (Chin-min, 2013). In agreement with the present study, research work done by Good and Lavigne (2017) on a group students showed that collaborative and individual concept mapping conditions promoted the use of effective learning strategies more than conventional teaching.

## CONCLUSIONS

From the findings gathered in this research, it can be concluded that collaborative learning brings about higher academic achievement for these participants. Collaborative learning is an important tool that can be used to improve students' achievement in any classroom. It fosters tolerance and acceptance in classroom which improves the students' academic performance in chemistry. Students who work individually must compete against their peers to gain praise or other forms of rewards and reinforcement. In this type of competition, many individuals attempt to accomplish a goal with only a few winners. The success of these winners can mean failure for others. Thus, in a collaborative classroom, there is a healthy competition which brings about higher academic achievements. Collaborative learning brings about improvement in the academic achievement of students with low performance as was observed in this present study. It improved communication skills among the learners. The collaborative approach set the stage for students to learn social skills. These skills helped them to build stronger cooperation among group members. Students in this study also gained leadership skills and trust building as they learn collaboratively.

### Ethics Statement

Researchers informed the student participants of their right to refuse to participate or withdraw from the study. There was not undue influence of them to take part in the work. Furthermore, student participants were made aware of the use of the data and their preference in the study considered.

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# APPENDICES

## APPENDIX A

### Pre-test for students on redox reaction

**Instructions**: Answer all the questions on this paper.

1. The reaction that does not show a change in the oxidation number of any of its elements is not ………………..

2. If the oxidation number of carbon changes from +4 to -4 during the course of a redox reaction, has it been oxidized or reduced?

3. The oxidation half-equation for the reaction
   $A_{(s)} + B^{2+}_{(aq)} \rightarrow A^{2+}_{(aq)} + B_{(s)}$ is
   A. $B^{2+}_{(aq)} + 2e \rightarrow B_{(s)}$
   B. $A_{(s)} \rightarrow A^{2+}_{(aq)} + 2e$
   C. $B^{2+}_{(aq)} \rightarrow B_{(s)} + 2e$
   D. $A^{2+}_{(aq)} \rightarrow A_{(s)}$

4. Consider the following reaction equation
   $SO_4{}^{2-}{}_{(aq)} + 2H^+_{(aq)} + ye \rightarrow SO_3{}^{2}{}_{-(aq)} + H_2O_{(l)}$
   The value of y in the equation is
   A. 6
   B. 4
   C. 3
   D. 2

5. How many moles of electrons are involved in the following reaction?
   $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$
   A. 1
   B. 3
   C. 5
   D. 8

## SECTION B (SUBJECTIVE QUESTION)

### Answer all the questions on this paper

1. Consider the following reaction equation:
   $H_2S_{(aq)} + SO_{2(g)} \rightarrow S_{(g)} + H_2O_{(l)}$
   i. Identify the following:
   (α) Oxidizing agent, (β) Reducing agent
   ii. Write the half-reactions for the equation in question 1
   (α) Oxidation, (β) Reduction
   iii. Write the overall balanced equation for the reaction above.

## APPENDIX B

### Post-test for students on redox reaction

**Instructions**: Answer all the questions on this paper.

1. Consider the following redox reaction
   $3Cu + 8HNO_3 \rightarrow 3Cu\ (NO_3)_2 + 2NO + 4H_2O$
   Which of the statements about the reaction is correct?
   A. Copper is oxidized and hydrogen is reduced
   B. Copper is reduced and nitrogen is oxidized
   C. Copper is reduced and hydrogen is oxidized
   D. Copper is oxidized and nitrogen is reduced

2. Consider the redox equation
   $I_{2(l)} + 2S_2O_3{}^{2-}{}_{(aq)} \rightarrow 2I^-_{(aq)} + S_4O_6{}^{2-}{}_{(aq)}$
   Which of the species in the equation is reduced?
   A. $I_2$
   B. $I^-_{(aq)}$
   C. $S_2O_3^{2-}$
   D. $S_4O_6^{2-}$

3. What is the oxidation number of manganese in $MnO_4^-$?
   A. +7
   B. +6
   C. +5
   D. +4

4. Which of the following metals is best purified by electrolytic means?
   A. Aluminum
   B. Copper
   C. Gold
   D. Iron

5. If the oxidation number of Iodine changes from 0 to −1 during the course of a redox reaction, has it been oxidized or reduced?