



Effect of Cooperative Instructional Approach on Student's Performance in Science

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Abstract

This study investigated the effect of cooperative instructional approach on the performance of Form One General Science students in chemical bonding in science. The study adopted an action research design and utilized the purposive sampling technique to select an intact class of forty (40) students for the research. Data was gathered using tests and analyzed using descriptive and inferential statistics. The findings of the study indicated that students exhibited a notable improvement in academic performance from the pre-intervention test (Mean= 6.18) to the post-intervention test (Mean= 9.84). The t-test analysis revealed a statistically significant difference between the pre-intervention test mean score and the post-intervention test mean score ($p= 0.037$; $p < 0.05$). Also, the study revealed that students possess certain ideas about chemical bonding and face difficulties during lessons. These ideas and difficulties should be taken into consideration while designing instructional approaches for teaching chemical bonding. Based on the findings, the researcher recommended that teachers should include a cooperative instructional approach in their lessons to increase students' academic performance.

Keywords: Cooperative instructional approach, Chemical bonding, Academic performance

1. Introduction

1.1 Background to the study

In the 1960s, cooperative learning did not capture the attention of scholars, as individualistic and competitive learning were the prevailing pedagogical approaches. Currently, cooperative learning is an essential approach in education, applicable in elementary, secondary, and higher education institutions (Johnson & Johnson, 2016) ^[23]. Cooperative learning denotes the pedagogical strategy involving small groups in which students collaborate to comprehend the academic material of a course. Smith (2004) asserted that learning can be cooperative when students collaborate to achieve certain tasks.

Global research has demonstrated the efficacy of cooperative learning in fostering profound understanding and enhanced performance in educational settings, particularly in science classrooms across all levels (Johnson & Johnson, 1989; Johnson *et al*, 2019) ^[22, 25]. Numerous studies have substantiated the efficacy of student engagement strategies, including cooperative, collaborative, and active learning; however, many of these studies focus on classroom behaviors such as student participation, attention span, and interest in learning chemistry rather than on test scores and other measures of academic achievement (Johnson, Johnson, & Stanne, 2018) ^[24]. These studies typically assess individual participation and interest due to student engagement with peers. While these studies enhance teaching, they neglect to address the long-term effects of particular learning styles on student academic performance. Researchers have consistently identified a correlation between student engagement and favorable classroom outcomes, including attention and interest (Ames, 2018; Carini, Kuh, & Klein, 2016; Pascarella & Terenzini, 2015; Skinner & Belmont, 2013) ^[1, 7, 39, 46]. While limited research has directly examined academic achievement, some have identified correlations between student involvement and problem-solving, retention, and logical reasoning skills (Cooper, Cox, Nammouz, Case, & Stevens, 2018) ^[11]. Research indicates that students collaborating with a varied cohort are more inclined to enhance their demand for cognition (Goodman, 2011; Loes, 2019) ^[16, 29].

A comprehensive examination of the existing literature indicated that research predominantly concentrated on the overall influence of senior high school students' experiences on their academic growth, with scant evidence substantiating the direct correlation between cooperative learning and students' performance in chemistry (Cabrera *et al*, 2017)^[6]. Chemical bonding in integrated science was taught in a science class at Asuom senior high school, and it was observed based on the scores of students to questions that the students could not answer simple questions on this topic. It was difficult for these students to define these rudimentary terms that underscored the whole concept of chemistry. This present study thus sought to assess the effect of cooperative learning approach on the academic performance of senior high school students in chemical bonding.

1.2 Statement of the problem

The Ghana Education Service Senior High School Integrated Science syllabus aims to provide students with essential scientific information and to cultivate character-oriented learners capable of contributing to personal, national, and global development (CRDD, 2010; NaCCA, 2020). However, the researcher's personal experience in the school showed that the students performed poorly particularly in chemical bonding. The WAEC Chief Examiner's Report, in the years 2015 to 2018, showed that students did not perform well in chemistry, and this was because of lack of understanding of basic concepts including chemical bonding. Since knowledge of chemical bonding and related concepts (ionic and covalent bonding) is important for understanding other integrated science topics, the researcher decided to design an appropriate intervention to enable the students gain conceptual understanding of chemical bonding.

1.3 Purpose of the study

The purpose of the study is to investigate the impact of cooperative instructional approaches on the students' academic performance in chemical bonding in science

1.4 Objectives of the study

The objectives of the study were to determine:

- a) the ideas the students possessed about chemical bonding as well as the difficulties they face during lessons.
- b) the effect of Cooperative Instructional Approaches on the students' performance in chemical bonding.

1.5 Research Questions

The following research questions were addressed in the study:

- a) What ideas do the students possess about chemical bonding and what difficulties do they face during lessons on the topic?
- b) What is the effect of cooperative instructional approach on the students' performance in chemical bonding?

1.6 Significance of the study

The study may help to enhance the students' conceptual understanding of chemical bonding in science. Again, the study may be helpful to arouse and maintain students' interest in learning science

1.7 Limitations of the study

The study might be affected by the unavoidable absence of some students at critical stages of the implementation, that is the pre-intervention, intervention and post-intervention stages.

1.8 Delimitations of the study

The study involved only Form One Students' in Asuom Senior High School. The intervention will focus on chemical bonding in science.

2. Literature review

2.1 Meaning and historical background of cooperative instructional approaches

Cooperative learning is a pedagogical approach that engages students in the learning process to comprehend and acquire subject matter (Slavin 2016)^[47]. The most prevalent model utilized in education is likely that of Johnson and Johnson (2016)^[23] from the University of Minnesota. Students collaborate in groups utilizing a cooperative learning technique to attain common objectives, characterized by positive interdependence, individual and collective accountability, direct interaction, effective use of cooperative skills, and group reflection. Cooperative learning techniques differ from group learning approaches. An educational technique is identified as cooperative learning based on the presence of the aforementioned features. The notion of cooperative learning has been present since ancient times. Educators have historically encouraged their students to collaborate on sporadic group projects, engage in group debates, or utilize peer tutoring techniques (Slavin, 2018)^[48]. Quintilian elucidated the notion of group debates in the early first century, positing that peer learning would enhance the students' development (Johnson, Johnson & Stanne, 2018)^[24]. Marcus Fabius Quintilian was a renowned Roman educator active from approximately 68 to 88 AD (Pappas, 2003)^[38]. Pappas (2003)^[38] noted that the concept of peer learning is referenced in the Talmud, a compilation of ancient Jewish legal and traditional texts, which underscores the significance of peer learning (Chiu, 2000)^[8]. The Palestinian Talmud and the Babylonian Talmud were composed by Jewish academics. Johnson, Johnson, and Stanne (2019)^[25] emphasized the significance of group disputes between 400 AD and 600 AD. John Comenius emphasized political peace, educational collaboration, and religious changes in his writings (Pappas, 2003)^[38]. Johnson, Johnson, and Stanne (2019)^[25] asserted that Comenius promoted the idea that students would learn during group debates by both receiving and imparting education. It was said that Joseph Lancaster and Andrew Bell established peer learning group-based schools in England in 1800, respectively. The evolution of these schools substantially fostered peer learning, and the concept of group debates was utilized across the Atlantic Ocean. In 1806, a school founded on Lancastrian principles was established in New York City, utilizing peer learning groups. In the early 19th century, peer-learning-based schools received support in the USA during prevalent educational practices. Priority was assigned to the implementation of group discussion learning in classrooms throughout the last quarter of the 19th century. He was capable of overseeing over 30,000 visitors annually to assess his application of peer teaching (Clarke, 2009)^[9]. The implementation of peer tutoring was also endorsed in John Dewey's renowned project method, crediting Parker's contributions. Johnson, Johnson, and Stanne (2019)^[25] asserted that peer learning approaches prevailed in the American school system until the end of the century. Simultaneously, Parker was fervently promoting the implementation of peer learning. Turner and Triplett (2007) commenced comparative research on competitive, individualistic, and peer learning in England and America, respectively. Miller was likely one of the pioneering academics that did an experimental investigation on peer learning practices in 1929. Deutsch (2015) asserted that May and Doob examined literature on cooperative and competitive

learning up to 1937. Cooperative learning has had periods of both success and failure within American educational institutions. During the 1930s, competitive learning garnered focus in American education, whereas peer learning lost its prominence in educational practices (Pepitone, 2008). Peer learning revitalized interest in the American education system when community schools were advocated for integration in the 1960s.

Peer learning was instituted in schools as researchers and teachers advocated fostering mutual interaction among learners of other races and aiding minority group learners in improving their educational outcomes (Oslen & Kagan, 2012). In America, few research studies were conducted to promote and evaluate cooperative learning approaches in classrooms before the end of the 20th century (Slavin, 2018)^[48]. Elliot Aronson and his colleagues devised the jigsaw approach at the University of Texas at Austin. Collaborative learning was established through the initiatives of Johnson and Johnson (2016)^[23] at the University of Minnesota, USA. Slavin (2018)^[48] and colleagues implemented the Games-Tournament and STAD methodologies at Johns Hopkins University in the United States. Effective cooperative learning strategies are presently accessible for teaching diverse subjects across several educational levels, owing to practical applications by numerous educators and extensive study over many years. Today, teachers have the opportunity to select empirical cooperative learning techniques for effective instruction across various subjects and educational levels. Therefore, instructors could employ a cooperative learning strategy to structure classrooms for effective instruction (Slavin 2018)^[48].

2.2 The nature of chemical bonding concept

Chemical bonding is a fundamental idea in chemistry that students must study. Hornby (2009) asserted that bonding is a fundamental idea in chemistry education. A comprehensive grasp of this subject is essential for the comprehension of all other topics in chemistry, including carbon compounds, proteins, polymers, acids and bases, chemical energy, and thermodynamics. The notions of chemical bonding and structure, including covalent bonds, molecules, ions, massive lattices, and hydrogen bonds, are exceedingly abstract. The abstract character of bonding renders it a complex concept for both trainee teachers and scientists to comprehend (Robinson, 2003; Taber, 2001)^[49]. Chemical bonding is a domain within the physical sciences, where comprehension is cultivated through various models that learners are required to interpret using a range of symbolic representations and modalities (Taber, 2001)^[49]. Levy, Mamlok-Naaman, Hofstein, and Taber (2010)^[27] assert that a comprehensive understanding of chemical bonding necessitates that learners are acquainted with the mathematical and scientific principles and laws related to bonding concepts, including orbitals, electronegativity, electron repulsion, and polarity. Understanding chemical bonding enables the student to predict and elucidate the physical and chemical properties of many substances.

Gomez and Martin (2003) asserted that the most sophisticated models accessible to chemists for comprehending the structure of matter are those deemed the closest approximations to the 'reality' of contemporary knowledge based on quantum chemistry. Nonetheless, Sanchez Gomez and Martin indicated that most chemists were generally satisfied with models that primarily predated advancements in quantum chemistry. This is seen as offering support and elucidating contemporary understanding of matter. It signifies that most chemists employ a set of models

and methodologies that are now recognized as having a limited representational capacity about the structure of matter.

Chemists perceive substances as aggregates of sub-microscopic particles interconnected by chemical connections (Levy, Mamlok-Naaman, Hofstein, and Taber, 2010)^[27]. The chemical linkages among these particles elucidate numerous chemical and physical aspects of substances and chemical processes (Hurst, 2002; Levy Nahum, Hofstein, Mamlok-Naaman & Bar-Dov, 2004). A comprehensive understanding of the nature and features of chemical bonding is essential for students, as it is a fundamental subject in chemistry education. Chemical bonding is defined as the force that binds atoms within molecules and crystals. It asserted that it is one of the six most essential core topics to be incorporated into every high school chemistry syllabus.

2.3 Cooperative learning theoretical bases

Learning theories are the foundation of the prevalent application of cooperative learning teaching. An examination of pertinent literature indicates that cooperative learning was largely inconsequential fifty years ago; however, it has since become a prevalent pedagogical method across all educational tiers (primary, elementary, and secondary schools, colleges, and universities) in numerous developed and developing nations. Many scholars have proposed various theoretical theories to elucidate the superior ranking of cooperative learning (Slavin 2016; Johnson & Johnson, 2016)^[47, 23]. Theories related to the cooperative learning approach are categorized into two fundamental types: social cognitive theories and motivational theories. The narratives of these two philosophical traditions follow. Learning theories underpin the extensive application of cooperative learning training. An examination of pertinent literature indicates that cooperative learning was largely inconsequential fifty years ago; however, it has since become a prevalent pedagogical approach across all educational tiers (primary, elementary, and secondary schools, colleges, and universities) in numerous developed and developing nations. Numerous scholars have proposed various theoretical theories to elucidate the superior ranking of cooperative learning (Slavin 2016; Johnson & Johnson, 2016)^[47, 23]. Theories related to the cooperative learning approach are categorized into two fundamental groups: social cognitive theories and motivational theories. The narratives of these two philosophical traditions follow.

2.3.1 Motivational Theory

As it serves as the foundation for these cooperative learning theories that enable learners to engage in learning activities, the motivational outlook of cooperative learning focuses primarily on the incentive structures and team goal formation. Deutsch (2015) identifies three types of goal structures:

- a) Cooperative goal structures, where each member of the group is required to contribute to the achievement of the goals of the others.
- b) A system of goals that is competitive and requires everyone to try to prevent others from achieving their goals.
- c) Individualistic goal structures, in which no one person's actions have an impact on the achievement of another person's goals.

Cooperative goal frameworks provide an environment where team members may only attain their objectives if every member succeeds (Johnson & Johnson, 2016; Slavin, 2018)^[23, 48]. Team

members are so anticipated to assist and motivate their colleagues to give their utmost effort in pursuit of their own objectives. The criteria for rewards in cooperative groups were predicated on the collective accomplishments of participants, creating an interpersonal incentive framework wherein group members could offer or deny support based on each other's endeavors to fulfill designated tasks (Slavin, 2018) ^[48].

Motivational theorists assert that conventional grading and incentive systems establish peer norms in typical classes that lead students to eschew academic endeavors. When students work collaboratively in groups to achieve instructional objectives within a cooperative goal framework, their learning endeavors contribute to the success of their peers (Deutsch 2015). Slavin (2016) ^[47] examined how students engaged in cooperative groups enhanced their social standing in the classroom to boost academic achievement, but those in conventional classes did not experience similar benefits. The disparities in the social consequences of intellectual achievement can be significant. Brook-Over *et al* (2014) identified that the support of group members in accomplishing goals was the primary predictor of success, after controlling talent and social standing. Cooperative goal frameworks clearly foster the establishment of pro-academic norms among participants in the treatment group, which in turn enhances learners' academic performance.

Locke and Lathan (2010) ^[28] assert that the establishment of personal goals is affected by elements including team objectives, role modeling, support, and evaluation. Objectives dictate human behavior. These elements correspond with Salvin's (2016) cooperative learning framework. Goal setting theory posits that team objectives enhance individual goal responsibility more effectively than individual goals alone. If personal objectives are prioritized over collective objectives. The cooperative learning approach posits that establishing team goals enhances motivation for learning and encourages colleagues to reciprocate. Slavin (2016) ^[47] asserts that the implementation of a cooperative goal structure establishes a group contingency, wherein the behavior of team members determines the allocation of incentives to everyone. The team members need not possess the ability to assist their colleagues to implement the group contingencies theory. The result is contingent upon the conduct of each party. The team's rewards motivate individuals to adopt goal-oriented behaviors, thereby sufficiently encouraging players to engage in actions that contribute to the team's success in receiving rewards.

2.3.2 Social cognitive theories

Slavin (2016) ^[47] asserts that cooperative learning promotes collaborative efforts among students to attain shared objectives and situates them in a social context conducive to cognitive development using the Slavin cooperative learning model. This thereby facilitates learning and enhances standardization. Merriam and Caffarella (2009) ^[32] and Hansman (2001) ^[17] assert that social context is essential for learning. Learning does not occur in isolation; it is influenced by students' interactions, the tools employed for engagement, the educational objectives, and the social context of the activity. It encompasses the social background, daily customs, and techniques and instruments necessary for learning to occur inside the educational setting. Cognitive theories are classified into two major groups:

- a) Developmental theories
- b) Cognitive elaboration theories

2.4 Traditional Learning (TL) versus Cooperative Learning (CL)

The essence of cooperative learning is interdependence. Hsiung (2011) ^[20] performed a comparative analysis of students' academic performance in cooperative learning against traditional learning utilizing Taguchi Quality Indexes. Forty-two sophomore mechanical engineering students comprised the participants. The researcher partitioned the pupils into two groups, with each group comprising 21 individuals. The initial group collaborated on resolving the tasks allocated to them. The second group operated independently. After doing a t-test, the researcher determined that students engaged in cooperative learning groups achieved superior grades relative to their counterparts who worked independently. Moreover, collaboration fosters engagement. Team members support one another and promote collaborative learning while assisting peers who may struggle with specific subjects or topics. Conversely, traditional centered learning promotes autonomous learning. Both systems possess advantages and disadvantages. Cooperative learning fosters collaboration, enabling students to independently assess their strengths and limitations in learning, rather than solely depending on teacher comments and support. Consequently, they rely less on teachers.

However, the disadvantage of collaborative learning is that it necessitates additional time and the cooperation of learners to achieve success. Traditional learning promotes self-reliance in individuals as it relies only on students' involvement with the content and feedback from the teacher (Manning & Lucking, 1991) ^[30]. Active learning techniques utilize a hands-on approach, animation methods, and jigsaw strategies, enhancing the appeal of the learning process. Moreover, methodologies such as project-based learning, inquiry-based learning, and problem-based education enhance students' familiarity and conceptual understanding (Doymus, Karacop, & Simsek, 2010) ^[13]. Recently, the jigsaw and animation cooperative teaching strategies have garnered the attention of school leaders, educators, and educational researchers. Researchers have indicated that a distinction between cooperative learning and traditional learning methods lies in the function of competition as a motivational factor for pupils. They asserted that establishing competitive objectives facilitates student competition. Consequently, students are necessitated to exert greater effort to surpass their peers. Conversely, cooperative learning lacks competitive instinct. Another distinction between TL and CL is that whereas individual learning facilitates the achievement of personal objectives, cooperative learning lacks the concept of personal goals. In cooperative learning, interdependence is beneficial; students assist one another in enhancing their academic achievement. The students aspire to attain certain academic objectives collaboratively through cooperative learning.

Furthermore, Peterson and Miller (2004) ^[41] conducted a comprehensive study of research studies comparing the three learning paradigms: individualistic, competitive, and cooperative learning, focusing on the quality of college students' experiences during cooperative learning. This study involved 113 students over four sections of a psychology course. The researchers employed a questionnaire to gather data. After a fortnight, the students replied. The researchers found that the best paradigm of learning was cooperative learning (CL). The study was conducted in a collegiate environment, where researchers observed students' collaborative learning experiences and contrasted them with individualistic and competitive learning approaches. Students with cooperative learning experiences exhibited a more

favorable attitude towards academic learning compared to those without such experiences. Furthermore, they exhibited greater appreciation for the ideas and perspectives of their peers compared to those lacking cooperative learning experiences. Furthermore, the students in the cooperative learning group engaged in contentious debates regarding academic topics, enhanced their interpersonal skills, and possessed higher academic aspirations compared to those in individualistic and competitive settings. Numerous empirical research globally has examined various cooperative learning methodologies, revealing a good correlation between cooperative learning and academic performance, along with enhanced attitudes towards learning. Bahar-ÖzvariŞ, Çetin, Turan, and Peters (2006) did a study in Turkey that analyzed the distinction between the cooperative learning technique, specifically problem-based learning (PBL), and lecture-based learning. A total of 150 students participated in this study, with the experimental group comprising 67 students and the control group consisting of 83 students in a mental health course. The pupils were randomly assigned to a control group and an experimental group.

The researchers employed pre- and post-intervention assessments alongside a T-test to evaluate the differences between the two groups. Results indicated that cooperative learning resulted in superior academic performance ($t=0.00$) compared to individualistic learning ($t=0.70$). Students performed effectively when they collaborated with one another. The researchers noted that collaboration enhanced pupils' motivation for learning. The students in the experimental group requested clarification, elaboration, and justification from one another. Furthermore, it allowed the students to exchange argumentative roles, procedural knowledge, and conceptual tasks. Research indicates that cooperative learning might be beneficial in passive learning situations. This form of learning relies on verbal lectures, with the learner assuming a passive role and no actions occurring during class time. Nen-Chen, Gladie, and Wu (2005) [35] conducted an empirical study to investigate whether cooperative learning enhances student outcomes in a passive learning setting. The study sample comprised 172 students enrolled in an intermediate accounting course at Hong Kong University. The students were randomly divided into two groups: one group instructed through cooperative learning (small group) and the other group taught exclusively via lectures. The researcher

employed ANCOVA to analyze the test outcomes between the two groups. The findings indicated that the p-value was 0.01, supporting the experimental group.

Furthermore, students who collaborated in groups surpassed those instructed by lectures. Perkins and Saris (2001) [40] conducted a study with a group of students over a duration of four weeks. The researchers examined the impact of jigsaw learning versus regular learning on student performance. The study revealed that students employing the jigsaw learning method achieved superior exam results at the semester's conclusion compared to those utilizing traditional methods, demonstrating a 5% improvement in pre-test and post-test scores relative to students who solely attended lecture-style classes. This enhancement is attributed to cooperative learning, which "stimulates cognitive activities that promote knowledge retention and achievement" (Peterson & Miller, 2004, p. 127) [41]. More than 500 research studies exist on cooperative learning. Researchers include Manning and Lucking (1991) [30], Huang (2011) [21], Brown and McIlroy (2011), and Peterson and Miller (2004) [41] demonstrate that cooperative learning is the most effective approach for educators in the contemporary educational landscape.

2.5 Cooperative learning and academic achievement

Global research has underscored the efficacy of cooperative learning in fostering profound understanding and enhanced academic performance in educational settings, particularly in science classrooms across all levels (Johnson & Johnson, 1989; Johnson *et al*, 2014) [22]. Cooperative learning fosters student participation and engagement in their education, offering all students the chance to articulate their thoughts, discuss their ideas, and contemplate the perspectives of others, thereby enhancing their higher-order thinking skills (Johnson *et al*, 2014). Consequently, effective cooperative learning fosters active engagement, allowing students to transcend mere text and fundamental memory, so enhancing the acquisition and application of higher-order skills. This would result, in addition to academic advantages, in the enhancement of learners' self-esteem, interpersonal interactions, and attitudes towards school and peers.

2.6 The conceptual framework

The conceptual framework of the study is shown dramatically in Figure 1.

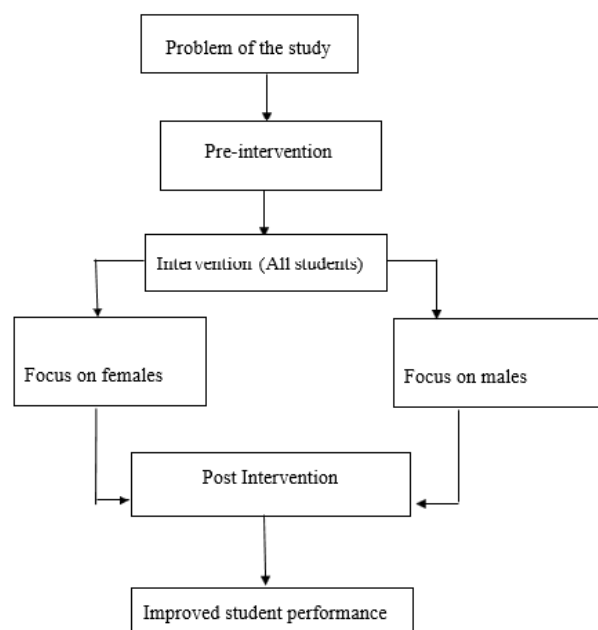


Fig 1: Diagrammatic representation of the conceptual framework of the study

2.7 Empirical Framework

Researchers have conducted various research to assess the efficacy of the cooperative learning strategy compared to traditional learning on students' performance in biology. Impact of Group Investigation and Jigsaw methodologies on students' success in biology as measured by test scores. The research findings revealed that students receiving treatment via group investigation attained superior scores in biology compared to those engaged in Jigsaw groups. Doymus, Karacop, and Simsek (2010)^[13] assessed the impact of cooperative learning on students' comprehension of certain biological topics. The study's results demonstrated that learners in the treatment group attained superior scores compared to those engaged in competitive and individualistic learning environments, as they actively participated in cooperative group activities and collaboration.

Okebukula and Ogunniyi (2014)^[37] examined the impact of the cooperative method on learners' performance, specifically regarding test scores and practical skills acquisition, in the 9th-grade biology course at the secondary education level in Nigeria. The study's results suggested that cooperative learners outperformed those who received training through traditional techniques. Okebukula and Ogunniyi (2014)^[37] assessed the impact of cooperative interaction strategies compared to competitive styles on the academic achievement of higher elementary school pupils in Nigeria. He indicated that collaborative learners surpassed competitive learners in performance. Shachar and Fischer (2004)^[45] conducted an experimental study to investigate the impact of the Group Investigation Technique on the accomplishment, motivation, and comprehension of higher secondary school students in an 11th-grade biology course. The study's findings indicated an enhancement in test scores among low and medium-ability students in treatment groups, whereas motivation appeared to diminish in cooperative learning groups.

Taran and Acar (2007)^[50] assessed the impact of the cooperative learning style through an empirical study on secondary school students' understanding of classification in 9th grade biology courses. The findings demonstrated that pupils instructed via a cooperative learning methodology surpassed those educated in traditional settings. Learners in cooperative groups actively engaged in the learning process and held favorable attitudes regarding their collaborative work experience. Zisk (2008)^[53] conducted a study to investigate the impact of cooperative tactics on exam scores and self-concept among secondary-level biology students. The results demonstrated favorable improvements in self-concept and accomplishments among students in cooperative groups compared to those in regular classrooms. Hanze and Berger (2007)^[19] conducted an empirical study to investigate the effects of the Cooperative Learning approach on secondary students' academic achievements and self-esteem. The study's findings suggested that the cooperative learning technique improved students' examination scores and fostered the self-esteem of those in cooperative groups. Students with low self-esteem appeared to be acquiring greater confidence and competence through collaborative intervention.

A study by Jenkins, Antill, and Vadasy (2003) examined the effects of cooperative learning on the outcomes of special education students, as perceived by secondary science teachers. They contended that cooperative learning positively influenced students' performance and enhanced their self-esteem. Tien, Roth, and Kampmeier (2002)^[51] commenced a comparison study to assess the influence of peer-led team learning on students' performance, specifically regarding test scores, grades, and information retention in biology during

the first semester of a three-year course. The results suggested that learners in peer-led teams did significantly better than those taught in traditional settings. Female and minority students attained greater exam results than their colleagues in the traditional group. Students in the experimental group evaluated the activities of the workshops as a useful learning tool in biology.

The effects of peer-led team learning strategies on students' achievement and persistence in biology classes were examined by Wamser (2006)^[52], who reported that students in treatment groups achieved higher average academic scores compared to their peers taught through conventional methods. Hanson and Wolf (2005)^[18] designed a study to investigate the effects of the cooperative learning technique (workshop process) on individual exam scores, self-confidence, attendance, and attitudes toward instruction and tutorial sessions in biology at SUNY-Stony Brook. Students were organized into groups of four to engage in cooperative learning activities centered on a singular idea. Students must complete the prescribed assignments within a one-hour timeframe. Quizzes on biology topics were administered to pupils individually to guarantee personal accountability. The application of this cooperative technique resulted in improved student performance, reflected in final grades, attendance at tutorial sessions, self-confidence, interest in biology, and attitudes towards learning, when compared to students who were instructed using traditional methods in the previous year.

Meta-analysis research concluded that cooperative learning methodologies yield positive outcomes in biology courses at both secondary school and college levels. Bowen (2012)^[4] conducted an empirical investigation to examine the impact of cooperative learning environments on students' academic achievement in biology courses. He reported that learners in cooperative groups attained the 64th percentile, whereas pupils in typical learning environments reached the 50th percentile.

3. Methodology

3.1 Design of the research

According to Kombo and Delno (2006)^[26], a research design is a plan, blueprint, or framework employed to address research difficulties. This study employed Action Research. Creswell (2008) asserted that Action Research is the most utilized practical research design in contemporary education. Cohen and Manion (2000)^[10] define action research as a little intervention accompanied by a thorough evaluation of its effects. Mills (2000)^[34] observed that the objective of selecting Action Research is to facilitate positive educational transformation. The study involved three main stages, namely, pre-intervention activities, intervention activities, and its implementation and post-intervention activities.

3.2 Population

Best and Kahn (2003)^[3] define a population as a collective of individuals sharing at least one common objective and possessing distinguishing traits that set them apart from others. Punch (2006)^[43] defines a population as a specific group of individuals that a researcher aims to study for knowledge acquisition. Neuman (2006)^[36] defines the population as the entirety of units encompassed by the investigation or to which the findings can be generalized. In this study, the targeted population involves all S.H.S students made up of **206** students while the accessible population consisted of all form 1 General Science Students which made up of 40.

3.3 Sample and sampling procedure

According to Fraenkel and Wallen (2000)^[14], the sample is any group on which information is obtained for study. The sample population for this study was from one General science Student of Asuom Senior High School. Forty students (20 males and 20 females) were purposively selected.

3.4 Data collection instruments

According to Fraenkel and Wallen (2003)^[15], an instrument is any device used to collect data for purposes of research. In this study, both qualitative and quantitative data gathering were used. The instrument used for collecting data for the study for both the pre-intervention and the post-intervention was a combination of a semi-structured questionnaire and an achievement test. The achievement test used for the study was of two types. These were pre-intervention and post-intervention. There were 10 test items each on the pre-intervention and the post-intervention instruments used. The test items used for the pre-intervention test were sampled from the set of past examination questions from the WAEC integrated science syllabus on chemical bonding. The pre-intervention items covered the cognitive, affective, and psychomotor domains. The purpose was to reveal the kind of thinking and understanding these students had in learning and teaching Integrated Science at the primary school level. The post-intervention items were similar to the pre-intervention items and therefore could be said to be of the same difficulty indices. Both tests were administered within 30 minutes. In this study, content validity was ensured since the content chosen is in comparison with the syllabus and was effected with the help of my supervisor. To ensure the reliability of the instruments, the instruments were tested using test-retest reliability method. The instruments were first administered and re-administered on the same respondents after a week.

3.5 Intervention

Pre-intervention activities

This stage included a pre-test that tested how well students know the principles of chemical bonding.

General intervention approach

The students were divided into groups of five and called to appoint a leader. Each group was given an instructional sheet detailing how they were to carry out their activities. Each group was to begin each activity with a brainstorming session in the lesson.

Post – intervention activities

At the end of the intervention, a test (post-intervention test) was allocated to the students. This test purposely evaluated the performances of the small groups after the four weeks' instruction. It was to help to find out the effect of cooperative instructional approaches on students' performance after the intervention.

3.6 Procedure for data analysis

Descriptive statistics such as means, mean difference, standard deviation, were used to analyses students' scores obtained in the pre- and post-intervention tests. These descriptive statistics were used to summarize the general trends in student performance. Inferential statistics such as student's t-test were used to assess the difference in means obtained by students in pre- and post-intervention tests at 95% and simple percentages were used.

3.7 Ethical Consideration

Permission was sought from the headmaster and stakeholders of the institution where the study was carried out. Participants in the study were duly informed about the nature of the study and what it sought to achieve. Respondents were assured of anonymity and confidentiality.

4. Results and Discussion

4.1 Demographic data respondents

This section analyses the various demographic characteristics of the respondents. Supporting tables and figures are provided by the participants, including gender and age.

Table 1: Gender of Respondents

Gender	Frequency (f)	Percentage (%)
Male	20	50
Female	20	50
Total	40	100

The results (from Table 1) showed that half of participants (50%) were male and half 50% were female. Further to this,

the study included respondents of various age groups.

Table 2: Age of Respondents

Age Groups	Frequency	Percentage (%)
13-15	6	15
16-20	30	75
20 and over	4	10

The data shows how the responses were distributed across three age groups. The study found that majority of respondents were aged 16 to 20 years (75%), followed by 15% of respondents aged 13 to 15 years and 10% of respondents aged over 20 years. This suggests that the study sample was primarily composed of adolescents and young adults.

4.2 Presentation of results by research questions

research question 1: what ideas do the students possess about chemical bonding and what difficulties do they face during lessons on the topic? This research question sought to identify the ideas students have and the difficulties of the

students when exposed to the questions on chemical bonding. Some ideas generated from the response of the participants are as follows.

1. Most students did not know the difference between covalent bonding and ionic bonding.
2. Some students were confused about ionic and electrovalent bonds, in other words they did not know they were the same
3. Some students were confused about hydrogen and oxygen being gases but when 2 atoms of hydrogen and an atom of oxygen combine, they form water which is a liquid but not gas but when hydrogen atoms combine with nitrogen gas, they form ammonia gas.

Table 3 provides a summary of the students' performance on the pre-intervention test. The findings observed from the

study reveal several factors that cause students' difficulties in learning chemical bonding.

Table 3: Students performance on chemical bonding pre-intervention test

Mark Range	Item	Option	Frequency	Percentage
1-2	1.	Very weak understanding	20	50%
3-4	2.	Weak understanding	8	20%
5-6	3.	Moderate understanding	2	5%
7-8	4.	Good understanding	6	15%
9-10	5.	Very good understanding	4	10%
		Total	40	100%

Table 3. shows that four students (10%) had very good understanding about chemical bonding while six students (15%) had good understanding about the topic. However, eight students (20%) possessed a weak understanding of the topic while twenty students (50%) exhibited a very weak understanding of the topic. Also, two students (5%) had an

average understanding about chemical bonding. So, in table 3, it can be concluded that almost all the students (60%) possess a weak understanding of chemical bonding.

Additionally, aspects of the topic about which students faced difficulties are shown in Table 4.

Table 4: Most challenging aspects of chemical bonding

Item	Option	Frequency
1	• Differentiating between ionic and covalent bonds	23
	• Differentiating between molecular and structural formulae	6
	• Identifying types of chemical reactions	3
	• Explaining the concept of valence electrons	5
	• Others	4

Table 4 indicates that 23 students faced difficulties in understanding the fundamental differences between ionic and covalent bonds, where ionic bonds involve the transfer of electrons between atoms, whereas covalent bonds involve the sharing of electrons. Also, 6 students struggled with comprehending the arrangement of atoms in a molecule and translating this understanding into chemical formulae. Whereas 3 students found it difficult to identify the type of chemical reaction. Additionally, 5 students faced difficulties in grasping the concept of valence electrons, which are the outermost electrons in an atom and determine its reactivity. Understanding valence electrons is crucial for comprehending electron configurations, bonding, and chemical properties. Four respondents indicated that they faced challenges in aspects not covered by the options provided. Overall, the findings demonstrate that students encountered various challenges in their understanding of chemical bonding. Differentiating between ionic and covalent bonds, understanding molecular structures and formulae, identifying types of chemical reactions, and explaining the concept of valence electrons emerged as the most cited challenging aspects.

5. Discussion

The findings from Table 3 and Table 4 provide insights into the idea's students possess about chemical bonding and the difficulties they face during lessons on the topic.

Table 3 reveals that majority of the students (60%) demonstrated a weak understanding of chemical bonding. This suggests that students may possess misconceptions or incomplete knowledge about this fundamental topic. These misconceptions can hinder their ability to grasp the nuances of chemical bonding principles and impede their overall comprehension. Similar findings have been reported by Mbage (2014)^[31] in a study conducted in the Volta Region. He found that the students only memorized information on chemical bonding but did not really understand what they memorized.

Also, Table 3 further highlights the difficulties students encounter during lessons on chemical bonding. The most

frequently chosen challenges include differentiating between ionic and covalent bonds, understanding molecular structures and formulas, identifying types of chemical reactions, and explaining the concept of valence electrons.

The challenge of differentiating between ionic and covalent bonds suggests that students may struggle to grasp the fundamental differences between these two types of chemical bonds. This difficulty could stem from confusion surrounding the concepts of electron transfer and electron sharing. These misconceptions can impede students' understanding of the mechanisms underlying these bonding types (Miller, 2001)^[33].

Understanding molecular structures and formulas presents another significant challenge for students. This struggle may arise from the complexity of visualizing and representing the arrangement of atoms within a molecule. Students may encounter difficulty translating their understanding of molecular structures into chemical formulas, hindering their ability to accurately represent and communicate chemical compounds.

Identifying types of chemical reactions emerged as another major challenge. The recognition and categorization of various chemical reactions, such as synthesis, decomposition, combustion, and displacement reactions, require students to apply specific rules and patterns. The difficulties faced by students in this regard may hamper their ability to identify the type of reaction and predict products accurately.

Additionally, students expressed difficulties in understanding the concept of valence electrons. Valence electrons play a vital role in determining an atom's reactivity and are crucial for understanding concepts such as electron configurations, bonding, and chemical properties. Difficulties in comprehending the concept of valence electrons can hinder students' ability to explain bonding patterns and predict chemical behaviour accurately. The difficulties the students faced might be related to their preferred learning styles (Pruitt, 2005)^[42]. It is possible that the cooperative instructional approach did not adequately cater for the learners' instructional needs.

Furthermore, 18 respondents identified challenges not

covered by the provided options, indicating the presence of additional complexities not captured by the predefined categories. Exploring these challenges in detail could provide further insights into the specific difficulties students encounter during lessons on chemical bonding.

In conclusion, the findings suggest that students possess varying ideas about chemical bonding, with a majority demonstrating a weak understanding. The identified challenges, including differentiating between ionic and covalent bonds, understanding molecular structures and formulas, identifying types of chemical reactions, and explaining the concept of valence electrons, shed light on the specific difficulty's students face during lessons on the topic. Addressing these challenges by employing targeted instructional strategies can help improve students' understanding and promote meaningful learning experiences in the field of chemical bonding.

Table 5: Frequency distribution of the achievement test scores of students

Score	1-2	3-4	5-6	7-8	9-10
Pre-Intervention test	18(45%)	14(35%)	6(15%)	2(5%)	0(0%)
Post-intervention test	0(0%)	2(5%)	12(30%)	11(27.5%)	15(37.5%)

From Table 5, for the pre-intervention test, as many as 32 (80%) students scored below 5 with the remaining 8(20%) students scoring from 5 to 10. In the post-intervention test, there was improvement in performance as 38(95%) students

Research question 2: what is the effect of cooperative instructional approach on the students' performance in chemical bonding?

This research question sought to explore the impact of cooperative instructional approaches to the performance of students in chemical bonding. To assess the effect of cooperative instruction on the students' performance in chemical bonding, the students were taken through five lessons of one-hour duration each. After completion of the intervention activities, a post-intervention test was administered

This post-intervention test aimed to offer a comprehensive overview of students' performance in chemical bonding. The results of the post-intervention test are summarized in Table 3.

scored from 5 and above. The means, standard deviations and t-test of students in the pre-intervention test and post-intervention test are presented in Table 6.

Table 6: The means and standard deviations of pre-intervention test and post-intervention test

Test	N	Mean Score	Standard deviations	p-value
Pre-intervention test	40	6.18	0.98	
Post-intervention test	40	9.84	1.55	0.037*

6. Discussion

Looking at Table 6, the results show that 95% of the students performed better in the post- intervention test after participating in the cooperative instructional activities. This indicates a positive impact on the students' comprehension and suggests that the instructional approaches were effective in enhancing their performance. Also, Table 5 provides further insight into the effect of the Cooperative Instructional Approaches on students' performance.

Furthermore, results from the present pre-intervention test and post-intervention test indicate the changes in performance before and after the intervention. There was an increase in the number of students scoring above 5 (from 8 to 38) between the pre-intervention test and post-intervention test. These findings indicate that there is an improved performance after the intervention.

Table 6 provides statistical analysis comparing the means of the pre-intervention test and post-intervention test. In the table, the p-value (0.037) is less than the alpha-value (0.05) and it suggests that the difference between the mean scores of the pre- intervention and post- intervention test was statistically significant. However, with a significant level of $p < 0.05$ where $p = 0.037$, we can say there was a significant difference in means scores between the pre- and post-intervention tests. These results collectively demonstrate that the Cooperative Instructional Approaches positively influenced students' performance in chemical bonding. The significant improvement reported by many participants, as well as the higher scores and the statistical analysis, support the effectiveness of the instructional approaches in enhancing students' performance. The data presented highlights the benefits of using cooperative instructional strategies in teaching chemical bonding, as they result in improved

performance and understanding among students.

In conclusion, the findings from the provided tables indicate that the Cooperative Instructional Approaches had a positive effect on students' performance in chemical bonding. Many participants experienced changes in their understanding and reported significant improvement in their performance. These findings emphasize the importance of implementing cooperative instructional strategies to enhance learning outcomes in chemical bonding. Similarly, Anati (2021) ^[2] found that group activities had a positive effect on students' cognitive achievement. In a study conducted in Oti Boateng Senior High School, Anati (2021) ^[2] found group activities among students greatly improved their performance in naming inorganic compounds.

7. Conclusions

The research conducted highlights the positive impacts of cooperative instructional approaches for lessons on chemical bonding. The findings demonstrate that cooperative learning strategies enhance students' understanding, engagement, and overall academic performance in this subject area. Thus, students possess certain ideas about chemical bonding and face difficulties during lessons. These ideas and difficulties should be taken into consideration while designing instructional approaches for teaching chemical bonding. Cooperative Instructional Approaches have a significant effect on the students' performance in chemical bonding. Implementing this approach leads to an improvement in their understanding and application of chemical bonding concepts.

8. Recommendations

All students should be encouraged to participate in cooperative learning activities, as it can improve their

comprehension of chemical bonding concepts and facilitate peer interactions, fostering collaborative skills and the development of a deeper understanding. Students should also embrace their role as active learners, seeking out opportunities for cooperative learning outside the classroom as well. Teachers can benefit from incorporating cooperative instructional approaches into their lesson planning, as it positively affects classroom dynamics and student learning outcomes. Implementing strategies such as group discussions, cooperative projects, and problem-solving tasks can provide students with a meaningful learning experience in chemical bonding, resulting in higher levels of motivation and success. Teachers should also continuously assess and modify their instructional methods to ensure they align with the needs and learning styles of their students.

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