UNIVERSITY OF EDUCATION, WINNEBA

EFFECT OF COOPERATIVE LEARNING ON SENIOR HIGH SCHOOL CHEMISTRY STUDENTS' UNDERSTANDING OF HYBRIDIZATION

CHRISTOPHER KWAME DEGBOR

JULY, 2014

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A THESIS IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE EDUCATION, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, IN THE UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR AWARD OF THE MASTER OF PHILOSOPHY DEGREE IN SCIENCE EDUCATION DEGREE.

JULY, 2014

DECLARATION

Students' Declaration

I, Degbor Christopher Kwame, declare that this dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Name: Degbor Christopher Kwame

Signature: ……………………… **Date**: ………………………….

Supervisor's Declaration

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of Dissertation as laid down by the University of Education, Winneba.

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ACKNOWLEDGEMENTS

I wish to express my profound gratitude to my principal supervisor, Dr. E. K. Oppong and co-supervisor Dr. Y. Ameyaw for their guidance and meaningful suggestions throughout the study. My sincere appreciation also goes to my lecturers at the Science Department including Prof. J. Eminah, Prof. M. K. Amedeke, Dr. E. Ngman-Wara, Dr. Tachie Young and Dr. Nana Annan. A special thanks to Mrs Rubby Hanson for supporting me with some materials.

To my roommate Mr. Eric Kakraba and colleague Mrs. Cynthia Kyekye, I say thank you for your moral support and for providing listening ears during the hash times.

Also worth appreciating are my colleague M.phil students; Grace Entsie, Debora Boyeteh, Bawa Mbage, Ras Kumabia, etc who made college life memorable and interesting. God bless you all.

DEDICATION

This dissertation is dedicated to my mother, wife and sons for their encouragement and moral support.

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GLOSSARY

(Operational Definitions)

Conceptual Framework: A group of concepts that are broadly defined and systematically organized to provide a focus, a rationale, and a tool for the integration and interpretation of information.

Cooperative Learning: An instructional method in which learners work in groups toward a common academic goal.

Individual Learning: An instructional method in which learners work individually at their own level and rate towards an academic goal.

Perception: The impression of students or their attitude and understanding based on what they have experienced.

Student-Teams-Achievement-Division: A type of cooperative learning where students study in small heterogeneous groups during lessons but break to do exercises individually at the end of the lesson.

ACRONYMS AND ABBREVIATIONS

ALSDE:	Alabama State Department of Education
ANCOVA:	Analysis of Covariance
ATCH:	Achievement Test on Concept of Hybridization
CL:	Cooperative Learning
DV:	Dependent Variable
ES:	Effect Size
GES:	Ghana Education Service
IL:	Individual Learning
IV:	Independent Variable
MOEYS:	Ministry of Education, Youth and Sports
NCATE:	National Council for Accreditation of Teacher Education
SHS:	Senior High School
SPSS:	Statistical Package for Social Sciences
STAD:	Student-Teams-Achievement-Division
QSAM:	Questionnaire on Students' Attitude and Motivation
QSP:	Questionnaire on Students' Perception
VSEPR:	Valence Shell Electron-Pair Repulsion
WASSCE:	West African Secondary School Certificate Examination

ABSTRACT

The study sought to investigate the effect of Student-Teams-Achievement-Division Cooperative Learning (STAD CL) as against Individual Learning (IL) on Senior High School (SHS) chemistry students' understanding of the concept of hybridization. It also aimed at finding out the effect of CL on their attitude and motivation as well as establishing their perception with regards to IL, STAD CL and benefits of CL. The study also sought the views of students on which of the modes of instructions (CL or IL) they would prefer as main mode of teaching at the SHS. Two control groups (class sizes 12 and 25) totalling 37 and two treatment groups (class sizes 14 and 31) totalling 45 were used. The study design was quasi-experimental, non-randomised pretest-intervention - postest control group design. Four instruments which include worksheets and lesson notes on the concept of hybridization; Achievement Test on the Concept of Hybridization (ATCH 1 & 2); Questionnaire on Students' Attitude and Motivation (QSAM); and Questionnaire on Students Perception about Peer Cooperation (QSP) in CL and IL were used. The results showed a significant difference between the group taught with the STAD CL and the group taught with IL ($f = 78.722$, $p < 0.05$) on the Analysis of Covariance (ANCOVA) Table (10) with a medium effect size of 0.36. A slight improvement in attitude and motivation towards the subject was also observed. Mean difference on pre and post treatment QSAM for CL group was 4.93 and that for IL group was 1.03. On the post-treatment QSP scale, means for perception of STAD CL (12.09) and its benefits (20.51) was more favourable than perception of IL (8.62). As to which of CL and IL should be the main mode of instruction at the SHS, 73.3% of students supported CL and 13.3% each either were undecided or disagreed. Based on these results and other studies, the researcher recommends a blend of methods with more emphasis on CL in the Ghanaian SHS which future educational reviews should make provision for.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter is the introductory part of the study and generally presents the background to the study, statement of the problem, purpose of the study, and research questions. It also looks at the significance of the study, limitation, delimitation and organizational plan of the study.

1.2 Background to the Study

An understanding of how students learn can help teachers to devise effective strategies for teaching. This requires research into the learning difficulties to be made accessible (Clow, 1998). For learners to retain and comprehend knowledge, it must be placed in a conceptual framework (Slavin, 1995), based on sound knowledge theory and research. Two very prominent perspectives on learning and knowledge acquisition are the behaviourists and the constructivists. To the behaviourists, "education is the establishment of behaviour which will be of advantage to the individual and to others at some future time" (Skinner, 1954). The goal of the behaviourist is to determine how external instructional manipulations affect changes in student behaviour. The focus is on teacher-centred approaches, "the importance of observable, external events on learning" and the role of reinforcers in influencing those events" (Kauchak & Eggen, 2003). Behaviourism provides precise measures for organizing curricula and teaching and stresses the attainment of specific objectives through carefully sequenced learning experiences and matching assessments. These objectives serve as a clear guide for learning activities and for standards by which the teaching and learning process can be evaluated (Martin & Pear, 1996): planning appropriate activities to achieve the objectives, monitoring performance through assessment, and emphasizing some degree of quality control (Dick, 1996).

Despite the benefits of behaviourist perspectives in structuring curricula, it is not able to account for the active internal process that students use to organise, store and retrieve information. It does not provide enough flexibility to allow the delivery of instruction in the most meaningful ways. It does not provide the desired latitude for more learner-centred education for emphasizing the crucial role that learners themselves play in their own learning and for the internal shaping of values and dispositions (ALSDE & NCATE, College of Education, 1990).

Meaningful learning requires active involvement and inquiry, problem solving and reflection, interaction and cooperation on the part of the teacher and learner. Knowledge is internalized and a framework established when social discourse takes place. This discourse leads to the conceptual framework in which to relate the new knowledge (Bruffee, 1992). The framework derives from a consensus of beliefs about the philosophy, values and dispositions that shape effective educators. Knowledge is shaped overtime by successive conversations, and by ever-changing social and political environments (MacGregor, 1990).

Cooperative learning is one of the most remarkable and fertile areas of theory, research, and practice in education (Johnson, Johnson, & Stanne, 2000). Cooperative learning exists when students work together to accomplish shared learning goals (Johnson, 1999). Individual students accomplish their learning goals only when other group members attain theirs in cooperative learning. Cooperative learning activities instil in learners important behaviours that prepare them to reason and perform in an adult world (Adams & Hamm, 1996; Marzano, Pickering, & Pollock, 2001). Attitudes and values of learners are formed through social interaction. Borich (2004) noted that most of our attitudes and values are formed by discussing what we know or think with others. Continuing in this manner, we exchange our information and knowledge with that of others who have acquired their knowledge in different ways. This exchange shapes our views and perspectives. Our attitudes and values are among the most important outcomes of schooling (Borich, 2004). They provide the framework for guiding our actions outside the classroom. Cooperative learning is important in helping learners acquire from the curriculum the basic cooperative attitudes and values they need to think independently inside and outside of the classroom (Ajaja & Eravwoke, 2010).

Science teaching and learning today is to a great extent focused on activities by which the learner acquires facts, rules and action sequences (Kpangban & Ajaja, 2007). In student-centred instructional approaches, using students' ideas means incorporating students' experiences, points of view, feelings, and problems into the lesson by making the student the primary point of reference. Research by Johnson and Johnson (1991) on learning together and alone showed that cooperative learning enhanced more positive attitude towards subject members and the teacher. Learners' background knowledge, development and motivation must be key consideration when planning for instructions.

The knowledge of chemistry is necessary for understanding composition, properties and behaviour changes of matter that form the environment. The teaching of chemistry also aims at developing scientific concepts, principles and skills in the learners (Kenya Institute of Education (KIE), 1992). Chemistry learning too often occurs by rote learning of factual knowledge (Gabel, 1999). Chemistry teaching has also often focused more on transmission of information than on knowledge construction in small groups (Zohar, 2004). Students hardly want to think for themselves and will rather want to be told the right answers to problems.

According to Novak and Gowin (1984) meaningful learning occurs when individuals "choose to relate new knowledge to relevant concepts and propositions they already know". This calls for commitment on the part of the learner to link new concepts with higher order and more inclusive concepts that are already understood by the learner that can serve to anchor new learning and assimilate new ideas (Novak, 1993). The commitment aspect calls for interest and general positive attitudes toward learning process as well as the subject being studied by the student. Meaningful learning can be enhanced based on positive attitudes and affective characteristics of learners. Development of instructional strategies that actively engage learners in the process of knowledge acquisition can help translate new conceptions into classroom practice. Cooperative learning by STAD, teaching strategy is perhaps one of the most suitable for this purpose.

The science education literature contains a large number of studies about students' understanding of scientific phenomena (Bahar, Johnstone, & Hansell, 1999). Some studies indicate that students have misconceptions and learning difficulties concerning atomic structure, chemical bonding and matter (Cros, *et al*., 1986 ; Cros, Chastrette, & Fayol, 1998 ; Taber, 1994 ; Tan & Treagust, 1999 ; Harrison & Treagust, 2000) as quoted by Nakibogu, (2003). Only a few researchers have touched upon students' difficulties and misconceptions related to the fundamental characteristics of hybridization (Zoller, 1990 ; Taber, 2001 ; Taber, 2002). For clear understanding of hybrid orbitals and hybridization, students need an understanding of the concepts of atomic orbitals, the real meaning of the s, p, d, f designations and direction of orbitals.

Such understanding is essential to learning other concepts, such as covalent bonding, molecules and matter.

During the researcher's practice as a chemistry teacher at Nkonya Senior High School for the past six years, it has been observed in assignments, tests and examinations conducted for different batches of students that, students perform poorly in the concept of hybridization as established by some research works; Taber (2001) reported that students used orbitals, shells and orbits interchangeably; Nakiboglu & Benlikaya (2001) found that most students thought that orbitals were equivalent to orbits or shells; and Tsaparlis & Papaphotis (2002) established that secondary students continue to think of the old quantum theory and that the electrons rotate around the nucleus like the planets around the sun. A major factor accounting for the persistent poor performance in the concept of hybridization has been largely blamed on students' misconceptions of the rather abstract concept. These misconceptions are often resistant to instructions and become obstacles to the acquisition of scientific concepts. Skelly and Hall (1993) categorize the misconceptions as experiential and instructional. They further contended that misconceptions pertaining to these more abstract phenomena result from some instructional experience, within or outside of the classroom, including independent study.

1.3 Statement of the Problem

Secondary school teachers usually prefer teaching with traditional techniques (Nakibogu, 2003). Instead of concept learning, most teachers rather use algorithmic or problem solving approaches in their instruction. They reason that the chemistry syllabus is loaded and for students to be able to do well in their West African Secondary School

Certificate Examination (WASSCE), such instructional methods are most appropriate. This phenomenon of focusing on teaching students to solve problems is perceived as a real barrier to an emphasis on conceptual learning (Nakibogu, 2003). The researcher through his own experience, observation and dialogue with some colleague teachers as well as students established this trend of whole class method of teaching and individual learning strategies in Nkonya Senior High School. This situation has in part contributed to the unimpressive performance of chemistry students in tests and examinations over the years especially in showing understanding of the Chemistry concept of hybridization.

For instance, the 1993 and 1995 November-December editions of WAEC Chief Examiner's Report identified a number of issues regarding poor performance of candidates in respect of the concept of hybridization. Similarly, the July-August 2003 and the May-June 2008 editions of the same report expressed reservations about the adequacy of students' answers to questions on hybridization. The reports among other things noted that students missed out on key words in definitions and explanations as well as general understanding of the concept that was needed in explaining for instance why the central atoms in H_2O and NH_3 molecules though sp^3 hybridized, have different bond angles.

Cooperative learning techniques have been shown to enhance students' learning and social relations relative to whole class methods of teaching (Adeyemi, 2002; Akinbode, 2006 & Esan, 1999). Its use in the Ghanaian educational system however is not widespread just as research into the area is limited. This assertion is further corroborated by Essuman (2004), that only one study (Eshun and Abledu, (1999)) was found that looked at cooperative learning in Ghana.

1.4 Purpose of the Study

This study sought to investigate the effect of Student-Teams-Achievement-Division (STAD) cooperative learning as against individual learning (IL) in understanding the concept of hybridization among Senior High School (SHS) chemistry students in some selected schools in the Volta Region. It also aimed at finding out the effect of cooperative learning on the attitude and motivation of the students studying the concept. Again, the study sought to establish the perception of students with regards to IL, STAD CL and its benefits after being exposed to the two modes of instructions. Last but not least, to find out the percentage of the students that recommends CL or IL as main mode of instruction in our Ghanaian SHS.

1.5 Objectives of the Study

The study was guided by the following objectives:

1. To find out the extent of the effect of STAD CL as against IL on SHS chemistry students' understanding of the concept of hybridization.
2. To determine if any difference exist in attitude and motivation towards studying chemistry between students exposed to STAD CL and those exposed to IL.
3. Find out the perception of students exposed to STAD CL with regards to;
   a) individual learning,
   b) STAD CL and
   c) benefits of cooperative learning.
4. To determine if SHS chemistry students prefer CL or IL as the main mode of instruction at the SHS.

1.6 Research Question

The study sought to provide answers to the following research questions:

1. To what extent does achievement test scores differ between students instructed using STAD cooperative learning and those instructed using individual learning on the concept of hybridization in chemistry?
2. What difference exist in attitude and motivation scores between students instructed using STAD cooperative learning and those instructed using individual learning on the concept of hybridization in chemistry?
3. What are the perceptions of students who have undergone STAD cooperative learning with regards to;

   a) individual learning,

   b) STAD cooperative learning and

   c) benefits of cooperative learning.
4. What percentage of SHS chemistry students prefer CL or IL as the main mode of instruction at the SHS?

1.7 Hypothesis

The following hypotheses were tested for research questions 1 and 2.

Null hypothesis (H_0 1):

There is no significant difference between the mean scores of students who studied by STAD cooperative learning and those who studied by individual learning.

Alternative hypothesis (H_1 1):

There is significant difference between the mean scores of students who studied by STAD cooperative learning and those who studied by individual learning.

Null hypothesis (H_0 2):

There is no significant difference between the mean scores on attitude and motivation scale of students who studied by STAD cooperative learning and those who studied by individual learning.

Alternative hypothesis (H_1 2):

There is significant difference between the mean scores on attitude and motivation scale of students who studied by STAD cooperative learning and those who studied by individual learning.

1.8 Significance of the Study

The study is significant because it provides empirical evidence that cooperative learning improves understanding of the concept of hybridization in chemistry. It also provides an insight into the effect of cooperative learning on SHS students' attitude and motivation towards learning chemistry as well as their perception about the benefits of peer-cooperation in their academic achievements. Besides, the fact that majority of students (as in this study) who are the direct beneficiaries of teaching preferring CL as the main mode of instruction at the SHS to IL means a lot to educational policy makers. This assertion could provide guidance for policy makers and stakeholders in education when structuring future curricula in chemistry. Findings of the study will contribute to body of knowledge as it provides evidence that is needed to justify whether to adopt cooperative learning strategy in our Ghanaian SHS or continue with the widely used individual learning strategy in teaching science concepts. It could also serve as basis for further research work.

1.9 Delimitation

The study was delimited to second year general science chemistry students from four SHS' in the Volta Region of Ghana including Nkonya Senior High School where the problem was identified. It was also delimited in content to the concepts of hybridization in Chemistry and only individual and STAD cooperative learning is discussed in the study.

1.10 Limitations

. Due to time and resource constraints, the study was limited to only four public SHS in the Volta Region of Ghana. The use of purposeful sampling in order to include variables such as academic performance and school location had diminished serendipitous impact on the results. The sample size, sample frame and sampling method were relatively small. As such, the findings should not be generalized to all SHS students and teachers in the country.

1.11 Organizational Plan of the Study

The study was organised into six chapters. Chapter one dealt with the study background and problem definition as well as its purpose and research question. Relevant literature review was presented in Chapter two and has related sub-headings relevant to the study. The research design and methodology were described in Chapter three. Results and analysis were presented in Chapter four. Chapter five looked at discussions and implications of findings. The summary of findings, conclusion, recommendations and suggestions for further studies into the problem, based on the findings of the study were discussed in Chapter six.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

Two categories of review were made: theoretical and empirical.

The theoretical review consided: Theoretical framework; Individual and cooperative theories of learning in establishing conceptual frameworks; Student-Teams-Achievement-Division (STAD) cooperative learning and its development; Elements of cooperative learning and Benefits of cooperative learning.

Empirical review of literature focused on: The concept of hybridization; and Using STAD cooperative learning strategy in enhancing understanding of the concept of hybridization.

2.1 Theoretical Review of Literature

2.1.1 Theoretical framework

There is no universally adopted meaning of the terms ‘collaborative learning and cooperative learning. Collaborative and cooperative learning strategies have marginal differences and are occasionally used interchangeably. The Cambridge International Dictionary of English, (1996) indicates the same meaning and etymologies for the terms “collaborative and “cooperative”. The two terms have no clear-cut definitions. For example Oslen and Kagan (1992) pointed out that no one has proposed a universally accepted definition for collaborative learning. Instead, researchers usually describe key elements, characteristics, or principles that contribute to achievement, socialization, and other gains. In the light of this, Ingram and Hathorn, (2004) define collaboration as consisting of three crucial elements: participation, interaction and synthesis.

In relation to instruction, both terms are used when small-group active student participation over passive, lecture-based teaching and the need for the completion of a specific task is required. Each strategy inherently supports a discovery based approach to learning. The two methods assign various group roles though collaborative learning can have fewer roles assigned. In both situations, student members are required to possess group skills though cooperative learning may include this as an instructional goal. Each plan comes with a framework upon which the group's activity resides, but cooperative learning is usually more structurally defined than collaborative learning (Rockwood, 1995a; Rockwood, 1999b).

However, some practitioners have indicated that these two terms are different. Rockwood (1995a, 1995b) characterizes the differences between these methodologies as one of knowledge and power: Cooperative learning is the methodology of choice for foundational knowledge while collaborative learning is connected to the social constructionist's view that knowledge is a social construct. He further distinguishes these approaches by the instructor's center of authority in the class, with group tasks usually more closed-ended and often having specific answers. In contrast, with collaborative learning the instructor abdicates his or her authority and empowers the small groups who are often given more open-ended, complex tasks. To Rockwood (1995a), the use of any of these approaches depends on the academic maturity of the students. Whiles structured cooperative learning strategy favours foundational knowledge, the laissez faire approach of collaborative learning favours higher levels of learning.

The researcher for the purpose of this work share the same view of Rockwood on cooperative learning where group tasks are more structured with closed-ended tasks and full supervision of the instructor is required. The researcher is however of the view that both instructional approaches could be designed for all levels of education. Cognitive development is an outcome of cooperative learning, wherein constructivist knowledge development and transformation result from collaborative attempts to discover, comprehend, and decipher (Vygotsky, 1978).

This study was thus conducted within the social constructivist framework of knowledge construction with regards to cooperative learning on one hand, and the traditional behaviourist with regards to individual learning on the other hand. The underlying premise of cooperative learning is founded in constructivist epistemology. It utilizes ideas of Vygotsky, Piaget, and Kohlberb in that both the individual and social settings are active dynamics in the learning process as students attempt to imitate real-life learning (Hijazi & Al-Natour, 2012). With proponents such as Vygotsky, the social constructivists offer theoretical perspective about the interdependence of individuals' construction of knowledge and the social environment. This interdependence is reflected in Vygotsky's formulation of the general genetic law of cultural development, which states:

> *Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and when within the child as an intrapsychological category* (Wertsch, 1985).

This is an indication that learning comes as a result of social interaction. Bentley and Watts (1991) thus defines constructivism as:

a family of theories that share the assertion that human knowledge and experience entail the (pro)active participation of the individual.

The constructivist position holds that knowledge is not passively received, but is actively built up by the cognizing subject (von Glasersfeld, 1989). The social constructivist approach emphasizes that knowledge is acquired through interaction with others as well as by individual processes. This assertion ties in with the current study on STAD cooperative learning, where learners study in small heterogeneous teams and then break to do exercises individually.

The traditional behaviourist motto is: "There is nothing in the mind that was not first in the senses." It is assumed that a person can obtain direct knowledge of any reality, because, through the senses, we create an exact image (a replica or photocopy) of reality. Behaviourists therefore assume that knowledge can be transferred intact from one person to another. The learner is viewed as a passive recipient of knowledge, an "empty vessel" to be filled. The behaviourist teacher therefore tries to create a rich, concrete learning environment, because it is believed that we understand what we see.

In sum, cooperative learning is often confused with collaborative learning in literature and practice. While their definitions are similar, they are different in theoretical perspectives and in practice. Cooperative learning is much more structured and operationally defined than collaborative learning. Both are used at all levels of education and in a variety of learning environments. Cooperative learning is thus an instructional strategy in which small groups of students work together to accomplish shared goals. It has well defined classroom structure as well as teacher and learner roles.

2.1.2 Individual and cooperative theories of learning in establishing conceptual frameworks

Behavioural learning theory suggests that students will commit to participation in both individual and team efforts if they are rewarded for that participation, and are likely not to commit if no rewards are evident (Morgan, 2003). Therefore, both individual and team rewards should be evident in cooperative learning environments, wherein rewards for participation in team productivity is purposeful (Johnson, Johnson, & Smith, 1998 a).

Cooperative learning strategy requires student cooperation and interdependence in its task, goal and reward structure. It requires students to be actively engaged in discussions, debates, tutoring and teamwork. Students must coordinate their efforts to complete given tasks. Cooperative learning aims at developing the cognitive and social skills of the learner. According to Arends and Kilcher (2010), cooperative learning model was developed to achieve at least three instructional goals; academic achievement, tolerance and acceptance of diversity, and social skill development.

To Arends (2009), cooperative learning lessons are characterized by the following features:

a) Students work in teams to master learning goals
b) Teams are made up of high, low and average achieving students.
c) Whenever possible, teams include a racial, cultural and gender mix
d) Reward systems are oriented to the group as well as individual.

To reiterate, cooperative learning in the current context is an instructional approach that emphasizes conceptual learning and development of social skills as learners work together in small heterogeneous groups according to the principles of positive interdependence, individual accountability, face-to-face promotive interaction, and group processing (Johnson, Johnson, & Stanne, 2000).

Various forms of cooperative learning have been developed by researchers over the years that can be adapted to suit different philosophies of teachers. Table 1 shows some of the modern methods of cooperative learning adapted from (Johnson, Johnson, & Stanne, 2000):

Table 1: Modern Methods of Cooperative Learning

Researcher / Developer	Date	Method
Johnson & Johnson	Mid 1960s	Learning Together & Alone
De Vries & Edwards	Early 1970s	Teams-Games-Tournaments (TGT)
Sharan & Sharan	Mid 1970s	Group Investigation
Johnson & Johnson	Mid 1970s	Constructive Controversy
Aronson & Associates	Late 1970s	Jigsaw Procedure
Slavin & Associates	Early 1970s	Student-Teams-Achievement-Divisions (**STAD**)
Cohen	Early 1980s	Complex Instruction
Kagan	Mid 1980s	Cooperative Learning Structures
Steve, Slavin & Associates	Late 1980s	Cooperative Integrated Reading & Composition (CIRC)

Theoretical framework of cooperative learning is mainly based on the theories of cognitive development, behavioural-learning, and social interdependence (Morgan, 2003). Cooperative learning is framed in the theory of social independence, grounded in the work of Koffka, Lewin, and Deutsch (Johnson, Johnson, & Smith, 1998 b). Besides, theoretical support for cooperative learning is found in the cognitive learning theory, developed by Piaget, which emphasized that learning is based on intrinsic motivation and is constructed by the student. In the cooperative classroom, students jointly construct knowledge, reinforcing resource and role interdependency. The behavioural perspective provides the structure for group work, in that it must be reward and task oriented, providing extrinsic motivation for learning (Johnson, Johnson, & Smith, 1998a). All the facets of learning are addressed collectively in the theoretical foundation for cooperative learning, as illustrated in the Figure 1.

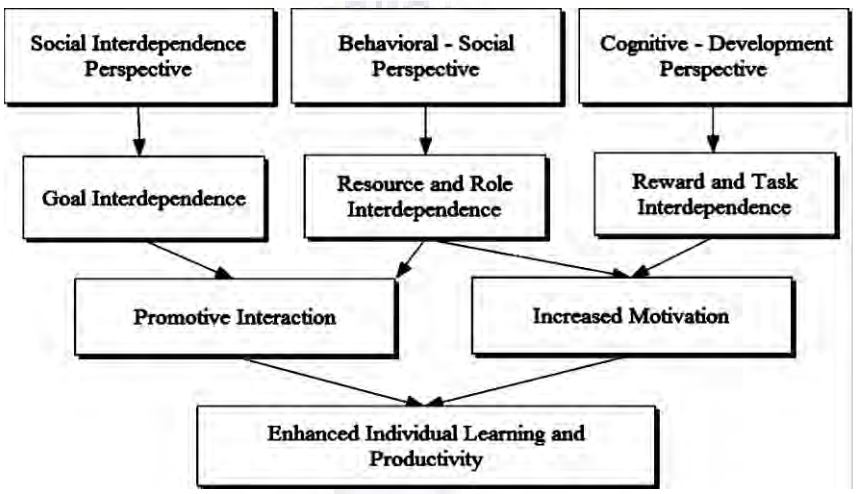


Figure 1: Theoretical Framework for Cooperative Learning; Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998a).

2.1.3 Student-Teams-Achievement-Division (STAD) cooperative learning and its development

The cooperative learning strategy that has been extensively researched and assessed specifically on academic achievements, attitudes, social interactions and interpersonal relationships is the Student-Teams-Achievement-Divisions (STAD). Cooperative learning strategies have been used with students in British Education since the late 1500s. The idea was sent to the United States for use in a New York City school in 1806 (Johnson & Johnson, 1991). During the past fifteen years, educators have been investigating curricula and instructional approaches that incorporate both effective and cognitive elements with their structure (Jone & Steinbrink, 1988; Kownslaw, 1974). Student-Teams-Achievement-Division (STAD) as a cooperative learning experiment was designed and researched by Robert Slavin and associates in Johns Hopkins University and was known as "student team learning" (Sharan, 1994). In the past two decades major theoretical perspectives have been explored, related to cooperative learning, namely motivational and cognitive theories on student learning (Slavin, 1987).

Meaningful learning takes place when students not only remember, but also make sense of and are able to apply, what they have learned (Anderson & Krathwohl, 2001). The ability to apply knowledge to a novel situation (transfer of learning) is affected by the degree to which students learn chemistry through understanding. Thus, meaningful learning is knowledge construction, in which students seek to "make sense" of their experiences. Meaningful learning occurs gradually over time. It is an active, constructive, and cumulative process (Shuell, 1990). Students who do not possess a meaningful learning orientation memorize facts (Novak & Gowin, 1984). The major limitations of rote learning are poor retention and retrieval of new ideas, potential interference in subsequent learning of related concepts, and inability to use the new knowledge to solve novel problems (Minzes & Wandersee, 1998). Cooperative learning (CL) is the instructional use of small groups so that student's work together to improve their own learning as well as each other's learning.

2.1.4 Elements of cooperative learning

According to Johnson et al (1998 a) five elements are required in cooperative learning. These are explained as follows:

1. *Positive interdependence*; team members perceive that they are dependent on other members of the group to complete the group's goal, task, or assignment.

2. *Individual accountability*; the quality and quantity of each member's contribution to learning is assessed and provided to the group and the individual. Each student, as well as the group, is responsible for learning the assigned task.

3. *Face-to-face promotive interaction*; team members promote each other's productivity by helping, sharing, and encouraging efforts to produce and learn. Group members explain, discuss, and teach what they know to team-mates.

4. *Interpersonal/social and small group skills*; team members purposefully learn social skills necessary to function effectively as a learning community. These team skills relate directly to job-performance skills, such as instructorship, decision-making, trust building, communication, and conflict-management.

5. *Group processing*; group members reflect on their progress as a learning team and define strategies for improvement. Instructors also monitor the performance of the group and provide feedback to the group.

2.1.5 Benefits of cooperative learning

Cooperative learning as a teaching strategy has been a success story in the transformation of education over the past decade (Adams & Hamm, 1996). Scholars in student learning have shown a growing interest in using STAD cooperative learning technique in classroom teaching (van Wyk, 2012).

Research studies in the use of STAD CL as a teaching technique has been applied with great success in various research projects (Slavin, 1987; Vaughan, 2002; Jacobs, Gawe, & Vakalisa, 2003; van Wyk, 2012). For example Wang (2012) conducted a research to find out the effects of cooperative learning on achievement motivation of female students in the department of Physical Education, University of Shanghai, China. The results indicated difference between the traditional teaching and the cooperative learning ($t = -2.00$, $p = 0.00 < 0.001$). The mean scores of motivation in the control group ($M = 7.12$, $SD = 8.63$) was significantly lower than the experimental group ($M = 20.39$, $SD = 6.99$). The CL group had significant difference of pre and post-test ($t = -2.15$, $p = 0.000 < 0.001$). The scores of pre-test ($M = 20.39$, $SD = 6.99$) was also lower than that of the post-test ($M = 6.90$, $SD = 9.76$).

In the University of South Africa, college of education, department of curriculum and instruction, (van Wyk, 2012) carried out a research to find out the effects of STAD-cooperative learning method on student achievement, attitude and motivation in Economics Education using both paired and unpaired t-test for both control and treatment groups. For the unpaired or independent t-test, the mean scores of the pre and post tests were computed between the experimental group and the control group. The mean of pre-test scores prior to instruction was not significantly different ($t_{66} = -0.078$, $p < 0.05$). The post-test mean score however indicated significant difference for the participants in the experimental group that studied by STAD-cooperative learning over the control group that studied by direct or traditional instruction ($t_{66} = -5.231$, $p < 0.05$). In the paired or dependent t-test both control and experimental groups showed significant difference in the mean scores. That is ($t_{168} = -2.631$, $p < 0.05$) and ($t_{168} = -29.018$, $p < 0.05$) respectively. However, the STAD-cooperative learning experience led to better performance in achievement than the direct learning experience. Using unpaired t-test, results of data gained from attitude scale were also reported. The mean of pre-test scores for both groups were statistically different (t_{168} = - 0.021, $p < 0.05$). The analysis of results of the post-tests in the attitude test indicated that the mean of post-test scores for experimental group (mean = 87.19) that studied the STAD-cooperatively performed better compared to the control group (mean = 77.23). With paired samples t-test results of data gained from the attitude scale that aimed to assess the effects of direct instruction on students attitude towards economics education, the STAD-cooperative learning experimental group showed statistically effective attitude towards economics education (t_{68} = - 4.018, $p < 0.05$). It is reasonable to claim that STAD-cooperative learning experience is more effective in promoting positive attitudes in students towards Economics Education than direct instruction.

In Ghana, Essuman (2004) investigated on “Effect of small-group cooperative learning on the performance in Mathematics of senior secondary school students”. Using statistically equivalent control and treatment groups, he found out that the mean score of the experimental group was about three times that of the control group. The t-test value for the mean difference between the mean score on the post-test for the control and experimental groups was -2.57 which was significant at five percent alpha level. The paired sample t-test for the difference between the mean scores on the pre-test and post-test of the control and the experimental groups of -12.23 and -12.16 respectively were both statistically significant showing that both groups (control and experimental) made significant improvement in achievement. Again, analysis of pre-test and post-test scores among different ability groups (low, medium and high) also showed that students at all the ability levels in the experimental group achieved a higher mean gain than their counterparts in the control group.

Research conducted by Klein (1985) revealed that competitively structured classrooms have the effect of favouring boys or reinforcing sex role stereotypes that may limit opportunities for girls. In cooperative learning this usually is not the case, where interaction among students is intense and prolonged and students gradually take responsibility for each other's learning (Borich, 2004). Stevens and Slavin (1995), for example, noted that cooperative learning increases academic achievement of learners at all ability levels. According to Glassman (1989) as well as Johnson, Johnson, and Stanne, (1986), cooperative learning equalize the status and respect for all group members, regardless of gender. Again, a study by Crosby and Owens (1993) found that different cooperative learning strategies can be employed to help low ability students who had difficulties making success in the traditional classroom to improve achievement.

In general, cooperative learning can be said to lead to the formation of attitude and values, provision of models of pro-social behaviour, presentation of alternative perspective and viewpoints, building a coherent and integrated identity, and promotion of critical thinking, reasoning, and problem-solving behaviour (Borich 2004; Stevens & Slavin 1995; Abruscato 1994; Zehm & Kottler 1993). All these result in collaborative skills improvement, better self-esteem and increased achievement (Johnson & Johnson, 1996).

Academic achievements of students have been found to be enhanced by the use of cooperative learning (Lampe, Rooze, & Tallent-Runnels, 1998; Johnson & Johnson, 1989; Slavin, 1990; Slavin, 1991; Webb, 1989). Stevens and Slavin (1995) stated that, the fact that it has been linked to increases in the academic achievement of learners at all ability levels is another reason for its use. Stahl and Vansickle (1992) opines that every cooperative-learning strategy, when used appropriately, can enable students to move beyond the text, memorization of basic facts, and learning lower level skills. This method which results in cognitive restructuring leads to an increase in understanding of all students in a cooperative group. Apart from academic benefits, cooperative learning has been found to promote self-esteem, interpersonal relationship and improved attitudes toward school and peers (Johnson & Johnson, 1996).

2.2 Empirical Review of Literature

2.2.1 The concept of hybridization

Hybridization

1. It is the mixing of two or more different atomic orbitals of different energies of the same atom to form new hybrid orbitals which are of equivalent energies and shape. The new hybrid orbitals formed have some of the properties of the different atomic orbitals which go into forming them. (Ameyibor & Wiredu, 1993; Bempong, Gbeddy, & Coffie, 2009).
2. Hybridization occurs in the valence shell of the central atom in a covalent bond. The central atoms often are C, N, O, S and P. Number of atomic orbitals mixed equals number of hybrid orbitals obtained.

Hybridization occurs in the formation of some covalent bonds. This theory is a way of explaining the shapes of molecules which are found in nature (and predicted by the VSEPR Theory). The theory states that electron pairs surrounding an atom mutually repel each other and will therefore adopt an arrangement that minimizes this repulsion. It is a model used to predict the shape of individual molecules based on the extent of electron pair electrostatic repulsion (Chang, 2005).

When atoms share valence electrons, orbitals of the two atoms overlap, which is they share the same region of space. The overlap balances the attraction for electrons of one atom to the nucleus of the other with the repulsions of the two nuclei and that of the electron for each other, producing the most stable orbital configuration. Molecular orbitals are formed when two atomic orbitals each containing an unpaired electron overlap resulting in the formation of covalent bonds. In other words, covalent bonds are formed by the overlap of atomic orbitals. An illustration can be found in the Figure 2.

e.g.

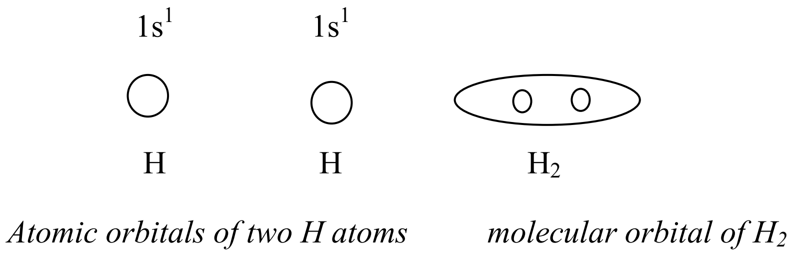


Figure 2: Atomic and Molecular Orbitals

NB: Atomic orbitals have single electrons whiles molecular orbitals have a pair of electrons and it is lower in energy.

Orbital is a region of space around the nucleus where there is a high probability of finding an electron. As can be seen in the Figure 3, there are different atomic orbitals which also have different shapes and orientations in space.

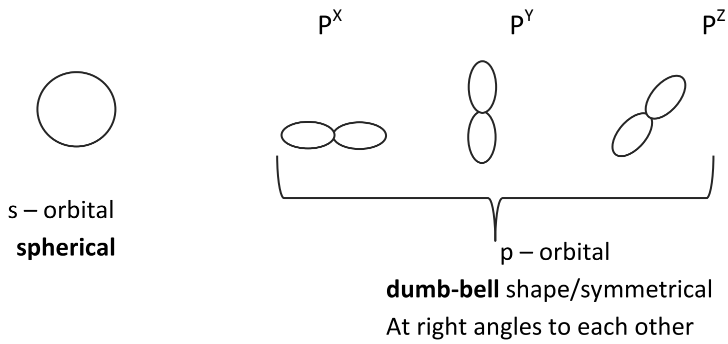


Figure 3: Shapes of Atomic Orbitals

Effects of hybridization on covalent bond

a) Increases stability of the molecule formed (Chang, 2005),

b) Produces bonds of lower energy (Bempong, Gbeddy, & Coffie, 2009) and

c) Contributes to the bond angles of molecules (Chang, 2005)

Types of bonds

Two types of bonds are formed during hybridization. These are **Sigma** (σ) and **Pi** (π) bonds.

1. **Sigma bonds** (σ – bonds); are formed by axial or head-on overlap of atomic orbitals (Ameyibor & Wiredu, 1993). The overlap could be between two s – orbitals, an s and p or between a p and p orbitals. Different types of hybrid orbitals are illustrated in the Figure 4.

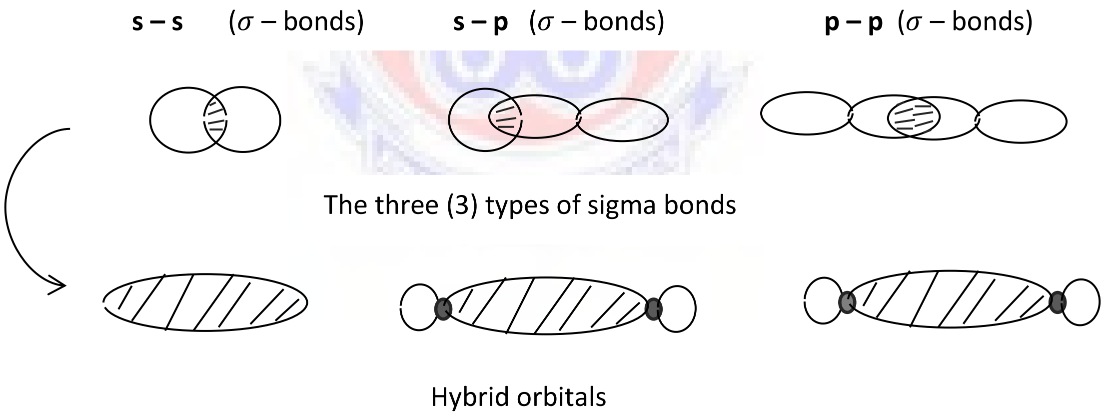


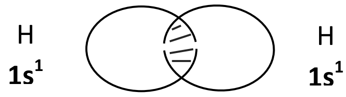
Figure 4: Types of Hybrid Orbitals

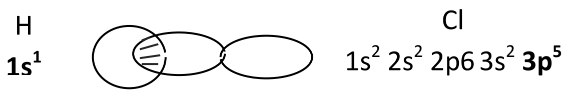
Formation of sigma bond in some molecules

When orbitals overlap end to end, electron density is symmetrically concentrated between the two nuclei. This is called a sigma (σ) bond. There are nodes at the nuclei and two small areas of electron density outside the nuclei.

Sigma bonds are possible with: **s-s** orbital overlap, **s-p** overlap and **p-p** end-to-end overlap.

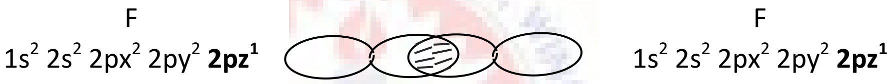
1. **s - s** overlap e.g. Hydrogen (H_2)





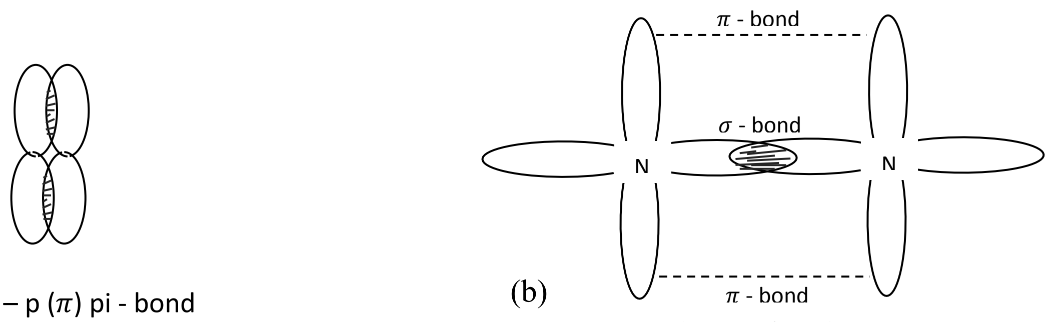
2. **s – p** overlap e.g Hydrogen chloride (HCl)

3. **p – p** overlap e.g Fluorine (F_2)



Formation of pi (π) bonds

These are formed by lateral or side-by-side overlap of p-orbitals. They are formed in some molecules together with sigma bonds as in nitrogen molecule. In a π-bond, two areas of electron density form above and below the σ-bond already in place.



(a) p – p (π) pi - bond

(b) Pi and Sigma bonds in N_2

Figure 5: Pi and Sigma Bonds

The pi bond in the Figure 5 (a) is not found in isolation but in association with a sigma bond as illustrated in the Figure 5 (b). Note also that the π-bond can be converted to σ bond. This is an example of an addition reaction in organic chemistry.

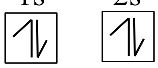
Differences between pi and sigma bonds

Sigma (σ) bonds	**Pi (π) bonds**
1. Formed by axial (head–on) overlap of orbitals.	1. Formed by lateral (side-by-side) overlap of p – orbitals.
2. Are stronger due to high degree of overlapping of orbitals.	2. Are weaker due to small degree of overlapping.
3. Very unreactive because electrons are strongly held together.	3. Very reactive because electrons are weakly held together.
4. There is free rotation about the bond.	4. No free rotation about the bond.

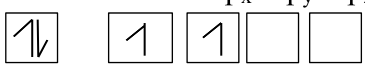
Formation of hybrid orbitals

sp Hybridization:– In forming hybrid orbitals, the central elements in a molecule rearranges its valence electrons from the ground state configuration (G.S.C) to the excited state configuration (E.S.C)

E.g. $_4Be$ G. S. C = $1s^2$ $2s^2$



E. S. C = $1s^2$ $2s^1$ $2p_x^1$ $2p_y^0$ $2p_z^0$



The example above shows sp hybridization where one s (i.e 2s) and one **p** (i.e 2p) orbitals mix to give 2 **sp** hybrid orbitals.

Formation of $BeCl_2$

The electron configuration of chlorine, $_{17}Cl = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p_x^2\ 3p_y^2\ 3p_z^1$. The $3p_z$ orbital of Cl has one unpaired electron and this overlaps with one unpaired orbital of one sp hybrid orbital of Be. The second Cl also used its $3p_z$ orbital to overlap the second sp hybrid orbital of Be as illustrated in Figure 6.

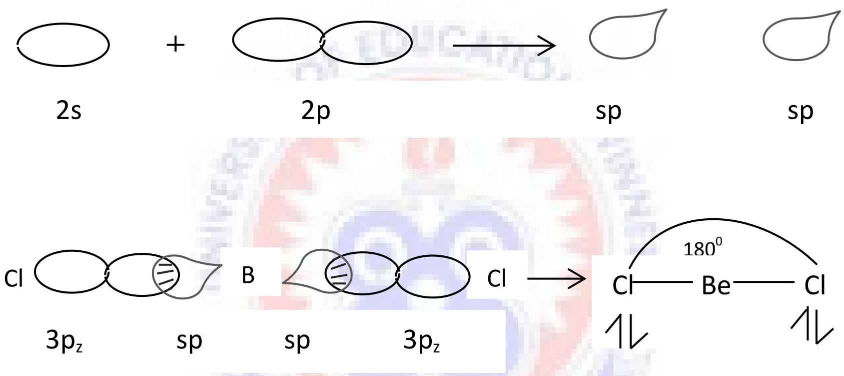
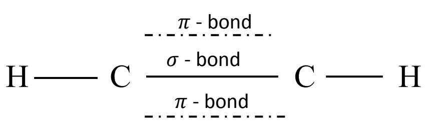


Figure 6: Formation of sp Hybrid Orbitals in $BeCl_2$

$BeCl_2$, thus has a linear shape with a bond angle of 180^0. Other molecules with sp hybridization of the central atom include the C_2H_2 (ethyne) BeI_2, CO_2, etc.



One σ- bond and two π – bond is formed between the C atoms in ethyne and σ-bond between the C and H atoms.

NB: Each C in C_2H_2 is sp hybridized

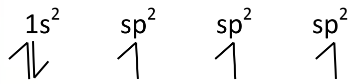
sp^2 Hybridization:- It is the mixing of one **s** – orbital and two **p** – orbitals to form three equivalent sp^2 hybrid orbitals. **sp^2** hybrid orbitals are trigonal planar in shape with a bond angle of 120^0.

E.g. BCl_3 (Boron trichloride) and C_2H_4 (Ethene)

Hybridization in **BCl_3** is as follows;

$_5B = 1s^2\ 2s^2\ 2px^1\ 2py^0\ 2pz^0$;- Ground State Configuration (**G. S**. C)

$_5B = 1s^2\ 2s^1\ 2px^1\ 2py^1\ 2pz^0$;- Excited State Configuration (**E. S**. C)



Hybridize to form (i.e all three orbitals; 2s, 2px and 2py mix up!)

$_{17}Cl = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p_x^{\ 2}\ 3p_y^{\ 2}\ 3p_z^{\ 1}$ (**E. S**. C)

Three Cl atoms with one 3pz – orbital electron each overlap head-on with the three sp^2 hybrid orbitals of B is as illustrated in the Figure 7.

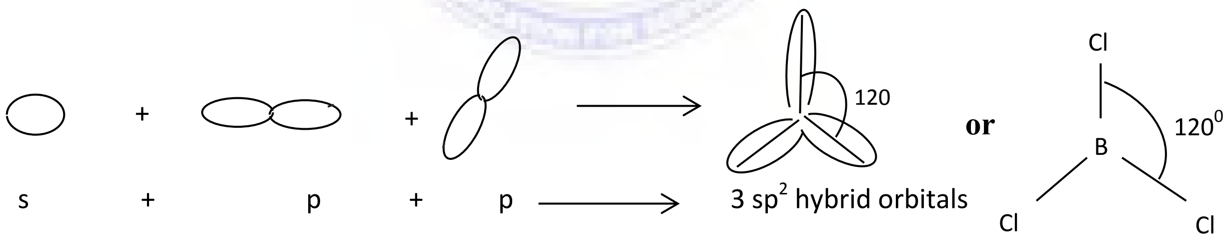
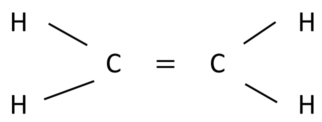


Figure 7: Formation of sp^2 Hybrid Orbital in BCl_3

The shape of BCl_3 is trigonal planar with a bond angle of 120^0. Similar sp^2 hybridization is found in AlI_3 and BF_3.

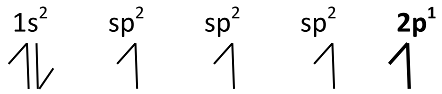
Hybridization in ethene (C_2H_4) is as follows:

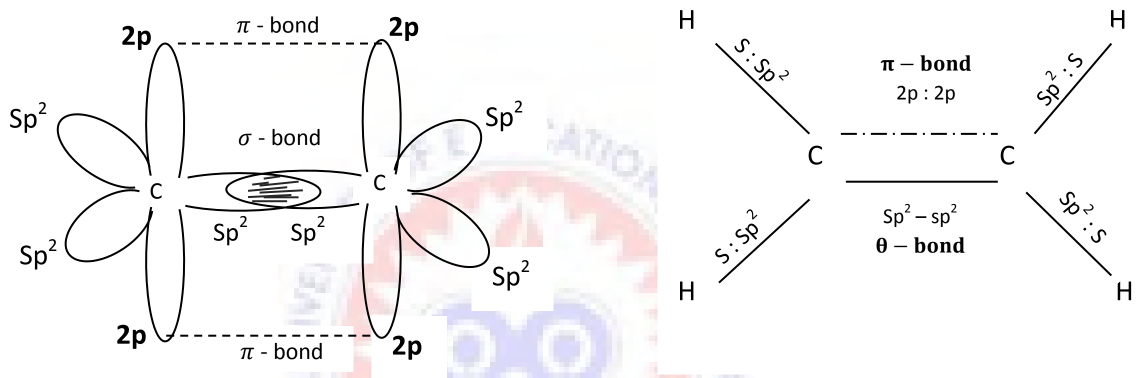


Each C is sp^2 hybridized

$_6\mathbf{C} = 1s^2\ 2s^2\ 2px^1\ 2py^1\ 2pz^1$ (E. S.)

One 2s and two 2p orbitals hybridize to form three hybrid orbitals leaving one pure p – orbital unhybridized. i.e.





(a) (b)

Figure 8: Formation of Pi and Sigma Bonds in Ethene (C_2H_4)

In the Figure 8 (a), each C atom used one of their sp^2 hybrid orbitals for head-on overlap to form a sigma bond. Their unhybridzed pure p-orbitals were then used to overlap laterally or side-by-side to form a pi – bond. The different types of orbitals (atomic or hybrid) that overlap in the formation of bonds in ethene (C_2H_4) are further illustrated in the Figure 8 (b).

sp^3 Hybridization

This occurs when one **s**-orbital mixes with three **p**-orbitals to form four equivalent sp^3 hybrid orbitals. Molecules with sp^3 hybridization of the central atom include **CH_4, NH_3** **PF_3** and **H_2O**.

Hybridization in **CH_4** is as follows:

The central atom C, in CH_4 is sp^3 hybridized.

	$1s^2$	$2s^2$	$2px^1$	$2py^1$	$2pz^0$
G. S. C.	↿⇂	↿⇂	↿	↿	

	$1s^2$	$2s^2$	$2px^1$	$2py^1$	$2pz^1$
E. S. C.	↿⇂	↿	↿	↿	↿

Mixing one **s** – orbital with three **p** – orbitals (2px, 2py and 2pz) generate four equivalent sp^3 hybrid orbitals (which has one electron each). Four hydrogen atoms with their single **s** – orbital electrons overlap with the four **sp^3** hybrid orbitals to form four sigma bonds. The shape is **tetrahedral** in space and has a bond angle of **109^0**. The Figure 9 is an illustration of formation of sp^3 hybrid orbital.

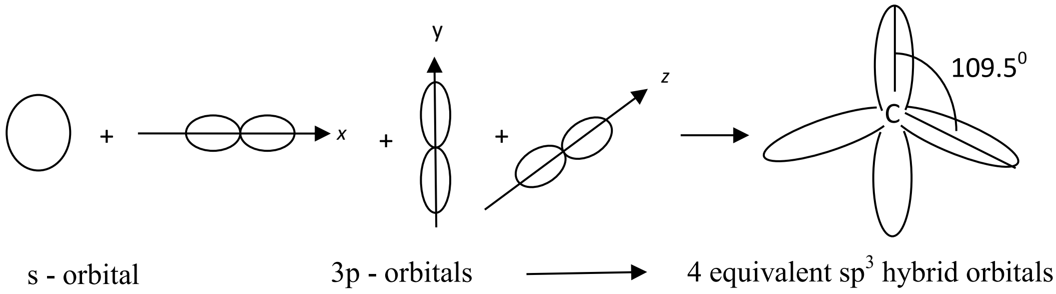


Figure 9: Formation of sp^3 Hybrid Orbital

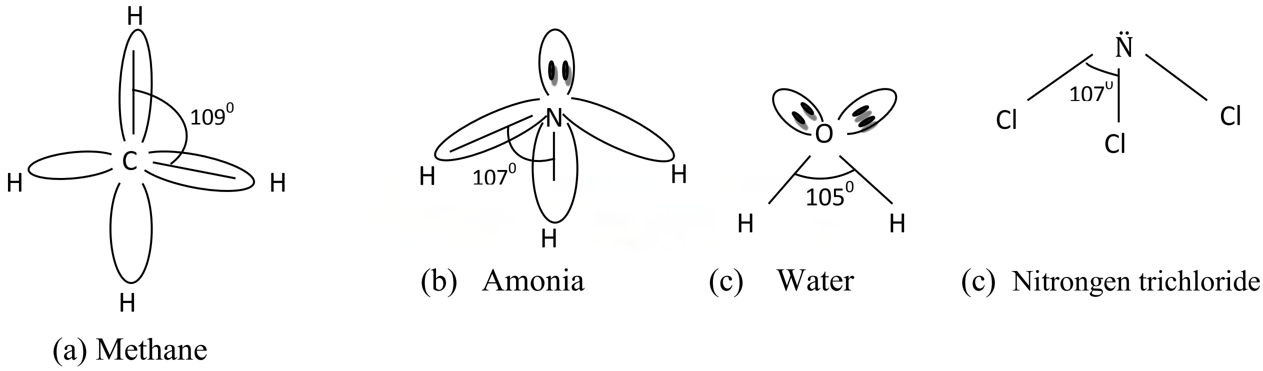


Figure 10: Shapes and Bond Angles of some sp^3 Hybrid Orbital Molecules

Shapes and bond angles of molecules are largely affected by repulsion between bonding pairs of electrons as well as lone pairs of electrons around the central atom in the molecule. As can be seen in the illustrations in the Figure 10, though the central atoms in all the molecules are sp^3 hybridized, their shapes and bond angles are not the same. Methane (Figure 10 a) for instance has no lone pair of electrons on the central atom carbon. As such the bond angle is 109^0 with a tetrahedral shape. Nitrogen in ammonia (Figure 10 b) and nitrogen trichloride (Figure 10 d) has one lone pair of electrons giving the shape of these molecules as trigonal pyramidal with bond angle of 107^0. Oxygen, the central atom in water (Figure 10 c) has two lone pairs of electrons resulting in a bond angle of 105^0 with a "V" or bent shape.

In case of a carbon atom, the four valence electrons are distributed among the four hybrid orbitals. This produces four half-filled orbitals capable of forming four bonds. An illustration of this is presented in the Figure 11.

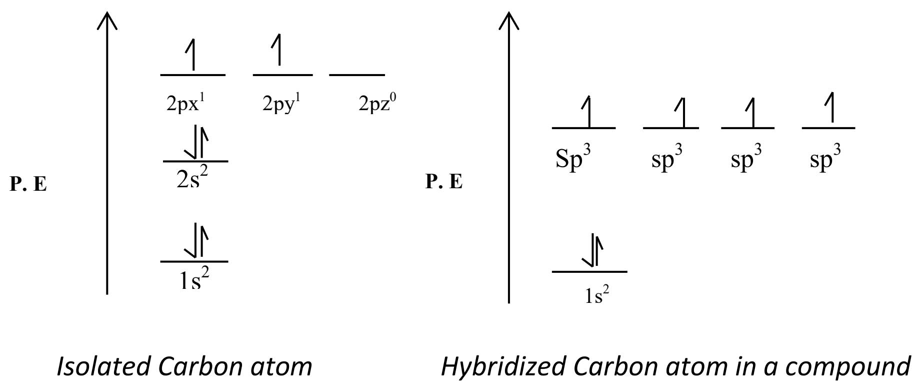
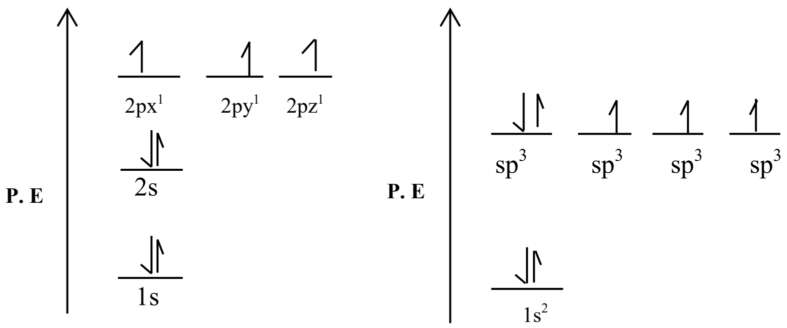


Figure 11: Relative Energy Levels of Electrons in Isolated and Hybridized Carbon Atom

Hybridization is also used to explain bonding in ammonia. If we assume that the Nitrogen bonds are due to the overlapping of its **p** orbitals then we should find that the bond angle in ammonia would be 90° since the **p** orbitals are located on the x, y and z axis.

This could not however explain the experimentally determined bond angle in ammonia of approximately 107°. Valence bond theory and Valence Shell Electron Pair Repulsion (VSPER) is used to predict a more satisfying structure, shape and bond angle in ammonia.

Let's assume that the nitrogen atom undergoes hybridization in a manner similar to carbon as shown the Figure 12.



Isolated Nitrogen atom *Hybridized Nitrogen atom in a compound*

Figure 12: Relative Energy Levels of Electrons in Isolated and Hybridized Nitrogen Atoms

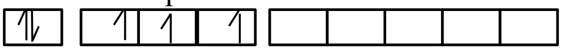
This approach yields four equal orbitals, three half-filled and one full, which is consistent with the (VSPER) prediction as well as the experimentally determined bond angle. The hydrogen atoms overlap on the three half-filled hybrid orbitals and the other hybrid orbital contains a non-bonding pair of electrons. The slight difference between the experimental bond angle (107°) and the theoretical angle (109°) can be explained by the fact that the repulsion of the lone pair electrons is greater than that for the bonding electrons. Just like ammonia, H_2O has sp^3 hybrid orbitals too, but two of them contain unshared electron pairs. These lone pairs try to be as far apart as possible. As such, the two O – H bonding pairs are pushed towards each other resulting in a bent geometry with a bond angle of 104.5^0 (Chang, 2005).

Sp^3d Hybridization

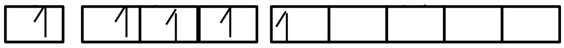
Central atoms in Period 3 or higher on the periodic table are capable of an expanded valence shell, breaking the octet rule. Part of the reason for this is their larger size and the fact that they have a d-sublevel, which can become part of the hybrid orbital picture.

As in Phosphorus pentachloride, (PCl_5), the central element P is sp^3d hybridized

G. S. C of P = [Ne] 3s 3p 3d



Because of the closeness of 3d energy level to 3s and 3p, one electron from 3s can be promoted to 3d. Thus E. S. C of P = [Ne]



Mixing of one 3s, three 3p and one 3d orbitals generate five equivalent sp^3d hybrid orbitals (with single electrons). Five Cl – atoms with single $3pz^1$ electrons overlap head-on with the five sp^3d hybrid orbitals. The Figure 13 is an illustration of an sp^3d hybridized molecule.

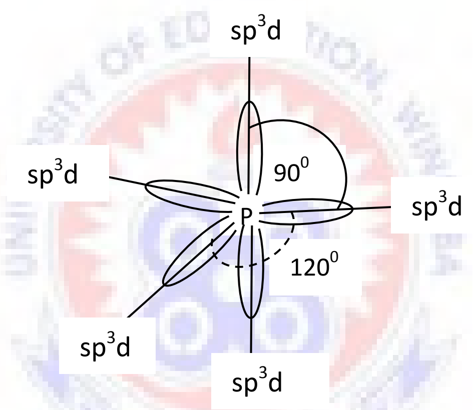


Figure 13: Shape and Bond Angles in sp^3d Hybridized Molecule

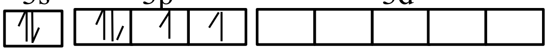
In other words, mixing five atomic orbitals of P produces five hybrid orbitals and with Hund's Rule in mind, five half - filled orbitals are capable of overlapping with the five **F** atoms to form $\mathbf{PF_5}$ as in the Figure 13. Any structure with trigonal bi-pyramidal electron pair geometry utilizes sp^3d hybridization, such as the $\mathbf{I_3^-}$ ion.

Sp^3d^2 Hybridization

When the central atom requires six bonding sites, sp^3d^2 hybridization occurs. This type of hybridization is associated with all octahedral geometries. **SF_6** and **XeF_4** are examples of this hybridization type.

As in sulphur hexafluoride, SF_6, the central atom S in SF_6 is sp^3d^2 hybridized.

G. S. C. [Ne] 3s 3p 3d



NB 3s, 3p and 3d energy levels are quite close

E. S. C. of S = [Ne] 3s 3p 3d

One electron each from 3s and 3p are promoted into the 3d –orbitals. This results in the formation of six equivalent $sp3d^2$ hybrid orbitals. Six F – atoms with single 2pz electrons overlap with the six sp^3d^2 hybrid orbitals (also with single electrons). The Figure 14 illustrates the octahedral shape with bond angle of 90^0 of sp^3d^2 hybridization in a molecule.

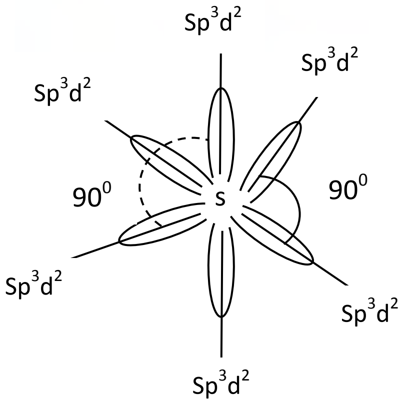


Figure 14: Shape and Bond Angle in sp^3d^2 Hybridized Molecule

Note that:

1. Formation of sp^3d hybridization in PCl_5 could be due to the high partial positive charge on P. (σ +5). This high charge is able to contract d – orbital to hybridize with s and p-orbitals.

2. S in SF_6 is surrounded by highly electronegative F-atoms.

Some Highlights

The Table 2 shows the type of hybridization which can be used to explain the various shapes found in nature and predicted by the VSEPR theory.

Table 2: Shapes of Types of Hybridization Predicted by the VSEPR Theory

Number of electron clouds	Electron cloud geometry	Number and Type of Hybridization	Atomic orbitals (formed from)
2	Linear	2 orbitals (called sp hybrids)	1s-orbital and 1p-orbitals
3	Trigonal planar	3 orbitals (called sp^2 hybrids)	1s-orbital and 2p-orbitals
4	Tetrahedral	4 orbitals (called sp^3 hybrids)	1s-orbital and 3p-orbitals
5	Trigonal bipyramidal	5 orbitals (called sp^3d hybrids)	1s-orbital, 3p-orbitals and 1d-orbital
6	Octahedral	6 orbitals (called sp^3d^2 hybrids)	1s-orbital, 3p-orbitals and 2d-orbitals

Note that the name of the hybrid orbital is determined by the atomic orbitals which were combined to form them. For instance: sp^3 hybrids were formed from 1s orbital and 3p orbitals. Atomic orbitals found in isolated atoms undergo a change (hybridization) when they are surrounded by other atoms in the compound. These changes in the orbitals allow scientist to explain the bonding of various atoms in nature. Hybridization theory is an attempt by chemists to adjust the concept of electron structures of various atoms, including carbon atom, to make them consistent with the way they are observed to bond in nature.

To determine number of required hybrid orbitals, simply count the number of peripheral atoms and the number of lone pairs on the central atom. Use the information to determine the shape and bond angle of the molecule.

Summary of the five types of hybridization addressed in this topic is presented in the Table 3.

Table 3: Summary of Types of Hybridization

Number of required hybrid orbitals	Electron Pair Arrangement	Type of Hybridization	Atomic Orbitals used to create Hybrids
2	Linear	sp	1 s-orbital and 1 p-orbital
3	Trigonal planar	sp^2	1 s-orbital and 2 p-orbitals
4	Tetrahedral	sp^3	1 s-orbital and 3 p-orbital s
5	Trigonal bipyramidal	sp^3d	1s-orbital and 3 p-orbitals s, 1 d-orbital
6	Octahedral	sp^3d^2	1 s-orbital, 3 p-orbitals and 2 d-orbitals

2.2.2 Using STAD cooperative learning strategy in enhancing understanding of the concept of hybridization.

Student's success in chemistry is influenced by a wide variety of factors including high mathematical and intellectual ability. Students with these high mathematical and intellectual abilities stand a greater chance of doing well in the subject than those with low abilities. However, Adjesoji and Ibraheem, (2009) are of the view that students understanding of the content of chemistry could be conceptual or algorithmic and neither of them seems to be responsible entirely for low test achievements. The presence of misconceptions has been well documented amongst students at all levels of education in numerous areas of the Chemistry curriculum (Taber, 2002; Kind, 2004; Cakmakci, 2010). It has been noted that this is, in the main, due to the abstract nature of the subject (Johnstone, 2009; Childs & Sheeham, 2009).

Abstract concepts are difficult for students to comprehend. Therefore, it is necessary to be aware of students' misconceptions so as to develop proper teaching strategies to deal with the misconceptions. Cooperative learning is a suitable strategy to deal with the misconceptions and improve students' conceptual understanding of abstract concepts (Acar & Tarhan, 2008).

Based on Slavin, (1995) cooperative learning model, when students have the motivation to learn and to encourage and help one another, a stage is created for cognitive development. Vygotsky, (1978) argued that cooperation promotes learning because the process enables learners to operate within one another's "zone of proximal development". Working with peers is academically beneficial because, when learners are closer to one another in their levels of proximal development, they are able to describe things to one another in a simpler way that is easier to be comprehended than being explained by a person with a very different mental stage. Thus there is the need to stress on active cooperation in the process of knowledge construction.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter entails detail description of the methodology that was used in the study. It includes the research design, population and setting, sample and sampling procedures, research instrument, data collection procedure and the method of data analysis that was employed to find the effect of cooperative learning on SHS Chemistry students' understanding of the concept of hybridization.

3.1 Research Design

Quasi-experimental, non-randomised pretest-intervention-postest control group design was used in the study. According to Vanderstoep and Johnston (2009), quasi - experiment involves conducting an experiment, usually in a real - life setting, without the benefit of random assignment of participants to conditions or other controls. The great strength of quasi-experiments lies in their practicality, feasibility, and, to a certain extent, their generalizability. In the real world, it is often impractical if not impossible to conduct true experiments (Polit & Hungler, 1995). The choice of quasi-experimental design was also informed by the fact that at the SHS level students are put into specific classes to do specific programmes. It is mostly unacceptable to heads of institutions to allow researchers to disorganise classes assigned to students of different academic programmes. Random assignment of students to groups was therefore impossible hence the use of the quasi-experimental design.

The use of non-randomized control group pretest-postest design has the advantage of reducing the reactive effects of the experimental procedure and, therefore, improves the external validity of the design. And pretest-postest designs are widely used in behavioural research, primarily for the purpose of comparing groups and/or measuring change resulting from experimental treatments (Dimitrov & Rumrill, 2003).

There were four groups consisting of two treatment groups and two control groups. The use of two treatment groups and two control groups is to level up the characteristic differences such as academic performance, gender and class size between the groups so as to increase the generalizability of the findings. Intact classes were used and like non-randomized designs, it helps to reduce reactive effects associated with randomized designs and thus improve external validity. The design is further explained in the Table 4.

Table 4: Summary of Research Design

Group		Pre-test	Mode of Instruction	Post-test
	G1	ATCH 1	STAD CL	ATCH 2
Treatment	G2	ATCH 1	STAD CL	ATCH 2
	G3	ATCH 1	IL	ATCH 2
Control	G4	ATCH 1	IL	ATCH 2

To reduce threats to internal validity by factors such as history and maturation, Achievement Test on Concept of Hybridization (ATCH 1 and ATCH 2) were similar but not the same. This was also to prevent learners from being "test-wise". In other words, to prevent guess work due to familiarity with the questions. The dependent variable was end of treatment tests (ATCH 2). The questions consisted of mainly two out of the three profile dimensions underlying behaviour for teaching, learning and assessment in Chemistry. These are knowledge and comprehension and application of knowledge but not much of practical and experimental skills based on Bloom's taxonomy of classification. A further summary of the design is as follows:

1. *Type of data* - Both qualitative and quantitative; the study employed the combined quantitative and qualitative paradigm.

2. *Independent variable* - Method of learning; individual learning and STAD cooperative.

3. *Dependent variable* - End of treatment tests (ATCH 2)

4. *Profile dimensions of questions* - Knowledge, comprehension and application of knowledge.

5. *Treatment period* – four weeks

3.2 Population and Setting

The target population of the study comprised of all public SHS Chemistry teachers and students in the Volta region of Ghana. The accessible population were eighty-two (82) chemistry students and three chemistry teachers including the researcher selected from four secondary schools in the Volta Region. The researcher taught at the two treatment schools while one teacher each taught at the control schools.

Volta region was chosen for the study because the researcher has been teaching in the region since September, 2008 and is thus familiar with the academic setting of the area.

3.3 Sample and Sampling Technique

The researcher employed purposive sampling technique to select four SHS' in the Volta Region of Ghana. Two out of the four schools served as treatment groups and the remaining two schools as control groups. Intact classes with a total of eighty-two General science chemistry students (64 boys and 18 girls) were used.

Forty-five students were in the treatment groups and thirty-seven students were in the control groups. The sampling was guided by the academic performance, gender, class size, teaching time table, topics already covered by the classes and distance between the sample schools. The use of purposive sampling is to buttress the importance of acquiring rich information from respondents to enable the researcher address the purpose of the study (Nakhado, 2002).

The distribution of the sampling procedure is presented in the Table 5.

Table 5: Distribution of Sampling Procedure

	Group	Boys	Girls	Total
Treatment	G 1	14	-	14
	G 2	23	08	31
Control	G 3	12	-	12
	G 4	15	10	25
Total		64	18	82

3.4 Research Instruments

After carefully reviewing relevant literature, four instruments were used for the study. These were;

1. Lesson notes with worksheets and end-of-lesson assessments on hybridization

A total of eight lesson notes were prepared for the four weeks treatments. Each lesson took 80 minutes (double periods) twice a week. Worksheets were answered in groups while end-of-lesson assessments were answered individually. The lesson objectives to the eight lesson notes can be found in the Appendix A and the worksheets that were used for the group works are in the Appendices B, C and D. The end of lesson assessments consisted of five multiple choices and three short answer questions which were answered individually after group discussions. These were mainly used to monitor progress of learning and were varied depending on what transpired during a particular lesson.

2. Achievement Test on the Concept of Hybridization (ATCH).

Two types were administered – ATCH 1(Appendix E) and ATCH 2 (Appendix F). ATCH 1 served as pre-test and a similar one (ATCH 2) as post-test. The two ATCHs were answered by both treatment and control groups of students. The questions consisted of twenty multiple choices and ten short answer type questions. The questions were used to test understanding and application on the concept of hybridization and were in line with the cognitive and affective domains of Bloom's taxonomy outlined in the SHS chemistry syllabus. Supervisor advice was sort in validating the questions and ensuring their reliability.

3. Questionnaire on students' attitude and motivation (QSAM) towards studying chemistry.

The questionnaire can be found in the Appendix G and consisted of nineteen items rated on five-point Likert scale ranging from strongly agree (SA) to strongly disagree (SD). In order to create balance on both sides of a neutral option and reduce bias measurement, the researcher adopted the five-point Likert scale and used the composite scores from the nineteen item questions to analyse the questionnaires.

4. Questionnaire on students' perception of peer cooperation (QSP).

This questionnaire consisted of eleven items also rated on five point Likert scale ranging from strongly agree (SA) to strongly disagree (SD) and is in the Appendix I. The Table 6 presents the three categories into which the eleven items have been classified.

Table 6: Category of Items on the QSP

Category	**Number of items**	**Item number on questionnaire**
Items in support of IL	3	1, 6 and 7
Items in Support of STAD CL	3	2, 10 and 11
Items in support of benefits of CL	5	3, 4, 5, 8 and 9
Total	11	11

The instruments were designed by the researcher after reviewing related literature and were validated by some senior colleague chemistry teachers at the SHS as well as my supervisors. The same questionnaires were administered before and after treatment.

3.5 Scoring the Instrument (Questionnaires)

Likert items on the Likert scale with five options (Strongly Agree, Undecided, Disagree, Strongly Disagree) was used to score the questionnaires. The items on the questionnaires were scored as follows:

Response Intensity	Score
Strongly Agree	5
Agree	4
Undecided	3
Disagree	2
Strongly Disagree	1

Negatively structured questions on the QSAM were coded reversely.

Composite scores were obtained by computing the mean values of the responses for the related items on the variable using SPSS for both questionnaires. The mean score ranged from a minimum of 1 to a maximum of 5. A mean value of 3 was considered as the middle point. A mean value below 3 indicated low level and above 3, a high level of attitude and motivation towards studying chemistry on the QSAM.

On the QSP however, composite scores were used for the three different categories of items on the questionnaire. That is the mean score of items in support of IL, CL and benefits of CL were determined. In order to ascertain the number of students that perceive either IL or STAD CL more beneficial method of instruction at the SHS, items 6 and 7 (which directly support IL) and items 10 and 11 (which directly support CL) were recoded on the Likert scale as follows:

Response Intensity	Score
Agree	3
Undecided	2
Disagree	1

Frequency count and analysis on these individual items was then adopted.

The Likert Scale

A Likert scale is commonly used to measure attitudes, knowledge, perceptions, values, and behavioural changes. A Likert-type scale involves a series of statements that respondents may choose from in order to rate their responses to evaluative questions (Vogt, 1999). It was developed by Likert, (1932) an educator and psychologist in his thesis at the University of Colombia, U. S. A., in response to the difficulties associated with measuring character and personality traits (Boone Jr. & Boone, 2012).

The original Likert scale used a series of questions with five response alternatives: strongly approve (1), approve (2), undecided (3), disapprove (4), and strongly disapprove (5). He combined the responses from the series of questions to create an attitudinal measurement scale. His data analysis was based on the composite score from the series of questions that represented the attitudinal scale. He did not analyse individual questions. While Likert used a five-point scale, other variations of his response alternatives are appropriate, including the deletion of the neutral response (Clason & Dormody, 1994).

3.6 **Validation of the Instruments**.

Validity of an instrument is the extent to which it measures what it intends to measure. It is concerned with how well it measures the concept(s) it is intended to measure (Alhassan, 2006). To ensure validity, the researcher used some WASSCE past questions related to the concept of hybridization. The self-constructed test items were edited by a senior chemistry teacher. All instruments intended for use in the study were also presented to the supervisors for editing and approval.

3.7 Reliability of the Instruments

Reliability according to Cohen, Manion, and Morrison (2001) refers to the consistency of test scores. Vanderstoep and Johnston (2009) define reliability as the extent to which a measure yields the same score across different times, groups of people or versions of instruments. To improve upon reliability, the ATCH instrument was pilot tested in two sister schools with relatively similar academic environments.

3.8 Piloting of the ATCH Instrument

According to Wilkinson and Birmingham, (2003) it is easy to overlook mistakes and ambiguities in question layout and construction when designing questionnaire. Besides, it is possible to design a questionnaire that is reliable because the responses are consistent, but may be invalid because it fails to measure the concept it intend to measure (Awanta & Asiedu-Addo, 2008). It is for this reason that the ATCH 1 and 2 were pilot tested. Feedbacks from the pilot test helped the researcher to make some changes with regards to the way the questions were framed, time allotted and provision of answer sheets. Random sampling was used to select a total of 20 students from two SHS' (10 students from each school) outside the accessible population but with similar academic environments. According to Gandhi (2012), the most common internal consistency or average correlation measure is Cronbach's alpha, which is usually interpreted as the mean of all possible split-half coefficients. Cronbach's alpha is a generalization of an earlier form of estimating internal consistency, Kuder-Richardson Formula 20. Cronbach's Alpha reliability coefficients were found using SPSS to be 0.725 (ATCH 1), 0.84 (ATCH 2) and 0.793 (QSAM) which were "acceptable", "good" and "acceptable" respectively (as presented in Table 7) based on the categorization of George and Mallery, (2003) (as presented in the Appendix J).

Table 7: Cronbach's Alpha Value and Interpretation

Instrument	Reliability Coefficient	Interpretation
ATCH 1	0.725	Acceptable
ATCH 2	0.840	Good
QSAM	0.793	Acceptable

3.9 Treatment Procedure

The treatment group was taught by the researcher whiles the control groups were taught by their respective class teachers for the four weeks treatment period. All teachers used the same note and similar exercises on the concept of hybridization prepared by the researcher and discussed together. There was regular communication between all teachers during the period.

A. Treatment groups

The following steps were followed during lessons:

1. Teacher presented the lesson in the form of lecture, illustration and discussion.
2. Students in five member heterogeneous academic teams engage themselves in cooperative study with the aid of worksheets.
3. Teacher gave end of lesson quiz/exercise

4. Students answered the questions individually without assistance from their team mates.

5. The average score of members of each team is calculated to find the team's mark.

6. Teacher recognised the best three teams.

7. Teacher gave (reading) assignments.

B. *Control groups*

1. Students sat individually throughout lessons.
2. Teacher presented the lessons in the form of lecture, illustration and discussion.
3. Students listened and wrote down chalkboard summary.
4. Opportunity was given to students to ask questions about any area that was not clear to them.
5. Students were given end-of-lesson exercises which they did individually.

3.10 **Data Collection Procedure**

Permission was sought from heads of selected schools for the study. A sample of permission letter can be found in the Appendix K. Seeking permission was also extended verbally to Heads of Science Departments as well as class teachers concerned. Both staff and students concern were previewed on the STAD-cooperative learning, benefits, the social skills and principles guiding intra-team cooperation. The cooperative learning guide used can be found in the Appendix H.

The following procedures were followed in collecting data:

1. Pre-test (ATCH 1) was administered to students to find out about their understanding of the concept of hybridization
2. Pre-treatment questionnaire on students' perception on peer cooperation (administered to only treatment groups) and
3. Questionnaire on their attitude and motivation (administered to both control and treatment groups) then followed. This was to eliminate the effect of cooperative learning strategy on their decisions.
4. Worksheets and end-of-lesson assessments were used to monitor students' progress on comprehension of the concept during lessons.
5. The post-treatment (ATCH 2) was then administered
6. Post-treatment questionnaire on students' perception of peer cooperation (administered to only treatment groups) as well as
7. Questionnaire on their attitude and motivation was then administered to both control and treatment groups again.

3.11 Data Analysis

According to Osuala (1993), data analysis is the ordering and breaking down of data into constituent parts and the performing of statistical calculations with the raw data to provide answers to the questions that initiated the research. Data collected was entered into the SPSS v. 16.0 software by the researcher and cleaned to get rid of errors resulting from coding, recording, missing information and outliers before running any analysis. Data was analysed using the Statistical Package for Social Science (SPSS) version 16.0. Inferences drawn from the statistical analysis results were used to answer the research questions. The statistical tool used (for the ATCHs) in the study was Analysis of Covariance (ANCOVA) with the pre-treatment test (ATCH 1) serving as covariate.

The ANCOVA is an extension of ANOVA that typically provides a way of statistically controlling for the effects of continuous or scale variables that you are concerned about but that are not the focal point or independent variable(s) in the study (Green & Salkind, 2003).

Inclusion of a covariate:

a) Increase power to detect group differences
b) Give precise estimates
c) Provides estimates of group means on the DV that statistically control or adjust, for differences on the covariate

The use of ANCOVA was to adjust the post-test means for difference among the intact groups (Dimitrov & Rumrill, 2003). For example, if the treatment group began the study with a higher mean IQ than the control group, ANCOVA can be used to provide a statistical estimate of group differences that account for this initial IQ difference.

ANCOVA Assumptions

The assumptions underlying the ANCOVA had a slight modification from those for the ANOVA, however, conceptually; they are the same and are as follows.

1. Independence: The cases represent a random sample from the population, and the scores on the dependent variable are independent of each other.

2. Normality: The dependent variable is normally distributed in the population for any specific value of the covariate and for any one level of a factor (independent variable). The assumption of normality can be checked with skewness values (e.g., within +3.29 standard deviations).

3. Homogeneity of variance: The variances of the dependent variable for the conditional distributions are equal. The assumption of homogeneity of variance can be checked with the Levene's *F* test.

Peculiar assumptions of ANCOVA are as indicated below:

1. Linear relationship between DV and covariate
2. The slope of regression line is the same for each group
3. Covariates are reliable and is a measure without error

NB: Homogeneity of slopes = homogeneity of regression = there is interaction between IVs and the covariate. If the interaction between covariates and IVs are significant ANCOVA should not be conducted.

The questionnaires were also analysed using SPSS. The QSAM was quantified into a scale and the mean scores calculated. The QSP was equally quantified into a scale based on the three categories of the items. Frequency count was conducted on selected items too.

CHAPTER FOUR

RESULTS AND FINDINGS

4.0 Overview

This chapter presents the statistical analysis of the research result and inferential statistical evidences needed to draw conclusions. Also, tested hypotheses, interpreted results, as well as evidence-based answers to the research questions have been adequately provided.

4.1 Research Question One

"To what extent does achievement test scores differ between students instructed using STAD-cooperative learning and those instructed using individual learning on the concept of hybridization in chemistry?"

The null hypothesis to this research question was "There is no significant difference between the mean scores of students who studied by STAD-cooperative learning and those who studied by individual learning". To answer this research question, ATCH 1 and 2 (Appendices E and F respectively) were used to collect data and which was fed into the SPSS v.16.0 and analysed.

The Table 8 presents the raw unadjusted means on the post-test. The post-test mean for STAD CL is 51.36 while that for IL is 24.76.

Table 8: CL and IL Groups' Post-test Raw Mean Scores and Standard Deviations

Mode of Instruction	Mean	Std. Deviation	N
STAD CL	51.36	7.981	45
IL	24.76	8.623	37
Total	39.35	15.652	82

The STAD CL treatment group scored higher marks on the post-achievement test (ATCH 2) than the control IL group as indicated in the Table 8.

After controlling group difference with the covariate (pre-test or ATCH 1), the adjusted mean for the STAD CL group was 52.325 and that for Lecture IL group was 23.577 as can be found on the Table 9.

Table 9: CL and IL Groups' Post-test Adjusted Mean Scores and Standard Deviations

			95% Confidence Interval	
Mode of Instruction	**Mean**	**Std. Error**	**Lower Bound**	**Upper Bound**
STAD CL	52.325[a]	1.203	49.930	54.720
IL	23.577[a]	1.336	20.919	26.236

a. Covariates appearing in the model are evaluated at the following values: Pre-test = 7.68.

Again, after adjusting for pre-test scores, a significant difference was found between the group taught with STAD cooperative learning and the group taught with IL $f(1, 79) = 78.722$, $p < 0.000$, $\eta^2 = 0.499$) ($f = 78.722$, $p < 0.05$) as illustrated in the ANCOVA Table 10 (against the labels "error" and "method").

Table 10: Summary of analysis of co-variance of achievement (Post with Pre) test scores on instructional method.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7904.294[a]	2	3952.147	40.081	.000	.504
Intercept	5820.534	1	5820.534	59.029	.000	.428
ATCH1	1804.229	1	1804.229	18.298	.000	.188
Method	7762.304	1	7762.304	78.722	.000	.499
Error	7789.719	79	98.604			
Total	109875.000	82				
Corrected Total	15694.012	81				

a. R Squared = .504 (Adjusted R Squared = .491)

The null hypothesis that "There is no significant difference between the mean scores of students who studied by STAD-cooperative learning and those who studied by individual learning" was thus rejected and the alternative hypothesis that 'There is significant difference between the mean scores of students who studied by STAD-cooperative learning and those who studied by individual learning" was accepted. Analysis of the dependent variable (post-test), using a Bonferroni adjusted alpha level of 0.05, showed that the treatment had significant effect on participants' achievement (Mean difference = 28.456) as shown in Table 11.

Table 11: Pairwise Comparison between STAD CL and IL

(I) Mode of Instruction	(J) Mode of Instruction	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
STAD CL	IL	28.456*	1.934	.000	24.607	32.304
IL	STAD CL	-28.456*	1.934	.000	-32.304	-24.607

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

4.2 Effect Size (ES) of the Treatment

The term 'Effect Size' describes indices that measure the magnitude of treatment effects (Kotrlik, Williams, & Jabor, 2011). Cohen (1962), sees it as a measure of the degree of difference or association deemed large enough to be of practical significance. Effect size provides a rigorous method for building on the findings of previous studies and aggregating the results to advance scientific knowledge and to guide policy development during educational reform (McNamara, Morales, Kim, & McNamara, 1998). Whereas statistical tests of significance tell us the likelihood that experimental results differ from chance expectations, effect size measurements tell us the relative magnitude of the experimental treatment (Thalheimer & Cook, 2002). Using standardised mean differences, the effect size of the control group (IL) is compared against the treatment group (STAD CL) in this study. This involves comparing the mean scores of the two variables and dividing them by the standard deviation. Researchers adopt different methods to calculate effect size among which is Cohen's 'd' or 'g'. Cohen's g ES is the difference between two means (treatment minus control) divided by the standard deviation of the two conditions. Table 12 presentes Cohen's suggested ES and its interpretation.

Table 12: Cohen's Interpretation of Effect Sizes

Effect Size	Interpretation
≤ 0.2	Small
≤ 0.5	Medium
≥ 0.8	Large

Depending on the statistical figures available, a researcher could choose from a number of several formulae for determining ES. Appropriate for this study is the one indicated below:

$$ES = \frac{\bar{X}_1 - \bar{X}_2}{S_{within}}$$

But $S_{within} = \sqrt{\frac{S_1^2\,(n_1-1) + S_2^2\,(n_2-1)}{n_1 + n_2 - 2}}$

Therefore,

$$ES = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2\,(n_1-1) + S_2^2\,(n_2-1)}{n_1 + n_2 - 2}}}$$

Where;

$\bar{X}_1$ = mean score of treatment group; $\bar{X}_2$ = mean score of control group

S_1 = Standard deviation of treatment group; S_2 = Standard deviation of control group

n_1 = sample size of treatment group n_2 = Sample size of control group

Some met-analysts argue that Cohen's g is a compromised form of ES since it has an inherent tendency to inflate the ES with small sample size. In other words, g is intuitively a biased estimator of the population effect size (DeCoster, 2004).

The corrected ES, also called Hedges' d is thus obtained using the following formula;

$$\text{Hedge's } d = g\left(1 - \frac{3}{4(n_t + n_c) - 2}\right)$$

Where;

n_t = sample size of treatment group

n_c = sample size of control group

Using the above formulae, both 'd' and 'g' values were found to be approximately 0.36 for the use of STAD CL in teaching the concept on hybridization. This ES according to Cohen's suggested interpretation is medium.

4.3 Research Question Two

What difference exists in attitude and motivation scores between students instructed using STAD-cooperative learning and those instructed using individual learning on the concept of hybridization in chemistry?

The null hypothesis was "There is no significant difference between the mean scores on attitude and motivation scale of students who studied by STAD-cooperative learning and those who studied by individual learning". Research question two was analysed with data from the QSAM (Appendix G).

Results of the means and standard deviations of the control and treatment groups on the attitude and motivation scale is summarised in the Table 13.

Table 13: Summary of Means and Standard Deviations on the QSAM

		Mean	**Variance**	**SD**	**N of items**	**Mean Difference**
Control	Before	77.97	87.471	9.353	20	1.03
Group	After	79.00	104.222	10.209	20	
Treatment	Before	75.31	75.856	8.710	20	4.93
Group	After	80.24	57.189	7.562	20	

From the Table 13, it can be seen that the treatment group had a larger effect size or mean difference (4.93) than the control group which had smaller mean difference (1.03). This though marginal, suggests that STAD CL improves students' attitude more towards studying chemistry.

4.4 Research Question Three

What are the perceptions of students who have undergone STAD-cooperative learning with regards to:

a) Individual learning,

b) STAD-cooperative learning and

c) Benefits of cooperative learning.

The QSP (Appendix I) was used to collect data which was analysed to answer the research question. The mean and standard deviation produced by the scale on the perception of students regarding IL, CL and benefits of CL before and after treatment are presented in the Tables 14 and 15.

Table 14: Mean and Standard Deviation for Pre-treatment on the QSP

Item	Mean	Variance	SD	N of items
Perception of IL	11.24	3.689	1.921	3
Perception of CL	9.02	4.022	2.006	3
Perception of Benefits of CL	17.22	6.449	2.540	5

As can be seen in the Table 14, the pre-treatment QSP scale produced a mean of 11.24 (SD = 1.921) for “Perception of IL”. “Perception of CL” had a mean of 9.02 (SD = 2.006) and “Perception of Benefits of CL” yielded a mean of 17.22 (SD = 2.540).

In the Table 15, it can be observed that for the post-treatment response to the QSP, the mean for “Perception of IL” is 8.62 (SD = 1.435), that for “Perception of CL” is 12.09 (SD = 2.032) and for “Perception of Benefits of CL” it is 20.51 (SD = 2.967). A glance at these means generally reveals that after exposing students to STAD CL, their “Perception of IL” dropped (from 11.24 to 8.62) whiles it increased for “Perception of CL” (9.02 to 12.09) and that for “Perception of benefits of CL” (17.22 to 20.51).

Table 15: Mean and Standard Deviation for Post-treatment on the QSP

Item	Mean	Variance	SD	N of items
Perception of IL	8.62	2.059	1.435	3
Perception of CL	12.09	4.128	2.032	3
Perception of Benefits of CL	20.51	8.801	2.967	5

The extent of effect of treatment by way of mean difference between the pre and post treatment response to the QSP is presented in the Table 16.

Table 16: Comparison between the Pre and Post Mean Scores on QSP

	Mean		Mean	Inference
	Post	Pre	Difference	
Perception of IL	8.62	11.24	-2.62	Drop in perception for IL
Perception of CL	12.09	9.02	3.07	Increase in perception for CL and its benefits.
Perception of Benefits of CL	20.51	17.22	3.29	

It can be observed from the Table 16 (summarised for Tables 14 and 15) that after exposing students to STAD CL, they perceived cooperative learning and its benefits as more viable instructional method than IL. Perception for IL saw a drop in mean by 2.62 (-2.62 in the Table 16) between the post-treatment and pre-treatment QSP scale whiles perception for both CL and its benefits saw an increase in mean difference of 3.07 and 3.29 respectively on the QSP scale. To answer the research question directly, students who have undergone STAD CL did not perceive IL as more beneficial in the teaching and learning process but rather they perceived STAD CL and its benefits brings more meaningful teaching and learning to them.

4.5 **Research Question Four**

What percentage of SHS chemistry students prefer CL or IL as the main mode of instruction at the SHS?

To answer this research question, frequency count was conducted on selected items (6, 7, 10 and 11) on the QSP (Appendix I).

Table 17 presents the frequency and percentages of students who responded to selected items relating to preference of IL and STAD CL as a viable instructional method at the SHS.

Table 17: Summary of Response to selected items on the QSP

Item 1. I prefer to work on my own

	Pre-Treatment		Post-Treatment	
	Frequency	Percentage	Frequency	Percentage
Disagree	9	20	13	28.9
Undecided	14	31.1	10	22.2
Agree	22	48.9	22	48.9
Total	45	100.0	45	100.0

Item 2. I learn more from direct teacher instruction

	Pre-Treatment		Post-Treatment	
	Frequency	Percentage	Frequency	Percentage
Disagree	7	15.6	3	6.7
Undecided	4	8.9	5	11.1
Agree	34	75.6	37	82.2
Total	45	100.0	45	100.0

Item 3. It is fair to use group effort at the SHS

	Pre-Treatment		Post-Treatment	
	Frequency	Percentage	Frequency	Percentage
Disagree	11	24.4	6	13.3
Undecided	14	31.1	6	13.3
Agree	20	44.4	33	73.3
Total	45	100.0	45	100.0

Item 4. All teachers should use cooperative group work in teaching at the SHS

	Pre-Treatment		Post-Treatment	
	Frequency	Percentage	Frequency	Percentage
Disagree	13	28.9	6	13.3
Undecided	18	40.0	6	13.3
Agree	14	31.1	33	73.3
Total	45	100.0	45	100.0

From the Table 17, item 1 “I prefer to work on my own”, supports IL. To this, 22 students representing 48.9% were resolute in agreeing to the statement in both pre and post treatment response to the QSP. A drop from 14 to 10 students (31.1% to 22.2%) respectively were undecided in responding to the item on the QSP in the pre and post treatment. An increase from 9 to 13 students (20% to 28.9%) respectively disagreed with the statement in the pre and post treatment on the QSP.

The item 2, “I learn more from direct teacher instruction” which also support IL on the QSP, produced the following responses in the pre and post treatment respectively:

A drop in number of students from 7 to 3 and in percentages, from 15.6% to 6.7%, disagreed to learning more from direct teacher instruction. A fairly constant number of students (4 to 5) representing 8.9% and 11.1% were undecided. Last but not least for item 2, a slight increase from 34 to 37 number of students which represents 75.6% and 82.2% respectively, agreed to learning more from direct teacher instruction.

The third item “It is fair to use group efforts at the SHS”, supports CL. 14 to 6 students (31.1% to 13.3%) were undecided just as 11 to 6 students (24.4% to 13.3%) respectively disagreed to the pre and post treatment QSP. Favourably, 20 to 33 students (44.4% to 73.3%) agreed that it is fair to use group effort at the SHS.

To item 4 “All teachers should use cooperative group work in teaching at the SHS”, a significant drop in number of students from 11 to 6 (24.4% to 13.3%) disagreed just as number of students who were undecided dropped from 14 to 6 (31.1% to 13.3%) respectively in responding to the item in the pre and post treatment QSP. 14 students (31.1%) agreed to the statement in the pre-treatment with more than double this number (33) representing 73.3% agreeing to the item in the post treatment item on the QSP.

To further define the percentage of students who prefer CL to IL, items 1 and 2 in Table 17 have been averaged and termed 'preference of IL' and items 3 and 4 into 'preference of CL' and summarised in the Table 18.

Table 18: Students' Preference of IL and STAD CL

Item 1. Preference of IL

	Pre-Treatment		Post-Treatment	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Disagree	8	17.8	8	17.8
Undecided	9	20.0	7*	15.5
Agree	28	62.2	30*	66.7
Total	45	100.0	45	100.0

Item 2. Preference of STAD CL

	Pre-Treatment		Post-Treatment	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Disagree	12	26.6	6	13.3
Undecided	16	35.6	6	13.3
Agree	17	37.8	33	73.3
Total	45	100.0	45	100.0

NB: * = fractions have been rationalised.

A glance at the Table 18 indicates that for perception of IL, a fairly constant response pattern to the QSP was recorded. 8 students, representing 17.8% disagreed in pre and post treatment response to the QSP, 8 and 7 students representing 20% and 15.5% respectively were undecided and 28 and 30 students representing 62.2% and 66.7% respectively agreed on the QSP.

Response to the second item labelled "Preference of STAD CL" indicates a more favourable preference of STAD CL to preference of IL by majority of students. The pre and post treatment responses to the QSP recorded 12 and 6 students representing 26.6% and 13.3% respectively registering their displeasure (disagreeing to) about using CL as a major instructional method at the SHS, 16 and 6 students representing 35.6% and 13.3% respectively were undecided and finally, 17 and 33 representing 37.8% and 73.3% respectively agreed to using STAD CL by teachers at the SHS.

Also worth noting is the fact that for preference of IL, number of students who were undecided dropped from 9 to 7 at the end of treatment period with those disagreeing remaining constant at 8 students whiles number of students who agreed, slightly increased from 28 to 30 students. On the item of preference of STAD CL, number of students who disagreed dropped significantly from 12 to 6 and the undecided number of students sharply dropped from 16 to 6 at the end of treatment. These culminated into an increase from 17 to 33 students who agreed to the use of CL as a major instructional method at the SHS.

CHAPTER FIVE

DISCUSSIONS AND IMPLICATIONS OF FINDINGS

5.0 Overview

This chapter discusses the findings of the study. Where necessary, explanations have been given as to why certain results were obtained. The state of Chemistry in Ghana currently and what can be done and perceived hindrances to CL have been discussed. Also discussed are the implications of the findings with the view to drawing conclusion from them.

5.1 Summary of the Major Findings

The study has come out with a number of findings worth considering by stakeholders in education. Not only do the results support or corroborate earlier and similar findings but it is indeed unique in the context of Ghanaian educational system where CL is hardly practiced. These findings are outlined below:

It was found that STAD-cooperative learning brought about more conceptual learning leading to significant achievement in test scores as compared to the widely used individual learning also referred to as traditional teaching method in some studies. In the ANCOVA Table 10 after adjusting for pre-test scores, produced a significant difference between the group taught with the STAD-cooperative learning and the group taught IL ($f = 78.722$, $p < 0.05$). Analysis of the dependent variable (post-test), using a Bonferroni adjusted alpha level of 0.05, showed that the treatment had significant effect on participants' achievement (Mean difference = 28.456). With a medium effect size of 0.36 the raw mean for the post-treatment test scores yielded 51.36 (SD = 7.981) for STAD CL and 24.76 (SD = 8.623) for IL. This surpasses some earlier findings for instance by (Ajaja & Eravwoke, 2010) where the use of cooperative learning in teaching integrated science at the Junior High School yielded a raw post-test mean score of 58.11 (SD = 9.60) and 38.62 (SD = 10.34). Similar achievement gains using STAD CL were also reported by Slavin R. , (1990) and van Wyk, (2012) and many others.

On students attitude and motivation towards studying the concept of hybridization in chemistry, the pre and post treatment QSAM scale produced a mean difference of 1.03 for the control group that studied by IL whiles their counterparts in the treatment group that studied by CL recorded a mean difference of 4.93, indicating a slight improvement in attitude and motivation towards the subject. The findings of this study are consistent with results obtained by (Wasanga, 1997) who also reported general moderately positive attitude towards science among students in Kenya. In CL, both boys and girls have generally positive attitudes towards science (Duncan, 1989). This assessment is further supported by an international assessment of science students in 20 countries carried out by International Assessment of Educational Progress (IAEP), (1992). Again this agrees with earlier findings by van Wyk (2012) where the use of STAD CL resulted in significant intrinsic and extrinsic attitude and motivation compared to the use of traditional teaching method.

Also important in this study is the establishment of the perception of students with regards to the use of STAD CL and IL. The study recorded a mean difference of -2.62 (Table 16) between the post and pre treatment QSP scale for IL indicating a drop in perception of the teaching method after sudents were exposed to the CL. As in Table 16 mean differences of 3.07 for STAD CL and 3.29 for benefits of STAD CL were also recorded at the end of treatment. This shows an increase in perception of STAD CL and its benefits over IL. It could therefore be said that in the opinion of majority of students, CL brings about more conceptual learning and improve their attitude and motivation towards studying chemistry which eventually results in better academic achievement gains.

With regards to which instructional method (IL or CL) should be mainly used at the SHS, results from Table 18 points to the fact that majority of students (73.3%) would prefer the use of CL as the main mode of instruction at the SHS.

5.2 Discusions

5.2.1 The Current state of SHS chemistry, findings of the study and what can be done

In Ghana, a fundamental challenge facing teaching of chemistry as a science subject in SHS is how to enhance students' conceptual understanding as well as favourable attitude and motivation towards the subject. This challenge has caused attainment of meaningful learning to elude students leading to poor performance in the WASSCE. This assertion is supported by many studies and reports including the chief examiners' report as as indicated in the statement of the problem in chapter one.

To address this poor performance, attitude and motivation about the subject, many researchers have pointed out that CL instructional methods are capable of reversing the negative trend. Sadly, many teachers in Ghana never practice them and it is also never suggested in the Chemistry syllabus.

In this study the first hypothesis tested if there is any difference in achievement test scores between students instructed using STAD-cooperative learning and those instructed using individual learning on the concept of hybridization in chemistry. The finding was that there was a significant improvement in the performance of the experimental group over the control group in the post-test scores. A clear indication that STAD CL instructional approach significantly increased students' conceptual understanding of the concept. This is consistent with the results of Eshun and Abledu (1999) in their investigation using female training college students where they used cooperative learning as an assessment procedure in addition to other alternative assessment procedures against traditional assessment procedures. The study also supports several other findings. For example findings of Dees (1991), Leikin and Zaslavsky (1997) on the achievement of students in experimental small-group learning approaches versus their counterparts in wholeclass approaches produced similar results. Infact cooperative learning methods has been found to contribute significantly to students achievement at all grade levels, in different subject areas and in different geographical locations. The findings therefore seem to suggest that students of the SHS exposed to STAD-cooperative learning retained significantly more chemistry taught in the study than those who learnt by IL. Besides, the finding suggests that CL learning can be used to assist SHS students to investigate and solve chemistry problems conceptually.

The second hypothesis tested if there is any difference in attitude and motivation scores between students instructed using STAD-cooperative learning and those instructed using individual learning on the concept of hybridization in chemistry? Scores obtained on the QSAM used, showed improvement in students' attitude and motivation towards studying chemistry. This study has therefore come to corroborate the assertions made by a number of researchers concerning poor performance of Chemistry students at the SHS and the fact that adopting more viable instructional methods such as STAD CL can improve performance, attitude and motivation towards the subject. Analysis of data gathered in the study and the findings clearly showed that given similar caliber of students under similar conditions, use of STAD CL produce better achievement scores, and attitude and motivation towards studying chemistry as compared to IL. This ties in with the observed increase in achievement and motivation gains made when CL rather than IL form of instruction was used by (Bernaus & Gardner, 2008). The use of ANCOVA made it possible to adjust for group differences and create a level playing field for the actual effect of STAD CL to manifest. It is imperative on stakeholders in education to train and equip teachers to adopt more viable instructional methods such as STAD CL to ensure good quality results since majority of students are in favour of the STAD CL.

5.2.2 Perceived hinderances to the STAD CL

There are numerous benefits of CL that are supported with numerous studies. However, practising CL comes with numerous challenges as well. Teachers need to understand the challenges in order to work their way around them so as to derive full benfits from using CL. These challenges might come from both students and teachers and have been outlined below:

1. Loss of control over the class

In IL, the teacher is on top of issues and has control over what is covered in a given lesson. Notes could even be passed on to students to write in advance or after the lesson. This is however not the case in CL most at times.

2. Lack of confidence in trying new methods

Most students' preconditioned their mind for ready answers from teachers. They are used to being spoon-fed and will feel lazy to try new things. Trying new methods means a move away from their comfort zone and even assuming some responsibility when students are not learning what is expected.

3. Fear for loss of content coverage.

A very common excuse given by most teachers for using IL is overloaded content for the average student. Group interaction may take more time. Since efforts at achieving conceptual understanding as in CL takes lot of time in planning and executing, teachers may be reluctant to practice CL. For instance just about two weeks treatment period might be allocated to the concept of hybridization under normal conditions and even when the researcher used four weeks treatment period a good proportion of the students were just about imbibing the concept when the researcher had to wrap up due to time constraints.

4. Lack of prepared materials for use in the class.

Current textbooks seldom provide ideas on how to use CL instructional methods, so the teacher has to prepare materials for groups. Not very many teachers may willingly do this.

5. The ego of the teacher.

Some teachers want and need to be the center of attention and to feel that they "know". Teachers who adopt CL or group activities are regarded in student circles as lazy or not competent enough. They want teachers who give them direct information of facts, figures and formulae without them doing much thinking.

6. Resistance to cooperative learning by students

CL eliminates competition among students. Many students especially those above average might feel pompous to help those below average. Those below average too might feel shy to seek help for fear of ridicule and name calling. In CL students will no longer compete against each other, but work to help each other learn. This might not be a welcomed idea for all categories of students.

7. Lack of background or training in the use of cooperative learning approaches.

Most teachers do not have the required skills from their training in the use of CL. As a result they teach the way they were taught.

8. Constituting and maintaining cooperative groups

It was made clear in the cooperative learning guide to students to feel responsible to each member of their groups and that if a group member is absent from class he/she should be able to depend on the other group members for notes and assignments for the class. However, it was observed in this study that it was quite unacceptable to some students in cooperative groups to have non-active members since group scores goes to the benefit of all individual members.

Practitioners of STAD CL need to prepare to deal with or accommodate some of the causes of instability and setbacks for CL groups as identified in this study. They include;

a. Students absenteeism due to; - Sack for school fees, Mid-terms (which may not be compulsory), and Sickness
b. Co-curricular activities: - Talks or symposia, music and culture, etc.; Sports and games; and water shortages.
c. Classroom arrangement: - Double desks and Overcrowding

5.2.3 How cooperative learning could be used to enhance conceptual learning

Students working in groups could be made to discuss ideas that conflict with their own understanding. In an attempt to explain and clarify their line of thinking, they seek new information. This could lead them to conceptual learning. Alternatively, the students could be tested only on the information they learned as a group. This will encourage their participation in the groups. Students working in cooperative groups can also generate new methods to solving problems which they have no previous knowledge of. Again, students give and receive help during discussions. This equips them with the ability to organize and clarify their thoughts leading to acquisition of in-depth knowledge and understanding of concepts better. It is important to note that the quality of feedback available to students is also enhanced when students receive help. Gaps in the receiver's mind are also filled which help clarify misconceptions. The praise and other reward systems attached to cooperative learning from both peers and teachers to individuals and groups help enhance their attitude and motivation as well as self-esteem towards the subject.

Teachers are to be encouraged to organize at least one exercise in the form of test or short quiz per week which should aim at measuring understanding and grasp of concept and may include group or individual assessment. Students' participation and contribution to teaching and learning should also be scored and added to their continuous assessment. This is to encourage students' participation in the teaching and learning process. It also help to erase the belief that the teacher is the only reservoir of knowledge and that students' need to be encouraged and made to understand that they can also contribute significantly to knowledge.

5.2.4 Benefits to be derived in cooperative learning

When used appropriately, cooperative learning has benefits for all subject areas and levels of students as well as teachers. To reiterate, some of the benefits of cooperative learning have been outlined in simple language below;

1. Provides opportunities for higher order thinking as opposed to passive listening.

Reinforces listening to others and gives opportunity for immediate feedback and adjustment of thought. Students talking together provide for input and listening. Students often have to assess the thoughts/ideas of peers, determine whether they "fit" their own, whether they disagree, or partially agree. Students have an opportunity to speak their ideas for better formulation.

2. Promotes greater student-faculty and student-student interaction.

Students assist each other in understanding material/content. This may even help students broaden their perspectives on issues or problems. Teachers have an opportunity to move from group to group, listen and if appropriate add comments. For some students this is the only personalization with a teacher that ever occurs. Teachers may answer questions that might never be asked without the closer interaction. Problems or misunderstandings can quickly and quietly be handled.

3. Increases student retention and limits anxiety.

Students are not overloaded with information. Students actually get time to think about, to talk about, and process information. Improves interaction and "talk" (Vygotskian Constructivism) and provides opportunities for students to think about and process the information. Time for "talking" and/or "writing" is needed to help students make sense of what they hear before attempting to "take in" even more information.

4. Give opportunities to connect the content to real life.

Students are often hesitant to speak up and offer opinions, especially in very large classes. Students can provide real life examples of the content being discussed, thus increasing the relevancy of the learning.

5. Builds self-esteem in students

Students help each other as discussion occurs. Students are more likely to respond to the whole class after discussing thoughts with a partner or small group. Responses may be more carefully conceived as they try responses with each other. Students may even discover that they understand the information because they must articulate the content to another.

6. Greater satisfaction with the learning experience occurs.

Students make personal connections to the content. Enjoyment of learning often leads to greater retention. Interaction often promotes a more positive attitude toward the subject matter or course.

7. Provides for improvement of social interaction skills

Greater acceptance of others and sense of "community" in the class - in part by addressing learning style differences. Students may even begin to create study groups for greater learning. Students who teach or tutor each other learn more about each other and how to better communicate information to others. Students benefit from building group skills by working together. Not everyone will agree; students may learn to cope with those who have differing viewpoints, or recognize that some problems can be very complex and not easily solved with simple responses.

8. Encourages alternative forms of assessment

Teachers have greater opportunities to observe actual processing of information, seeing the results of group assignments or field experiences. The applied projects indicate true knowledge.

9. Promotes higher levels of achievement, greater depth of thought and improved attendance.

Enjoyment of interaction and relevancy of content tend to encourage students to master the content. When students are responsible for reading a chapter, then use or discuss the content to create a product find that retention is greater. This often leads to improved attendance.

10. Encourages innovation in both teaching and student involvement.

Technology is easily incorporated by students and/or teachers. Students may share information via e-mail, WhatsApp or Facebook each other, join chat rooms, and collaborate on group activities effectively using the technology, rather than meeting face-to-face.

5.3 Implications of the findings

Results from this study revealed that achievement levels of the treatment group that studied using STAD CL was higher than the control group that studied using IL. This means that the use of STAD CL in teaching chemistry is more effective in bringing about conceptual learning than the use of IL. Cooperative learning instruction strategies enhance conceptual change (Lonning, 1993).

To reiterate, using cooperative learning at the SHS will increase conceptual learning and achievement as well as improve students' attitude and motivation towards chemistry and other subjects. These research findings have implications for curriculum planners, teacher training, GES and Ministry of Education workshop and seminars as well as classroom practice. As can be found in the Table 5 (p. 45), two control group (class sizes 12 and 25) totalling 37 and two treatment groups (class sizes 14 and 31) totalling 45 have been used in this study. Using the same variables, similar trends of results were identified when preliminary tests were run on data from individual classes just as when similar groups have been combined. The implication is that the findings of this study can be generalized to classes with similar student populations and academic environment. Analyses of results using the combined classes with similar treatment provided strength and increased the generalizability of the results. The positive and significant impact of the STAD CL strategy on learning outcomes and overall improvement in attitude and motivation towards chemistry provides direction for future research and implications for practice in the classroom.

Furthermore, the fact that majority of students (73.3%, in the Table 18 p. 68) expressed favourable opinions about its use at the SHS provides credible evidence for implementation and practice to improve their learning. The theory of social interdependence was adequately confirmed when majority of students indicated their support for “perception of benefits of CL” on the QSP scale. From Table 17 items 3 and 4, it can be seen that students who were provided the opportunity to learn cooperatively, perceived that they learned more, and that it will be in their interest for all teachers to adopt and use CL in teaching at the SHS.

Research conducted by Klein (1985) revealed that competitively structured classrooms have the effect of favouring boys or reinforcing sex role stereotypes that may limit opportunities for girls. In cooperative learning this usually is not the case, where interaction among students is intense and prolonged and students gradually take responsibility for each other’s learning (Borich, 2004). Apart from academic benefits, cooperative learning has been found to promote self-esteem, interpersonal relationship and improved attitudes toward school and peers (Johnson & Johnson, 1996). In STAD cooperative learning, students frequently interact with each other for learning and teaching, whereas in IL, the interaction among students is not available. A more organized interaction between the teacher and students is available in CL than in IL. Group learning has significantly more positive effects than individual learning on student individual achievement (Abrami & Apollonia, 2001). In cooperative learning, students also have opportunity to explain their opinions; present the alternative strategies and approximations that help them understand chemistry concepts. While students explain, transfer, and question their opinions through cooperative learning, they are passive learners in individual learning class atmosphere.

A positive attitude among students is an important goal of science education in many jurisdictions (Mayer, Mullen, & Moore, 2000). For instance section 5.0 of the White Paper on the Report of the Education Reform Review Committee by MOEYS (2004) under the headline "The Future Direction of Education in Ghana" indicated that:

> *....Government accepts that education should result in the formation of well-balanced individuals with requisite knowledge, skills, values, aptitudes and attitudes to become functional and productive citizens.*

A favourable attitude and motivation towards studying chemistry was expected in this study based on anecdotal evidence from teachers and researchers. CL is expected to provide and integrate the conditions necessary to promote persistence within a course (in the chemistry classroom) which according to Tinto (2003), are expectations, support, feedback, involvement and learning.

Cooperative learning group students showed less misconception when compared to traditional classroom students (Basili & Sanford, 1991). In view of this, students prefer using cooperative learning approach in their learning more than using individual learning method. According to Pintrich, Roeser and Groot (1994), students' positive motivational beliefs were positively related to higher levels of self-regulated learning and cooperative work. Cooperative learning activities instil in learners important behaviours that prepare them to reason and perform in an adult world (Adams & Hamm, 1996; Marzano, Pickering, & Pollock, 2001). Attitudes and values of learners are formed through social interaction. Borich (2004) noted that most of our attitudes and values are formed by discussing what we know or think with others. Continuing in this manner, we exchange our information and knowledge with that of others who have acquired their knowledge in different ways. This exchange shapes our views and perspectives. Our attitudes and values are among the most important outcomes of schooling (Borich, 2004). They provide the framework for guiding our actions outside the classroom. Cooperative learning is important in helping learners acquire from the curriculum the basic cooperative attitudes and values they need to think independently inside and outside of the classroom (Ajaja & Eravwoke, 2010).

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.0 Overview

This chapter covers the summary and conclusion of the study. Also, recommendations based on the findings have been provided for use by stakeholders in education as well as suggestions for further studies.

6.1 Summary

The two hypotheses used in the study have been supported by the results obtained. Student learning increased when STAD-cooperative learning was used. Besides, attitudes and motivation of students were improved by use of CL. Last but not least, majority of students perceive CL as more beneficial to them at the SHS. However, considering the fact that not all students perceive CL as useful to them, a diverse instructional method that incorporates more cooperative learning is recommended. In other words, a variety of instructional methods should be used in the classroom to accommodate the different learning styles of all students.

STAD-cooperative learning strategy improved academic achievement, increase attitude and motivation as well as establish the perception of students towards the instructional strategy in our SHS chemistry classrooms. The data from the study suggested a significant increase in academic achievement among most students. With an effect size of 0.36 one will say it is significant considering the fact that the concept of hybridization was not known to them previously. Also an entirely new instructional approach to teaching was used to treat the concept. It could therefore be said that the use of STAD-cooperative learning increases conceptual learning and improves achievement of students in the concept of hybridization in chemistry. Besides, the acquisition of team-work spirit and self-directed education imbibed in the benefits of cooperative learning is worth mentioning. This had a mean difference of 3.29 (Table 16, p. 64) between the pre and post treatment assessments. Similarly, a slight increase in student's attitude and motivation towards the subject with mean difference of 4.93 (Table 13, p. 62) was also recorded.

On the issue of all teachers using CL in teaching at the SHS, 73.3% of the students agreed with 13.3% each disagreeing or were undecided (Table 18, p.68). Though the percentage of students who are not in support of CL might be in statistically small, it is significant in educational circles where the need to address individual differences is important. Also considering the content load against time available for the average chemistry student, class size, the need for elaborate planning and organization involved in CL, etc, the researcher recommends a blend of STAD CL with other teaching and learning strategies in the Ghanaian SHS classrooms. However, more emphasis should be placed on CL than IL for more conceptual and meaningful learning.

6.2 Conclusion

Conceptual and meaningful learning has eluded many chemistry students for a long time making them to memorize facts and formulae in an attempt to pass their examinations. Some researchers identified cooperative learning as a viable instructional method than the widely use individual learning that could reverse the negative trend. In this study, two hypotheses were tested in the study. The first one tested if there is any difference in achievement test scores between students instructed using STAD CL and those instructed using IL on the concept of hybridization in chemistry. The finding was that there was a significant improvement in the performance of the experimental group over the control group in the post-test. This gives a clear indication that STAD CL instructional approach significantly increased students' conceptual understanding of the concept. This is consistent with the results of Eshun and Abledu, (1999), in their investigation using female training college students where they used cooperative learning as an assessment procedure in addition to other alternative assessment procedures against traditional assessment procedures. The study also supports several other findings. For instance CL method has been found to contribute significantly to students' achievement at all grade levels, in different subject areas and in different geographical locations. (Slavin, 1995). The findings therefore seem to suggest that SHS students exposed to STAD CL retained significantly more chemistry taught in the study than those who learnt in IL classes.

The second hypothesis tested was if there is any difference in attitude and motivation scores between students instructed using cooperative learning by STAD and those instructed using individual learning by lecture on the concept of hybridization in chemistry. Again, scores obtained on the QSAM used, indicated improvement in students' attitude and motivation towards studying chemistry. This agrees in with Kraus et al. (2009) as cited by Wang (2012) that when learning in a cooperative group setting, students develop a positive interdependence towards their classmates, which increases motivation. As students work cooperatively, positive behaviours like hard work, attending classes regularly, and active participation, acknowledgement of peer efforts, receiving and giving help among colleagues prevail thereby motivating students and changing their attitudes positively towards learning. In all, cooperative learning approaches offers a suitable environment of learning that allows students to be active learners. Contrary to this assertion, students in the learning environment of IL method are passive learners who cannot benefit properly in cognitive, affective and psychomotor domains of learning compared to those in CL.

As to whether students have favourable perception towards CL, the study confirms that students see cooperative learning approach as a valuable way for their learning, and since students are the main inputs of the educational process, their perceptions of learning and teaching methods should be seriously taken into consideration by stakeholders in education.

6.3 Recommendations

In view of the results obtained in this study, the following suggestions are presented:

Curriculum developers should take advantage of any future review of educational reforms at the SHS level to bring on board innovative teaching strategies such as the STAD-cooperative learning in teaching chemistry at the SHS.

Teachers teach the way they were taught. As used in ICT terms, garbage in, garbage out (gigo). If CL is to be given any serious attention in our schools, then student teachers at the training colleges and educational faculties of the universities should be taught how to incorporate cooperative learning strategies in their lessons.

The Ghana Education Service should hold workshops to educate teachers with the theory and practice of cooperative learning in chemistry classrooms.

Cooperative learning method should be introduced at the SHS for the education of students offering chemistry and other subjects.

Teachers in particular should be encouraged to adopt the use of STAD cooperative learning to improve performance of students in chemistry.

Teachers should be supported by school administrators with teaching learning material and equipment (e.g worksheets, computers and models)

A more comprehensive research with long period should be done with respect to cooperative learning to determine the effect of the method on science teaching and in all subjects and levels of education.

6.4 Suggestions for Further Research

The following are suggestions for further research:

1. It is suggested that the study be replicated in other schools in the Volta Region using the following as considerations;

   a) Different cooperative learning methods
   b) Different topics in chemistry
   c) Different science subjects
   d) Boys schools and Girls schools
   e) Public schools and Private schools
   f) Well-resourced schools and less-resourced schools

2. It is also suggested that an elaborate and long-term research involving all subject areas and levels of education be carried throughtout the Regions of Ghana to determine the efficacy of including cooperative learning strategies in our educational policies. This is to ensure that the academic and social benefits of schooling are achieved.

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APPENDIX A

LESSON OBJECTIVES ON HYBRIDIZATION

By the end of each lesson, students were expected to:

LESSON ONE

1. Explain hybridization
2. Describe how and when it occurs
3. Differentiate between atomic and molecular orbitals

LESSON TWO

1. Define sigma bonds
2. State the types of orbitals that overlap to form sigma bonds
3. Name some molecules in which sigma bonds are formed
4. Illustrate how sigma bonds are formed in the named molecules

LESSON THREE

1. Explain formation of pi bonds
2. Name compounds that contain pi bonds and how they are formed
3. Discuss differences between sigma and pi bonds

LESSON FOUR

1. Describe how hybrid orbitals are formed around the central atom in a molecule
2. Explain sp hybridization with regards to $BeCl_2$ and C_2H_4

3. Indicate the bond angles of sp hybrid orbitals

LESSON FIVE

1. Explain sp^2 hybridization

2. Draw the structure of BCl_3 and indicate the bond angles

LESSON SIX

1. Explain the formation of sp^3 hybrid orbitals

2. Describe the hybridization in CH_4, NH_3, PF_3 and H_2O

3. Indicate the bond angle in each case

LESSON SEVEN

1. Illustrate formation of sp^3d hybrid orbitals using PCl_5

2. Indicate the bond angle

LESSON EIGHT

1. Describe sp^3d^2 hybridization using SF_6

2. Explain the geometry of sp^3d^2 hybrid orbitals

APPENDIX B

WORK SHEET (Lesson 1 - 3)

WORK SHEET ONE

1. a) Explain the term hybridization.

   b) When does hybridization occur?

   c) Explain the difference between atomic orbitals and hybrid orbitals.

2. With the aid of box diagrams, write detail electron configuration of the following elements; C, N, O, S and P.

3. Write the Lewis structures for the following molecules and polyatomic ions:

   a. **N**H_3 b. **C**Cl_4 c. S**C**N^- d. **Br**F_2

   The central atoms are highlighted.

WORK SHEET TWO

Name the type of hybrid orbital formed when the following atomic orbitals mix up.

a) one s and one p orbital

b) one s and three p orbitals

c) one s and two p orbitals

What is the bond angle separating the hybridized orbitals formed?

WORKSHEET THREE

Determine the total number of sigma (δ) and pi (π) electrons in the following molecules.

a) $COCl_2$ b) CH_3CH_2CCN

b) A molecule XY_2 contains two σ, two π bonds and one lone pair of electrons in the valence shell of X. The arrangement of lone pairs as well as bond pairs is

c) (i) Square pyramidal (ii) Linear
(iii) Trigonal planar (iv) Unpredictable

APPENDIX C

WORKSHEET (Lesson 4 - 8)

NAME OF SCHOOL……………………………………………………………

NAME OF TEAM………………………………………………………………

LESSON NUMBER………………… DATE………………………

Valence Bond Theory and Hybridization

For the molecule(s) or ion(s), **…………………………………………**, perform the following operations on the **central atoms**.

1. Draw the correct Lewis Structure.
2. How many sigma bonds does it form?
3. How many lone pairs does it have?
4. Show the Ground State electron configuration of the valence electrons on it.
5. Show the Excited State electron configuration of the valence electrons
6. What type of Hybridization does it exhibit based on the number of hybrid orbitals required?
7. Show the hybridized state distribution of the valence electrons on it.
8. What is the molecular shape of the molecule/ion(s)?

Procedure/Useful suggestions

1. Draw the Lewis Structures and construct the models for the molecules given. Have your teacher check the models before proceeding.

2. To determine the type of hybridization, simply count the number of peripheral atoms plus the number of lone pairs on the central atom to determine the number of hybrid orbitals required according to your Lewis Structure.

3. The orbitals diagrams are for the central atom only.

4. Answer the remaining questions concerning the number and type of bonds, molecular shape, etc.

APPENDIX D

REPORT SHEET ON VALENCE BOND THEORY AND HYBRIDIZATION

(Lesson 4 - 8)

INSTRUCTION	**MOLECULE/ION**		
Lewis' Structure			
Number of sigma bonds on the central atom			
Number of lone pairs on the central atom			
Type of hybridization			
Ground state electron configuration			
Excited state electron configuration			
Hybridized state distribution of valence electrons			
Electron pair arrangement			
Molecular shape			
Bond angle(s)			

APPENDIX E

ACHIEVEMENT TEST ON THE CONCEPT OF HYBRIDIZATION (ATCH 1)

UNIVERSITY OF EDUCATION, WINNEBA

FACULTY OF SCIENCE EDUCATION

This questionnaire aims to find out your basic knowledge about hybridization in chemistry. Please respond to each item to the best of your knowledge. Your thoughtful and truthful responses will be greatly appreciated. Your responses will be kept confidential; it will be used only for research purposes.

Thank you for taking time to complete this questionnaire.

Please read the following statements and kindly provide the information.

School……………………………………………………………………………..

Name……………………………………………………………………………….

Sex…………………………………………………………………………………

Time: 40 minutes

SECTION A

[Multiple-Choice Objective Test]

Instruction: *Each question in this section is followed by four options lettered '**a**' to '**d**'. Choose the most appropriate option for your answer by circling around the letter that corresponds to your chosen option with a pen/pencil.* ***If you decide to change your answer, erase/cancel out the first one completely and re-circle your new choice***

SECTION A

1. Which of the following statements about the 2s and 2p orbitals is correct?
   a) They have the same maximum number of electrons
   b) They have the same number of sub-orbitals
   c) Electrons in the 2p are more strongly attracted to the nucleus
   d) The 2s has a lower energy than the 2p.
2. Which of the following statements is/are true?
   I. The s-orbital is spherical
   II. The p-subshell, in a magnetic field, has three orbitals namely px, py and pz
   III. The d-subshell splits into five orbitals under the influence of a magnetic field
   IV. The s-orbital and p-orbitals in their ground states have similar energies

   a) III only b) I and IV only c) I, II and III only I, II, III and IV
3. Which of the following orbitals has a dumb-bell shape?
   a) s-orbital b) p-orbital c) d-orbital d) f-orbital
4. An s-orbital is described as spherically symmetrical because the probability of finding an electron in the s-orbital depends on
   a) Distance from the nucleus only b) Direction from the nucleus only
   c) Neither the distance nor direction from the nucleus
   d) Both the distance and direction from the nucleus.
5. Are sigma (δ) and pi (π) different kinds of chemical bonds or the same kind of bond?
   a) They are certainly different kinds of bonds. b) They are a kind of ionic bond.

c) They are a kind of covalent bond. d) They are merely intermolecular forces.

6. Which of the following activities results in the formation of a pi bond?

   a) Side-by-side overlap of two p-orbitals b) Head-on overlap of two p-orbitals

   c) Overlap of two s-orbitals d) Overlap of an s-orbital and p-orbital

7. Overlap of sp^3 hybrid orbitals gives

   a) hydrogen bonds b) metallic bonds c) pi-bonds d) sigma bonds

8. Does hybridization determine the geometric structure of a molecule?

   a) Yes, it does b) No, it doesn't c) sometimes it does

   d) there are no relations between hybridization and molecular geometry.

9. Beryllium chloride ($BeCl_2$) has linear structure because the hybridization of Be is

   a) sp b) sp^2 c) sp^3 d) sp^3d

10. Mixing one s – orbital with three p-orbitals results in the formation of

    a) three sp^2 hybrid orbitals b) three sp^3 hybrid orbitals

    c) four sp^3 hybrid orbitals d) four sp^2 hybrid orbitals

11. The hybridization of the central carbon in $CH_3C{\equiv}N$ and the bond angle are

    a) sp^2, 180° b) sp, 180° c) sp^2, 120° d) sp^3, 109°

12. Which of the following statements about an sp hybridized carbon is **false**?

    a) It is divalent. b) It forms bonds that are linear.

    c) It has two p orbitals. d) It always forms triple bonds to carbon.

13. How many native orbitals are combined for the sp^3 hybridization?

    a) 1 b) 2 c) 3 d) 4

14. The planar shape of BCl_3 molecule can be explained in terms of the

a) sp hybridization of B b) sp^2 hybridization of B

c) sp^3 hybridization of B d) sp hybridization of Cl

[atomic numbers; B = 5, Cl = 17]

15. Which of the following statements about the shapes of NH_4^+ and NH_3 is true?

a) They are both tetrahedral in shape b) They are both planar

c) NH_4^+ is tetrahedral while NH_3 is pyramidal

d) NH_4^+ is square planar while NH_3 is triangular.

16. What is the shape of CH_4?

a) linear b) planar c) pyramidal d) tetrahedral

17. The hybrid orbital used in the formation of the C – Cl bond in CCl_4 is

a) spd^2 b) sp^3 c) sp^2 d) sp

18. The hybrid orbital with a geometry of trigonal bipyramidal shape is

a) dsp^3 b) sp^3d c) sp^3d^2 d) sp^3

19. The sp^3d^2 orbital has a geometry of

a) Trigonal planar b) octahedral c) tetrahedral d) trigonal bipyramidal

20. Which of the following compounds has a tetrahedral shape?

a) C_2H_4 b) C_2H_2 c) CH_4 d) H_2O

SECTION B

1. What is hybridization?
2. Is it possible for an isolated atom to exist in hybridized state? Explain.
3. What effect does hybridization have on bonds?
4. Explain briefly what atomic orbitals are?
5. Why do atomic orbitals undergo hybridization?
6. How does a hybrid orbital differ from a pure atomic orbital?
7. The two $–CH_2$ groups in C_2H_4 do not rotate freely around the bond connecting them, although the two $–CH_3$ in C_2H_6 have almost an unhindered rotation around the C – C bond. Why?
8. State the type of hybridization shown by the central atoms in

   (i) CO_2 and (ii) SiO_2
9. Why is water not a linear molecule?
10. Draw a complete structural formula for the compound CH_3CCCH_2CN

    i) Indicate the type of hybridization in each carbon atom in the compound.

    ii) For each carbon atom in the compound, state the geometry of the hybridized orbitals.

APPENDIX F

ACHIEVEMENT TEST ON THE CONCEPT OF HYBRIDIZATION (ATCH 2)

UNIVERSITY OF EDUCATION, WINNEBA

FACULTY OF SCIENCE EDUCATION

This questionnaire aims to find out your basic knowledge about **hybridization in chemistry**. Please respond to each item to the best of your knowledge. Your thoughtful and truthful responses will be greatly appreciated. Your responses will be kept confidential; it will be used only for research purposes.

Thank you for taking time to complete this questionnaire.

Please read the following statements and kindly provide the information.

School…………………………………………………………………………..

Name…………………………………………………………………………….

Sex……………………………………………………………………………….

Time: 40 minutes

SECTION A

[Multiple-Choice Objective Test]

Instruction: *Each question in this section is followed by four options lettered '**a**' to '**d**'. Choose the most appropriate option for your answer by circling around the letter that corresponds to your chosen option with a pen/pencil.* ***If you decide to change your answer, erase/cancel out the first one completely and re-circle your new choice.***

SECTION A

1. The following statements about the 2s and 2p orbitals are **false** except;

   a) They have the same principal quantum numbers

   b) They have the same number of sub-orbitals

   c) Electrons in the 2p are more strongly attracted to the nucleus

   d) The 2p is farther away from the nucleus than 2s.

2. Which of the following statements is/are true?

   I. The s-orbital and p-orbitals in their ground states have similar energies

   II. The p-subshell, in a magnetic field, has three degenerate orbitals

   III. The d-subshell splits into five orbitals under the influence of a magnetic field IV. The s-orbital is non-directional

   a) III only b) I and IV only c) I, II and III only d) II, III and IV

3. The shape of a *p* electron orbital is like that of

   a) Two pyramids touching each other b) Two spheres touching each other

   c) Two circles touching each other d) Tetrahedron.

4. An s-orbital is described as spherically symmetrical because the probability of finding an electron in the s-orbital depends on

   a) Direction from the nucleus only

   b) Neither the distance nor direction from the nucleus

   c) Both the distance and direction from the nucleus.

   d) Distance from the nucleus only

5. Which of the following best fit your understanding of sigma (δ) and pi (π) bonds?

a) They are interatomic bonds. b) They are formed by overlap of atomic orbitals.

c) They are a kind of covalent bond. d) They are merely intermolecular forces.

6. Which type of bond is formed when unhybridized p-orbitals overlap?

   a) Sigma b) covalent c) pi d) ionic

7. Overlap of sp^3 hybrid orbitals gives

   a) sigma bonds b) metallic bonds c) pi – bonds d) hydrogen bonds

8. Does hybridization determine the geometric structure of a molecule?

   a) Yes it does b) No, it doesn't c) sometimes it does

   d) there are no relations between hybridization and molecular geometry.

9. Carbon dioxide (CO_2) has linear structure because the hybridization of C is

   a) sp b) sp^2 c) sp^3 d) sp^3d

10. Mixing one s – orbital with two p – orbitals results in the formation of

    b) two sp hybrid orbitals b) three sp^3 hybrid orbitals c) two sp^2 hybrid orbitals

    d) three sp^2 hybrid orbitals

11. The hybridization of the central carbon in $CH_3C{\equiv}N$ and the bond angle are

    a) sp^2, 180° b) sp, 180° c) sp^2, 120° d) sp^3, 109°

12. Which of the following statements about an sp^2 hybridized carbon is **false**?

    a) It is trivalent. b) It forms bonds that are trigonal.

    c) It has three p-orbitals. d) It always forms triple bonds to carbon.

13. How many molecular orbitals are formed by the overlap of two sp^3 hybrid orbitals?

    a) 1 b) 2 c) 3 d) 4

14. The shape of BCl_3 molecule is trigonal planar due to

a) sp hybridization of B   b) sp^2 hybridization of B

c) sp^3 hybridization of B

d) sp hybridization of Cl   [atomic numbers; B = 5, Cl = 17]

15. The correct statement about NH_4^+ and NH_3 is

a) NH_4^+ is tetrahedral while NH_3 is pyramidal   b) They are both planar

c) They are both tetrahedral in shape

d) NH_4^+ is square planar while NH_3 is triangular.

16. What is the shape of CCl_4?

a) linear   b) planar   c) pyramidal   d) tetrahedral

17. The hybrid orbital used in the formation of the C – H bond in CH_4 is

a) spd^2 b) sp^3 c) sp^2 d) sp

18. The geometry of PCl_5 is trigonal bipyramidal shape. It's hybrid orbital is therefore

a) dsp^3 b) sp^3d c) sp^3d^2 d) sp^3

19. The shape of sp^3d^2 orbital is

a) Trigonal planar   b) octahedral   c) tetrahedral   d) trigonal bipyramidal

20. All the following are sp^3 hybridized except?

a) H_2O b) SiO_2 c) NH_3 d) CO_2

SECTION B

1. Explain why **C** forms **CH_4** and not **CH_2** even though it has two unpaired electrons in its **2p** orbitals?
2. When does hybridization occur?
3. Explain hybridization in NH_3. What is the bond angle and shape of the molecule?
4. What is a molecular orbital?
5. Give **two** reasons why atomic orbitals hybridize.
6. State **two** differences between an atomic orbital and a molecular orbital.
7. Which of these has free rotation around their **C – C** bonds?

   i) **CH_2CH_2** ii) **CH_3CH_3** **Explain**
8. Consider the molecules **CO_2** and **SiO_2**. State the type of hybridization shown by the central.
9. Explain the geometry of water molecule.
10. Draw a complete structural formula for the compound **$CH_3CCCH_2CH_2$**.

    i) Indicate the type of hybridization in each carbon atom in the compound

    ii) For each carbon atom in the compound, state the geometry of the hybridized orbitals.

APPENDIX G

QUESTIONNAIRE ON STUDENTS' ATTITUDE AND MOTIVATION TOWARDS LEARNING CHEMISTRY (QSAM)

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

This questionnaire aims to find out students **attitude** and **motivation** in studying Chemistry using cooperative learning. Please respond to each item to the best of your knowledge. Your thoughtful and truthful responses will be greatly appreciated. Your responses will be kept confidential and will not affect your examination result anywhere; it will be used only for research purposes. Thank you for taking time to complete this questionnaire.

Name of Student: ………..…………………………………………………………..

Sex………………………………..……………………………………………..

School ……………………………..………………………………………………

Please tick (√) the appropriate column of the response that much your thought.

Cooperative learning Motivation scale	Strongly Agree (SA)	Agree (A)	Undecided (U)	Disagree (D)	Strongly Disagree (SD)
1. Chemistry is the subject that I am most interested in.					
2. It is worthwhile to spend more time studying chemistry.					
3. I am pleased to take chemistry course.					
4. I solve more chemistry problems with my colleagues.					
5. I do well in chemistry.					
6. I will always do my best when solving chemistry problem.					
7. I do my chemistry homework conscientiously.					
8. I often participate in discussions during chemistry classes.					
9. I think I understand chemistry when the teacher teaches.					
10. I believe I am able to help others in chemistry classes.					

Cooperative learning Motivation scale	Strongly Agree (SA)	Agree (A)	Undecided (U)	Disagree (D)	Strongly Disagree (SD)
11. I am satisfied with my performance in chemistry					
12. I learn a lot from chemistry discussions with classmates and teachers.					
13. I feel a great sense of accomplishments when I finish my chemistry assignments.					
14. I like chemistry very much.					
15. chemistry learning is my hobby					
16. I don't like chemistry even though I know it's important.					
17. Learning chemistry can prove my ability to my parents.					
18. Good chemistry ability makes me get respect from my classmates.					
19. Good performance in chemistry can place me in a good job in the future.					

APPENDIX H

COOPERATIVE LEARNING GUIDE

To the Student

1. You will be assigned to a group. You should do your best to make adjustment and stick together with the group for the treatment period on hybridization. You are to develop a stable relationship with members of the group. Note that in real life we sometimes cannot choose the group we have to work with on a task. For example, we will have to cope with other players in a soccer team or on a school committee. However, you should discuss any serious misgivings you may have with your teacher and change your group if necessary.

2. You are to have regular interactions with other members. Aim to work together as a group in completing assignments.

3. A significant proportion of your end of term examination will be the evaluation of your group's work. Since group achievement reflects in individual achievement.

4. Through group effort your grade should be higher than the grade any individual in the group should earn by his/her own effort. Even if you would have gotten "**A**" by yourself, it will be a more quality grade by group effort. In addition you would have learnt things from other members that might not otherwise be possible.

5. The group activity should enable you to reflect on **science** ideas and discuss alternative approaches to answering questions. Thus you are not to be satisfied when the correct answer is obtained or one approach to a problem is used.

Always ask if you could have used a different approach. Learn to clarify your own thinking about a problem or concept by communicating your ideas to others in the group.

6. Individuals must strive to participate fully in group discussions since end-of-lesson exercises will be done and scored individually.

7. Try to work cooperatively with the other members of the group. You should encourage others to correct your errors in **science** reasoning.

8. Your group should select a name (e.g. **science** giants) and develop spirit de corps. This name should remind you of the goals you have set out for yourselves.

9. You must feel responsible to each member of the group. If a group member is absent from class he/she should be able to depend on you to get the notes and assignments for the class.

10. You should be willing to share responsibility to get work done. You may have to take turns to do things in the group (e.g. write-up assignments neatly for presentation if only one copy is required). First few groups to complete given task will be rewarded.

To Teachers

1. **Teach**:

    - Clarify objectives and motivate students; go over objectives for the lesson and establish learning set.

    - Present information and or material; this could be done verbally or with text

2. **Team Study**:

   - Organize students into learning teams; put students into cooperative learning teams based on mixed ability

   - Assist teamwork and study; assists and direct learning teams as they do their work

3. **Test**:

   - on material; test students' knowledge based on lesson presented

4. **Provide recognition**:

   - Find ways to motivate and reward both individual and group effort and achievement.

APPENDIX I

QUESTIONNAIRE ON STUDENTS' PERCEPTION OF STAD CL AND IL (QSP)

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

This questionnaire aims to find out the **perception** of students about **cooperative learning**. Please respond to each item to the best of your knowledge. Your thoughtful and truthful responses will be greatly appreciated. Your responses will be kept confidential and will not affect your examination result anywhere; it will be used only for research purposes. Thank you for taking time to complete this questionnaire.

Name of Student …...…………………………………………………………..

Sex …………………………..…………………………………………………

School …………………………………………………………………………

Please tick (√) the appropriate column of the response that much your thought.

Opinion on cooperative learning	Strongly Agree (SA)	Agree (A)	Undecided (U)	Disagree (D)	Strongly Disagree (SD)
1. I normally study chemistry on my own.					
2. I often study chemistry in groups.					
3. Group work encourages me to participate more in class.					
4. I gain more knowledge by discussing with my peers.					
5. I contribute fairly during group discussions.					
6. I prefer to work on my own.					
7. I learn more from direct teacher instruction.					
8. I relate well with other group members.					
9. Other group members explain things I do not understand to me.					
10. It is fair to use group effort at the SHS.					
11. All teachers should use cooperative group work in teaching at the SHS.					

APPENDIX J

CRONBACH'S ALPHA RELIABILITY COEFFICIENTS FROM SPSS

Cronbach's Alpha categorization by George and Mallery, (2003)

Cronbach's Alpha ≥	Interpretation
≥ 0.9	Excellent
< 0.9 α ≥ 0.8	Good
< 0.8 α ≥ 0.7	Acceptable
< 0.7 α ≥ 0.6	Questionable
< 0.6 α ≥ 0.5	Poor
< 0.5	Unacceptable

Reliability Statistics (ATCH 1)

Cronbach's Alpha	N of Items
.725	20

Reliability Statistics (ATCH 2)

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.084	.041	20

Reliability Statistics (QSAM)

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.793	.804	20

APPENDIX K

SAMPLE LETTER OF INTRODUCTION TO SAMPLE SCHOOLS

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

Our Ref. No.: FSF DPT 08 VOL 2 (2)

Your Ref. No.

October 28, 2021

TO WHOM IT MAY CONCERN

INTRODUCTION LETTER

The bearer of this letter, Mr. Degbor, Christopher Kwame is a Master of Philosophy student in the Department of Science Education in the above University.

He is conducting a research in "Effect of collaborative learning on the comprehension of the concept of hybridization by Kwanyako SHS 2 students".

Your school has been selected as part of his sampling area.

I hope you would assist him to have a good thesis write-up.

Thank you.

DR. K. D. TAALE

Head of Department