UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF CONSTRUCTIVIST INSTRUCTIONAL APPROACH ON STUDENTS' PERFORMANCE IN CHEMICAL BONDING CONCEPTS

GWENDOLYN OWUSU ANSAH

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A DISSERTATION IN THE FACULTY OF SCIENCE EDUCATION, DEPARTMENT OF SCIENCE EDUCATION SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF EDUCATION IN SCIENCE EDUCATION OF THE UNIVERSITY OF EDUCATION, WINNEBA

DECEMBER, 2015

DECLARATION

STUDENT'S DECLARATION

I, GWENDOLYN OWUSU ANSAH declare that this dissertation, with the exceptions 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.

SIGNATURE: ………………………………

DATE: ………………………………………

SUPERVISOR'S DECLARATION

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

NAME OF SUPERVISOR: **DR. ISHMAEL K. ANDERSON**

SIGNATURE: ………………………………

DATE: ………………………………………

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DEDICATION

This thesis is dedicated to my father, Mr Peter Owusu Ansah to my mum Madam Johanna Eduafo for her unflinching support of taking care of my beautiful children in order that i could do my Master of Education Science work; including this thesis. My husband, Emmanuel Adom Ofori for his support, my children; Henry Ofori Boateng and Michelle Asantewaa Ofori for their endurance during sandwich sessions.

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ABSTRACT

The purpose of this study was to examine the effectiveness of instruction based on constructivist approach on students‘ achievement and views of students towards constructivist instructional approach in teaching chemical bonding. The study was a mixed-method (quantitative and qualitative) within the Action Research Paradigm. A diagnostic pre-intervention and post-intervention test questions and a questionnaire were used to collect data. The questionnaire was on a 5-point Likert Scale and was used to investigate students‘ attitude towards constructivist instructions. The mean percentage of students on correct answer for the pre-intervention Multiple Choice Questions was 38.6 percent and that of the post-intervention was 88.0 and for the pre-intervention theory it was 27.13 and that of the post-intervention theory was 83.207. The findings of this study showed that students‘ conceptual understanding and performance in chemical bonding was largely improved after instructions based on the constructivist approach. The study also showed that majority of students appealed more to the constructivist approach than traditional instructions. Students agreed to have a higher interest in the participatory class since the mean of attitudinal scale was 3.9; they also agreed that chemistry should be taught in an interactive way with a mean of 3.8 on the attitudinal scale. It was therefore recommended that active student‘s participation approach could be used in the teaching of chemical bonding for effective learning and conception of chemical bonding.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter is the introductory part of the study. It unfolds starting with the background of the study. It proceeds through the statement of the problem. The purpose of study will give a brief description of what motivated the researcher to undertake this study. This is followed by the objectives of the study. Research questions formulated to achieve the objectives continue in this chapter, as well as the significance of the study. Limitations encountered during the course of the study, the delimitations of the study and the organisation of the remainder of the chapters of the study are the final part of the introduction.

1.1 Background of Study

There is no doubt about the fact that our world is being developed but based on the pace of progress in science and technology. In view of this, science education is seen to secure a key position in the curriculum of schools of countries around the world, and with Ghana as no exception to this. As to the learners of science, understanding and applying the scientific concepts learnt to effect the needed development or not, depends largely on the teaching and learning approach used. One of the important roles of science education is to develop learners‘ ability to improve their conceptual understanding and acquire knowledge in the subject (Siemens, 2014). Therefore method of instruction adopted by the teacher must be seen to be very crucial. New science teachers should be equipped with the ability to integrate and design the curriculum and technology for innovative teaching (Jang, 2010). Designing instruction that will promote better understanding of scientific concepts is key to the development of science education (Clark & Mayer 2016). However, the kind of science to be taught and how to teach it at different levels appear to be challenging over the past decades. This is because students have difficulty in imbibing abstract scientific concepts especially in chemistry as having been asserted by Chukwuka & Ezeudu (2014).

Ghana introduced science and mathematics teaching in the sixties but it appears there has not been much improvement on it since that time (Akyeampong, 2010). Despite efforts of the various stakeholders in the educational sector, the problem of lack of interest in science still persist (Akyeampong, 2010). Students' interest in science has been declining despite the growing importance of science and technology in all realms of life in every society; many young people appear to lose interest for it in schools (Entwistle & Ramsden, 2015). It is therefore in the interests of society, and the responsibility of educators, to improve students' attitudes toward science, and to prepare students to live in a highly scientific and technological society. A positive attitude toward science may improve students' academic performance in not only science classes, but in other classes as well. This is because science is seen as a way of knowing and understanding through the exercise of reason, a construction of the mind based on actual observation to explain natural phenomena Cohen, Manion & Morrison, (2013). Since science is limited to questions that can be approached by the use of reasoning, questions that can be answered by the discovery of objective knowledge and the elucidation of natural laws of causation (Hoover & Donovan, 2010)

There are many theories of learning, however, in this study the focus is based on Constructivist's theory of learning. "If we teach today as we taught yesterday, we rob out children of tomorrow" (Peake, 2010). It is believed that the world is constantly changing and students need to learn critical thinking skills in order to deal with these changes. Traditional teaching approach treats students as docile, non-active receptive entities that learn only from books and teachers. Knowledge is taught as a finished product. Students cannot learn essential problem solving skills if they are taught that all problems and solution to problems have already been worked out (Peake, 2010). Constructivism is basically a theory about how people learn. The theory says that people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences (Van Manen, 2015).

Learning is therefore an active social process. There is dynamic interaction between the task (learning), the teacher and the learner. The teachers are facilitators. It emphasizes on hands-on approaches, so the learning is by doing (Fink, 2013). Again traditional approach is criticised because the type of experiences promoted did not lead to the continuity of new experiences or aroused curiosity or initiative. When we encounter something new, we have to reconcile it with our previous ideas and experience, maybe changing what we believe, or maybe discarding the new information as irrelevant. In any case, we are active creators of our own knowledge. To do this, we must ask questions, explore, and assess what we know. (Darling-Hammond et al, 2015).

In other words, we as human actively construct knowledge and knowing is an adaptive process in which we make sense of the world on the basis of our experiences, goals, curiosities and beliefs (Cohen, Manion, & Morrison, 2013)

This may be done through asking of questions, exploring, and assessing what is known. In the classroom, the constructivist‘s view of learning can point towards a number of different teaching practices. In the most general sense, it usually means encouraging students to use active techniques (experiments, real-world problem solving) to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing (Brandon & All, 2010). The teacher makes sure she understands the students' pre-existing conceptions, and guides the activity to address them and then build on them (Brandon & All, 2010). Constructivist teachers encourage students to constantly assess how the activity is helping them gain understanding. By questioning themselves and their strategies, students in the constructivist classroom ideally become "expert learners." This gives them ever-broadening tools to keep learning. With a well-planned classroom environment, the students learn _howto learn‘ (Brandon & All, 2010). In all, it must be realised that the future of our society will be determined by citizens who are able to understand and help shape the complex influences of science and technology on our world (Ungar 2010).

1.2 Statement of the Problem

Many students in senior high school in Ghana appear to perform poorly in science, especially in integrated science and in particular topic like chemical bonding. This situation must be remedied. The chemical bond is one of the key concepts that should be taught in every upper secondary school, college and undergraduate chemistry course Levy Nahum et al (2010). Chemical bonding is one of the key principles as in chemistry and one of the most fundamental ones. It is also an aspect in of science where understanding can also be developed through diverse models – which are in turn built upon range of physical principles - and when learners are expected to interpret a disparate range of symbolic representations standing for chemical bonds (Dhindsa & Treagust, 2014).

Over the past years, concerns have been raised about the poor academic performance of students in the integrated science in Ghana. The chief examiner of the West African Examination in 2008 and 2009 revealed this shortcoming. The University Of Cape Coast Institute Of Education (an institution in charge of teacher training examinations) in 2008 and 2009 also report students‘ poor performance in science especially in the area of chemical bonding which will enable them to write chemical equations correctly. This might have contributed to students‘ inability to grasp the required fundamental concepts in writing chemical formulae and nomenclature. Furthermore, this situation raises questions about the depth of understanding of factors affecting the low performance of students in science. This is among the pertinent questions that must be answered to address low performance of students in integrated science. Is the fault entirely that of teachers or students or both of them? Or is the poor performance of students caused by the instructional approach used to teach? The present study therefore sought to look at how instruction in the classroom can contribute to helping improve the performance of students in integrated science and in particular at Wesley S.H.S.

1.3 Purpose of the Study

The purpose of the study was to investigate the effect of constructivist‘ learning approach on students‘ performance in chemistry, especially the concept of chemical bonding.

1.4 Objectives of the study

The objective of the study was to determine students‘:

1. Performance in the concept of chemical bonding before the use of constructivist‘ learning approach.
2. Performance in the concept of chemical bonding after the use of constructivist‘ learning approach.
3. Views about the use of constructivist‘ learning approach to teach chemical bonding

1.5 Research Questions

The following research questions were formulated to guide the study

1) What is the performance of students in the concept of chemical bonding before the use of constructivist‘ learning approach?
2) What is the performance of students in the concept of chemical bonding after the use of constructivist‘ learning approach?
3) What are the views of students‘ about the use of constructivist‘ learning approach to teach chemical bonding?

1.6 Significance of the Study

Producing students of value and not just for academic success is what drives a nation forward. According to Levy Nahum et al (2010) many studies conducted worldwide revealed that traditional pedagogy in chemistry appears not to help learners to understand fundamental concepts such as structure and chemical bonding. Students taught by constructing their own knowledge do not easily forget what they learnt. They are able to work effectively in their various workplaces and take their own initiative if their mode of learning was not by the rote memorization of chew, pour, pass and forget. Students with low cognitive abilities find the rote memorization of the abstract nature of science even more cumbersome hence it dampens their interest in the subject.

1.7 Limitations

Limitations as explained by Best and Kahn as cited in Amankwaa (2012) are conditions beyond the control of the researcher that will place restriction on the conclusion of the study and its application. This study was also limited to the unit of chemical bonding. It was also limited to only one class in form two.

1.8 Delimitations

The study was done with one school due to time constraint and funds. Also students were assessed on chemistry content alone as captured within the integrated science curriculum, but the researcher believes that chemistry holds central position in the sciences. Chemistry and physics have been labelled as difficult subjects Ogunkola and Samuel (2011); hence methods used in improving achievement for chemistry will equally work effectively in the other areas of sciences.

1.9 Organization of the Study

The research work is structured into five chapters. The first chapter is the introduction. The chapter is divided into sub- sections as the background to the study, statement of the problem, aims of the study, research questions, and definition of terms, delimitation of the study, limitation of the study and organization of the study. The second chapter deals with the literature review. It contains the theoretical framework of the study and conceptual framework basis of the study. Chapter three of the study deals with the methodology used to solicit information for the study. It entails research design, population and sampling, data analysis. Chapter four deals with analysis, results and discussions of the study. Chapter five which is the last chapter of the study summarizes the study, draws conclusion, makes recommendations and provides suggestions for further studies.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter is about literature which relates to this study concerning the teaching and learning of the concept of chemical bonding. The chapter begins with theoretical framework, which underpins the study. Some studies about performance of students in the concept of chemical bonding and its importance are considered. It continues with the relevance of studying the concept of chemical bonding and the difficulty associated with the learning of the concept. The final part of this chapter is about some methods of instruction in the study of the concept of chemical bonding.

2.1 Theoretical Framework of the Study

Constructivist's theory of teaching underpins this study. It is about a theory of knowledge that argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas Moreno (2010). This argument has influenced a number of disciplines, including psychology, sociology, education and the history of science. The core dependent variable ‗promoting conceptual change' is actually the implication or more clearly the consequence of cognitive development theories of Piaget and Vygotsky (Moreno, 2010). According to Moreno (2010), as Piaget contends that cognitive development can be promoted through equilibration or creating cognitive conflict, Vygotsky emphasises the need to assess the child zone of proximal development (ZPD) to navigate with scaffolding. Piaget also considered three processes important in cognitive development: assimilation, accommodation and equilibration. If a child uses existing concepts to deal with new phenomena, this is called assimilation (Knauer, 2015). When the students' current concepts are inadequate to allow him to grasp new phenomenon, then he replaces or reorganizes his central concepts. This is called accommodation (Moreno, 2010). Equilibrium, determines the child‘s transition from one stage of development to the next. At each stage, at the beginning, the child uses his logical structure that work well but toward the end of the stage, he becomes dissatisfied with his structure, organizes it and attains a new equilibrium. According to Piaget, equilibrium encompasses both assimilation and accommodation (Moreno, 2010). On the other hand, Vygotsky (2014) dealt with mechanism of development to the exclusion of distinguishable developmental stages. He rejected that single principle, such as Piaget‘s equilibration, couldn‘t explain development. He claimed that development is more complex. Vygotsky focused on process rather than product, his interest was not how well the children perform, but what they did under varying task conditions. Cultural and social factors affect the development of intelligence (Uzuntiryaki, 2003).

Unlike Piaget, Vygotsky focused on social activity. Development is transformation social relations to mental operations. Vygotsky claimed that learning and development are separate. Each school subject has its own relation to the child development and it varies as the child goes one stage from another (Knauer, 2015). As well as prerequisite skills and knowledge within a discipline, solving problems that enable them to improve their skills is important. Learning is more than acquisition of thinking ability; it is acquisition of many specialized abilities for thinking and occurs through social interactions. Partners work together and co-construct the solution to a problem (Knauer, 2015). Ausubel also described reception learning and discovery learning. In reception learning, the concepts and prepositions are presented to the learner by the independent agent (a teacher, a computer or a film) in its final form. In discovery learning, the learner rearranges new information, integrate it with existing structure and construct significant prepositions (Knauer, 2015).

Learning should be presented as a process of active discovery. The role of the instructor in constructivist‘s teaching is not to drill knowledge into students through consistent repetition, or to goad them into learning through carefully employed rewards and punishments but rather, the teacher is to facilitate discovery by providing the necessary resources and by guiding learners as they attempt to assimilate new knowledge to old and to modify the old to accommodate the new (Knauer, 2015). This may imply that teachers are expected to take into account the knowledge that the learner currently possesses when deciding how to construct the curriculum and to present, sequence, and structure new material.

Social constructivist theorizes that learners construct meaning through interactions with others, with materials, and by observation and exploration of events (Cobb & Steffe, 2010). According to Driver and colleagues as cited in Cobb and Steffe, the construction of the new meaning is most often facilitated by a more knowledgeable other. Strike and Posner opined that constructivist-based research suggests that informal science experiences lay the critical foundations for deep conceptual understanding (cited in Jones *et al.,* 2000). As such constructivists hold the view that learners‘ understanding of school science, to a large extent, is conditioned by their present common-sense experiences. This understanding, in turn is shaped by their prior encounters with various natural phenomena, even though their interpretations of such encounters may or may not be scientifically valid (Badri et al, 2016).). Hence, it is important that the curriculum should be shaped to reflect pupils' learning experiences in the affective domain Anderson (2006).

In the construction process, what a learner already knows or believes interacts with a new conception to which the learner has been exposed. Without both cognitive and social interaction, a new understanding will be difficult to achieve (De Jaegher, Di Paolo, & Gallagher, 2010). A constructivist teacher plays a key role at the interface between curriculum and student to bring the two together in a way that is meaningful for the learner. Thus, teachers with a constructivist viewpoint can influence the understandings of their students, and plan mediating events that assist students in moving from a current understanding, which is not scientifically based to a more scientifically accepted understanding (Windschitl, Thompson, Braaten, & Stroupe, 2012). Teaching strategies using social constructivism as a frame of reference relate to teaching in contexts that might be personally meaningful to students. These also involve negotiating understanding with students through class discussion in small as well as large groups of students (Anderson, 2006).

2.2 Students' Attitude and Performance towards Science

Research has confirmed the development of students' positive attitude is necessary because attitude is linked with academic achievement, Cheung (2009). Every science teacher considered the development of positive attitude towards science subjects as his centre responsibility (Cheung, 2009). According to Yara (2009), teacher, attitude and his method of teaching can greatly influenced the students' attitude. Bennett, Rollnick, Green and White (2001) also explored that the undergraduate students who had developed a lower constructive attitude towards chemistry almost always got low grade in examination. Understanding of students' attitudes is important in supporting their achievement and interest toward a particular discipline like chemistry. Students' attitudes towards science have been extensively studied (Dhindsa & Treagust 2014; Osbourne, Simon & Collins, 2003). These studies focused on science in general (Dawson, 2000) and less attention was addressed to particular discipline like Biology, Physics or Chemistry (Salta & Tzougraki, 2004). This can partly camouflage students' attitudes because science is not viewed as a homogenous subject (Spall, Barret, Stanistreet, Dickson & Boyes, 2003).

Achievement in chemistry has been a challenge for many educators not only here in Ghana but all over the world for the past few decades (Marasigan & Espinosa, (2014).). Research data collected over more than three decades has shown that the majority of students come to science classes with pre-instructional knowledge or beliefs about the phenomena and concepts to be taught and many students develop only a limited understanding of science concepts following instruction (Duit & Treagust, 2003). These students construct sensible and coherent understandings of phenomena and concepts as seen through their own eyes that do not match the views that are universally accepted by the scientific community. The resulting misunderstandings or alternative conceptions, if not challenged, become integrated into students' cognitive structures and interfere with subsequent learning. As a consequence, students will experience difficulty in integrating any new information within their cognitive structures, resulting in an inappropriate understanding of the new concept.

Educators of Science are facing rapidly increasing demands. They have been asked to devote more time to get students engage in scientific practices (Edelson, 2001). Educators must therefore employ interactive activities to elicit prior knowledge towards conceptual change and understanding (Carale & Campo, 2003). Chemistry has a lot of real life application and hence the teaching-learning context should be a combination of process and content learning activities, which equip students with a content in which they can construct their own questions and problems to answer through proper investigations (Clarke & Biddle, 1993). In order for the students to learn the abstract concepts in chemistry they must know how to make models or analogies, aside from doing laboratory tasks. In this way, students will have the potential of enhancing their understanding (Gabel, 2003).

Osborne, Bell and Gilbert as cited in Awan and Khan (2011) pointed out that students understand little about the nature of matter or about other chemical phenomena in their everyday lives. Unfortunately it appears to be a difficult field of study to both science students and teachers (Awan and Khan, 2011). It may be due to abstract nature of the fundamental concepts of chemistry (). The other problem seems to be not having the cognitive sophistication and the cumulative background of experiences necessary for the development of basic concepts of chemistry. In learning chemistry the basic unseen particles of matter like molecules, atom, electron and proton are taught in abstract. Another major problem appears to be with the teaching methodology, which does not meet the requirement to deal with the above-mentioned complexity, which is the abstract nature of basic concepts of chemistry. The ability to handle concepts as they currently exist and deal with them in a flexible and changing fashion must be seen as a joint objective of school learning communities (Awan and Khan, 2011).

2.3 Teaching and Learning the Concept of Chemical Bond

In school science teaching, ideas need to be presented in ways that are both authentic representations of the scientific concepts, and yet simple enough to be meaningfully understood by the learners. But chemical bonding is inherently an abstract and complex concept. Most often, when considering the teaching of chemical bonding, the arguments are engrossed on pedagogical issues rather than scientifically related disagreements (Levy Nahum et al (2010), & Taber 2010). Pointless to say, seeking a core understanding of chemical bonding becomes more problematic when we try to translate key ideas to the classroom practice. This review sets out to come out with the best way regarding the teaching and learning of chemical bonding.

2.4 Students' Achievement in Chemical Bonding

Chemical bonding is the cognitive key that students need to be able to unlock the door to understanding the microscopic world of chemistry. However, most students find it difficult to understanding the concepts in chemical bonding (Dhindsa & Treagust, 2014). One possible reason is that chemical bonding is an abstract and theoretical topic (Taber & Adbo, 2013). Also prerequisite knowledge such as the particulate nature of matter, electronegativity, energy and force in which students have difficulty in understanding are necessary requirements in understanding chemical bonding. Students hold a lot of alternative conceptions on chemical bonding as a result of this difficulty. Students misunderstanding of chemical bonding constitute a major problem of concern to science education researchers, teachers and students alike. The most common alternative conception among students was about ionic bonding, especially ionic bonding with Sodium Chloride (NaCl). Taber and Adbo (2013) investigated students' alternative conceptions dealing precisely with ionic bonding. Taber further established that students had difficulty in understanding ionic bonding and as a solution it was proposed that ionic bonding be presented in terms of a molecular framework.

Peterson et al (1989) also developed a multiple-choice diagnostic instrument to measure grade 11 and 12 students understanding of covalent bonding and structure and described the alternative conceptions by using this instrument. This diagnostic instrument was composed of a 15 two tier multiple-choice items. The first tier of each item consisted of a content question having two, three, or four possible reasons for the answer given in the first tier, which included the correct answer and three reasons of alternative conceptions. The alternative conceptions were identified from unstructured interviews, students' concept maps and open-minded pencil-and-paper test items. This test was administered to one hundred and fifty-nine 11^{th} grade high school students. The alternative conceptions that students held were as follows: equal sharing of electron pairs occurred in all covalent bonds, the polarity of a bond is dependent on the number of valence electrons in each atom involved in the bond, bond polarity determined the shape of the molecule, the shape of the molecule is due to equal repulsion between the bonds only. The shape of a molecule is only influenced by nonbonding electron pairs in a molecule;, intermolecular forces are molecules within a molecule, covalent bonds are broken when a substance changes state, nonpolar molecules are formed when the atoms in the molecule have similar electronegativity, nitrogen atoms can share five electron pairs in bonding and high viscosity of molecular solid is due to strong bonds in the covalent lattice.

Boo (1998) explored grade 12 students' understanding of chemical bonding and energetics through semi-structured interviews. The findings of the study indicated that most of the students confused ionic and covalent bonding with each other, and with other kinds of bonds. Also, some students believed that in aqueous sodium chloride there are ionic bonds existing between sodium ions and chloride ions and that half of the students confused the concept of element with the concept of compound or of an atom with ion. It was further shown that majority of students believed that bond making requires input of energy and bond breaking release energy.

A recent study conducted in Israel by Frailich, Kesner, and Hofstein (2009) investigated the effectiveness of a web-based environment in enhancing 10th grade students' understanding of the concept chemical bonding. Computer-based visual models were developed and implemented for the purpose of demonstrating bonding and the structure of matter. These were substantially based on student-centered learning. Drawing on a combined quantitative and qualitative research study Frailich et al. (2009) were able to conclude that the web-based learning activities which integrated visualization tools with active cooperative learning strategies provided students with opportunities to construct their knowledge regarding the abstract aspects concept of chemical bonding.

2.5 Types of Teaching Approach

Teaching method is said to be one of the strongest influence on pupils' attitudes towards science. Evidence has been provided by Osborne and Dillon (2008) that the quality of teaching of school science is a significant factor of attitude towards school science. An analysis of Woolnough's work according to Osborne and Dillon (2008), revealed six factors that were responsible for pupil choice or non-choice of the sciences. The two strongest factors were the influence of pupil's positive experience of extra-curricular activities and the quality of the science teaching. It has also been acknowledged that all teachers in the teaching field know that the teaching method or the pedagogy does indeed make a difference (Anderson, 2006).

2.6 Traditional Learning Approach

In traditional approaches to teaching and learning, textbooks and lecture provide the truth; there is little room for questioning, independent thought, or learner interaction (Entwistle, 2013). One of the goals of the chemistry teaching community is to develop more effective, pedagogically and scientifically sound, strategies to teach high-school students the concept of chemical bonding. According to Levy Nahum et al (2010), & Taber 2010), this aim is motivated by many studies conducted worldwide that clearly revealed that the traditional approach to teaching bonding is problematic, and misconceived. The problematic approach through which this concept is presented in many chemistry textbooks worldwide has been examined extensively in the last two decades by researchers of chemistry teaching and learning (Ashkenazi & Kosloff, 2006; Atzmon, 1991; Hurst, 2002; Justi & Gilbert, 2002; Taber, 2010). In these textbooks, elements are conveniently classified as metals or-non-metals (although sometimes semimetals are also mentioned). Very often this dichotomy among elements leads to a dichotomous classification of bonding related to compounds, namely covalent (existing between non-metallic elements) or ionic (existing between metallic and non-metallic elements). Hurst (2002) suggested that a common approach used by chemistry curriculum developers (and also by textbooks writers) is to present four different groups of substances: the ionic lattice, the metallic lattice, and the molecular lattice, and the covalent lattice. According to Hurst, these divisions and characterizations are then (wrongly) used to differentiate between substances.

Furthermore, many chemistry textbooks do not refer to the hydrogen and van-der- Waals interactions as bonds, they refer to them just as ‗forces' presumably since they do not meet the ‗octet rule' (the problematic aspect of using this ‗rule' for molecules is discussed below). This traditional pedagogical approach which is commonly used worldwide for studying bonding can be found not only in high-school textbooks but also in general chemistry textbooks intended for college freshmen (Hurst, 2002). Levy Nahum et al (2010) focus on two main problems. Firstly, the presentation of each bond type as a different entity that belongs to a specific category does not foster a deeper understanding of chemical bonds. Specifically, it may obscure the important notion of a unified rationalization of all chemical bonds based on underlying principles. Secondly, over-emphasis of the four ‗ideal' bonding categories (mentioned above) is misleading and may actually hinder the learning process. While the ‗ideal' classification is not without merit, it is now known (Naaman & Kronik, 2004) that many important groups of modern materials simply cannot be ‗forced' into one of the rigid categories.

In the following section, several limitations of the rigid traditional approach, which were mentioned above are illustrated, with specific examples from literature.

(1) *Covalent versus ionic bonding*. Typically, covalent and ionic bonds are presented dichotomously, as ‗electron sharing' as against ‗electron transferring' bonds, respectively. However, in hetero-atomic systems, bonding is better described in terms of a continuum of a covalent-ionic dimension or ‗scale' (Levy Nahum et al, 2010;

Sproul, 2005). Furthermore, bonds between two identical atoms are purely covalent, but purely ionic bonds actually do not exist at all (Levy Nahum et al, 2010). The dichotomous presentation impedes the understanding of the more subtle ‗scale'.

(2) *Electronegativity and bond polarity.* Because within the traditional approach bond polarity is essentially viewed as an additional characteristic of covalent bonds (Levy Nahum et al, 2010), the important concept of electronegativity (EN) is only introduced in the context of covalent bonding and not as an integral part of bond polarity concepts (Weinhold & Landis, 2005). EN differences between atoms are then used as an indication of whether compounds should be classified as ionic or covalent. However, EN differences are not the ultimate measure for predicting bond type (Sproul, 2005). Indeed, cases of bonds between atoms with large EN differences that nevertheless possess a significant covalent nature are known experimentally (Woicik et al, 2005).

(3) *The octet 'rule'*. Because it is simple for the learners to visualize and use, the octet ‗rule' is often presented as an obligatory condition for ‗proper"' bonding. Thus, students often adopt the anthropomorphic notion of atoms ‗wanting' to possess ‗octets' or ‗full outer shells' and consider that chemical reactions occur in order to ‗allow" atoms to achieve this ‗natural desire' (Taber & Adbo, 2013). But this causes some students to have difficulties in accepting anything that is not clearly explicable in ‗octet' terms, e.g., hydrogen bonds or even covalent bonds or transition metal bonding not leading to ‗octets'(Levy Nahum et al, 2010). It is now known that many molecules and complexes do not ‗obey' this rule (e.g. the ‗1998 Nobel Prize molecule ‗NO' (Nitrogen II Oxide) is a good example (Levy Nahum et al, 2010). The octet rule is certainly a time-honoured useful guideline and shall remain so.

2.7 New Directions for Teaching the Chemical Bonding Concept

In recent years computer technologies in general, and web-based teaching and learning in particular, have gained momentum in teaching and learning the sciences. Several studies have noted the benefits of web-based learning and its vast potential to empower learning and teaching in terms of its visualization, accessibility, and dynamicity (Capri, 2001; Clark, 2004; Linn, Clark, & Slotta, 2003). More specifically, in alignment with the idea of visualization to support students' learning the chemical bonding concept, Clark, (2004) noted the importance of integrating computer-based visualizations in learning abstract concept and phenomena. Kozma and Russel (2005) suggested that molecular models, simulations, and animations have the potential to contribute to the learning of chemistry in general and to better understanding of the chemical bonding concept in particular. Gilbert and Justi (2002) wrote that the use of computerized models has been advocated as a way to improve students' understanding of chemical phenomena by translating information expressed in different representations (see also Kozma & Russel, 2005). Moreover studies on students' use of computer-based models have shown that they can also improve students' visualization in chemistry (Barnea & Dori, 2000).

A study conducted in Israel by Frailich, Kesner, and Hofstein (2009) investigated the effectiveness of a web-based environment in enhancing 10th grade students' understanding of the concept *chemical bonding.* Computer-based visual models were developed and implemented for the purpose of demonstrating bonding and the structure of matter. These were substantially based on student-centred learning. Drawing on a combined quantitative and qualitative research study Frailich et al. (2009) were able to conclude that the web-based learning activities which integrated visualization tools with active cooperative learning strategies provided students with opportunities to construct their knowledge regarding the abstract aspects concept of chemical bonding.

2.8 Constructivist's Learning Approach

A fundamental shift towards student-centred or constructivist teaching and learning in classrooms is needed in order to fulfil the responsibility of producing members of society who will have the skills required to be effective citizens of the 21st century (Plourde & Alawiye, 2003).

One of the most important principles of educational psychology is that teachers cannot simply give students knowledge (Anderson, Greeno, Reder, & Simon, 2000). Students must construct knowledge in their own minds. The teacher can facilitate this process by teaching in ways that make information meaningful and relevant to students, by giving students opportunities to discover or apply ideas themselves, and by teaching students to be aware of and consciously use their own strategies for learning (Waxman, Padron, & Arnold, 2001). Teachers can give students ladders that lead to higher understanding, yet the students themselves must climb these ladders. A revolution is taking place in educational psychology. This revolution goes by many names, but the name that is most frequently used is constructivist theories of learning. The essence of constructivist theory is the idea that learners must individually discover and transform complex information if they are to make it their own (Brown, Collins, & Duguid, 1989; Tishman, Perkins, & Jay, 1995). Constructivist theory sees learners as constantly checking new information against old rules and then revising rules when they no longer work. This view has profound implications for teaching, as it suggests a far more active role for students in their own learning than is typical in many classrooms. Because of the emphasis on students as active learners, constructivist strategies are often called student centred instruction. In a student-centred classroom the teacher becomes the ―guide on the side" instead of the ―sage on the stage," helping students to discover their own meaning instead of lecturing and controlling all classroom activities (Windschitl, Thompson, Braaten, & Stroupe, 2012).

Golafashani (2003) presented constructivism as another paradigm in qualitative research that views knowledge as socially constructed and may change depending on the circumstances. Constructivism in social perspective is defined as the view that all knowledge and therefore all meaningful reality, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context. Constructivist approaches are student centred in that they use subject matter for interactive engagement with students. Classroom climate encourages discussions and negotiation of ideas. This gives opportunity to students to revise their structure and see other students‘ ideas Cohen and Lotan (2014). Constructivist teaching strategies take students‘ existing ideas as a starting point in instruction. To investigate students‘ pre-instructional conceptions many methods can be used such as observations, interviews, and conceptual relationships such as concept mapping, diagnostic test items and computerized diagnosis.

2.9 Critics of Constructivist's Learning Approach

Critiques of this approach (Kricshner, Sweller, & Clark, 2006; Mayer, 2004) argue that it is not workable for novice learners since they do not have underling mental models (schemas) necessary for ―learning by doing". They claimed that many educators misapply constructivism instead of using teaching techniques that require learners to be behaviourally active. They claimed that that not all teaching techniques based on constructivism are efficient or effective for all learners. They group a number of learning theories together and described as *Discovery, Problem-Based, Experiential, and Inquiry-Based learning* and stated that highly scaffold constructivist methods like problem-based learning and inquiry learning are ineffective.

2.10 Research Successes of the Constructivist Approach

A research performed by Guthrie et al. in 2004 did a comparison of three instructional approaches to compare third grade reading. The traditional approach, constructivist and collaboration activities were used. The constructivist approach resulted in better student reading comprehension, cognitive strategies, and motivation. Another research was done on students' retention of knowledge by Doğru and Kalender using traditional teacher- centred approaches to those using student-centred, constructivist methods. Their initial results showed no significant difference between the two methods. However in a follow up assessment two weeks later, students who learned by constructivist methods showed better retention of knowledge than those who learned through traditional methods.

In studies where constructivist approach was used, it has been shown that constructivist teaching strategies were effective in enhancing students understanding and achievement. For example, Niaz (1995) studied on dialectic constructivist framework based on cognitive conflict for freshman chemistry students. He reported that students exposed to cognitive conflict method were more successful than students studied traditionally. Also, Caprio (1994) examined the effectiveness of the constructivist approach compared with the traditional lecture-lab method. It was concluded that students taught by constructivist methodology had significantly better exam grades. Moreover, these students seemed more confident of their learning. Akku- et al. (2003) investigated the effectiveness of the instruction based on the constructivist approach by focusing on the in-class teacher-student and student-student interaction within small groups over traditional method. The results indicated that the students who were instructed by constructivist approach acquired chemical equilibrium concepts better than the students taught by traditional method. This study also concluded that students' previous knowledge and science process skills had an influence on their understanding of the concepts related to chemical equilibrium.

Research studies revealed that constructivist teaching strategies are useful not only improving achievement but also they help students construct their views about science and develop thinking ability. Carey (2011) concluded that prior to the constructivist methodology that included scientific inquiry, most students viewed science as a way of understanding facts about the world. After the constructivist methodology, most of the students saw scientific inquiry as a process guided by questions and ideas Carey (2011).

Tynjala (1998) found similar results, too. She compared learning outcomes of educational psychology students studied traditionally with examinations and studied constructivist learning tasks without examination. Constructivist group students were given assignments that require transforming knowledge, activating previous knowledge, comparing and criticizing different theories. Students discussed their assignments in groups and wrote an essay. To provide research material they were administered a control group's exam but they were not graded. Traditional group students were instructed by traditional methods. They attended classes, studied the textbook on their own and had an examination. Results showed that students in the constructivist group acquired an ability to apply knowledge and developed their thinking and communication skills.

As well as better students' understanding and improvement in thinking skills, students' perception of these types of strategies is an important factor for their achievement. Hand et al. (1997) examined junior secondary school students' perceptions of implementation of constructivist approach to the teaching of science. An open-ended questionnaire followed by semi structured interviews was used. It was concluded that most students liked the constructivist teaching learning approaches because of being more actively involved, having more discussion, practical work, less note-taking, and having more fun and greater understanding of concepts. By examining interviews, it was seen that students were more active in the learning process. They could state their ideas whether they are wrong or right. They had opportunity to see and control their thinking. They constructed correct knowledge more confidently and became more confident in their understanding of science. Teichert and Stacy (2002) investigated the effect of students' prior knowledge, integration of ideas with their existing structure and their explanations affected their conceptual understanding of the principles of thermodynamics and chemical bonding. Experimental group students participated in the intervention discussion sections whereas students in the control group were instructed traditionally. Using a curriculum that encouraged students' explanations of their conceptions made students gain a better understanding of the concepts.

2.11 Confusion between Constructivist and Maturationist Views

Many people confuse constructivist with maturationist views. The constructivist (or cognitive-developmental) stream "is based on the idea that the dialectic or interactionist process of development and learning through the student's active construction should be facilitated and promoted by adults" (DeVries et al., 2002). Whereas, "The romantic maturationist stream is based on the idea that the student's naturally occurring development should be allowed to flower without adult interventions in a permissive environment" (DeVries et al., 2002). In other words, adults play an active role in guiding learning in constructivism, while they are expected to allow children to guide themselves in maturationism.

CHAPTER THREE

METHODOLOGY

3.0 Overview

Chapter three describes the methodology of the study. It covers the research design, the intervention, population, sample and sampling procedure used as well as research instruments used for data collection. Other issues considered in this chapter were validity and reliability of the research instruments, data collection and data analysis.

3.1 Research Design

It is a fact that research designs are often equated with qualitative and quantitative research methods. Researchers in education and science education have three general choices of methodology; a qualitative or a quantitative and mixed methods approach (Creswell, 2009) and each approach possesses both advantages and disadvantages. Qualitative studies typically use resource intensive data gathering techniques such as interviews. These studies are useful in that they allow researchers to study issues of interest in great depth and, for example, allow investigators to probe for underlying reasons about students views for abstract scientific concepts (Coll & Treagust, 2002). However, because data collection in qualitative studies is more labour intensive, these studies typically involve small numbers of participants, which may result in a lack of generalisability (Dalgety & Salter, 2002). In other words it is not always clear what implications the findings hold in other contexts. Quantitative studies are seen to involve a large number of participants and allow researchers to quantify the issues under study. By the judicious use of statistical analysis, researchers can investigate changes and trends and extrapolate their findings to a target population

(Dalgety & Salter, 2002). However, whilst the results from quantitative studies are more generalisable, they are often less detailed. Hence, researchers are confronted with a trade-off situation in which they must choose between the depths of understanding provided from qualitative studies, versus the generalizability of a quantitative approach hence, because of this dilemma; some researchers employ a mixed-methodology approach (Coll & Chapman, 2000).

A definition provided by Sensing (2011) adhere that qualitative research is multi-method in focus, involving an interpretive, naturalistic approach to its subject matters. This may imply that qualitative research study things in their natural settings, attempting to make sense of, or interpret phenomena in terms of the meanings people bring to them. The qualitative researcher often goes to the site of the participant, enabling to develop a level of details about the individual or place to be highly involved in actual experiences of the participants (Bashir, Afzal, & Azeem, 2008). Qualitative research involves the studied use and collection of a variety of empirical materials (case study, personal experience, introspective, life story, interview, observational, historical, interactional, and visual texts) that describe routine and problematic moments and meanings in individuals' life (Bashir, Afzal, & Azeem, 2008).

This study was of Action Research Design. This design was employed because the researcher had been teaching at Manso Adubia Senior High school for the past six years, where the problem of students‘ poor performance in integrated science especially in chemistry and physics component for this study was observed. More particularly because Action Research does not just involve asking about it, it involves doing it. Action Research is a framework that is Collaborative and there is a practical intervention made. Thus something is done to make a change or intervention in a situation that the researcher will be actively involved in the planned intervention.

Therefore in this research, the data collection practice for this study was a diagnosis pre-intervention and post-intervention test questions within the quantitative research convention and a questionnaire under the qualitative research tradition. The study was a mixed-method (quantitative and qualitative) within the Action research paradigm. Justification for the mixed method design is that it is erroneous to equate a particular research design with either quantitative or qualitative methods. Yin (cited in Goodman, 2015), a respected authority on case study design, has stressed the irrelevance of the quantitative/ qualitative distinction for case studies.

3.2 Population

Population is used to refer to the entire group the investigator wishes to make inferences about (Yin, 2013). Hope and Dewar (2015) suggest that population is all possible cases of what we are interested in studying. A research population is generally a large collection of individuals or objects that is the main focus of a scientific query. It is for the benefit of the population that researches are done (World Medical Association, 2001). For this research the target population was all students of Wesley Senior High School in Konongo Municipality. The accessible population was all the students of the school. The target population for the study consisted of all form two students made up of 300 students. However the sample size was 66 students from the general arts two (2A2) class.

3.3 Sample and Sampling Procedure

Non-Probability Sampling: where the researcher has little initial control over the choice of who is presented for selection, or where controlled selection of participants is not a critical factor was chosen for the study. Due to time constraint and the need for the researcher to be at her teaching post while conducting this research convenience sampling technique where sampling those most convenient; those immediately available was used to select the school, the researcher used the school where she works. Purposive sampling technique was used to select the classes that were to be used as sample for the study. Creswell (2002) stated that, in purposive sampling, researchers intentionally select individuals and sites to learn or understand a phenomenon. Cohen, Manion and Morrison (2013) also assert that purposive sampling enables researchers to handpick the case to be included in the sample on the basis of their judgment. In this case, the researcher builds up a sample that is satisfactory to specific needs.

The sample for the study was 66 students from form two general arts class in the senior high school. The samples used for the study was the Form 2A2 students. Form two students were chosen as the accessible population since at the time of sampling for the study in September, 2015, form one students were not yet in school and the researcher being a new teacher posted in the school was not allowed to handle form three students since they were busily preparing for their WASSCE exams in May 2015. Form two students had covered more topics with the traditional style of teaching and are much conversant with that mode of teaching in the school. The Form two Students had done this topic with a different teacher and therefore are likely to make better comparative judgement on the new intervention.

In order to avoid the John Henry effect, control groups were not used. It effects is the tendency of persons in a control group to take the experimental situation as a challenge and exert more effort than they otherwise would do .They try to do better than the experimental group. Another threat to validity is compensatory equalisation of treatment which occurs when people in a control group demand to be reassigned to the other group, the group that is receiving the programme or treatment (Holden, 2001).

3.4 Research Instrument

The main instrument employed in collecting data for this study was the Diagnostic (one group-pre-test –post-test design) instrumentation and was supplemented with a Questionnaire in order to triangulate the instrument. Patton (2001) advocates the use of triangulation by emphasizing ―triangulation strengthens a study by combining methods. This can mean using several kinds of methods or data, including using both quantitative and qualitative approaches". Triangulation is defined as a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study (Creswell & Miller, 2000).

3.5 Diagnostic Instrumentation Tests

The Cambridge online dictionaries define tests as a way of discovering, by questions or practical activities, what someone knows, or what someone or something can do or an act of using something to find out if it is working correctly or how effective it is (Cambridge dictionary, 2015). There was a pre-intervention, followed by the intervention and then a post intervention which was used as a treatment. The pre-intervention activity involved questions which aimed at knowing the weakness and strength of the students before the intervention. It contained thirteen multiple choice questions (MCQs) test items; each was scored a mark and a theory part where students will provide their own answers. The theory part was used to access students‘ alternative conceptions. The post-test was administered after the intervention and was made up of the same number of questions but similar to that of the pre-intervention questions. The instruments were well designed for easy collection, interpretation, analysis and organisation of the data collected. A pre- intervention test was conducted to find students‘ basic knowledge in solving chemical bonding questions. This was to enable the researcher get to know the students prior knowledge and misconceptions on chemical bonding. A post-intervention test was conducted to find ability with the subject matter. This was to help the researcher to find out whether the intervention was successful or not. The pre- and post-intervention test was sampled from test books and past SSCE and WASSCE questions. The test was made up of 27 questions (the same number of questions for both pre-test and post-test). Question one to thirteen were multiple choice questions. Questions fourteen to 15 with sub-questions were theory questions. Question fourteen required students to draw the formation of potassium Chloride. The sub questions for question fourteen had seven sub-questions numbered a to g. question fifteen had seven sub questions. Some sub-questions still had further divisions. The questions were administered for one hour duration.

3.6 Intervention Design

The intervention was designed in the form of lessons and delivered using constructivist instructional approach based. The intervention lasted for four weeks and was structured such that the first three weeks were used for lesson presentations. The last week was used to test students to determine the effect of the intervention.

The timetable of the school is structured in such a way that the physics period is merged with the chemistry period. There are four periods in all for a week, which is spread for two days. That is two periods on Tuesday and the remaining two periods on Wednesday, according to the time table of the classes involved. A period is forty minutes and two periods is eighty minutes. The intervention was structured as follows:

Week1:

Day 1: Researcher introduces herself to the class, informs them about the thesis and the need for cooperation from them to enable a successful work done. Students were assured that the test were not going to affect their exams score and that their cooperation would help to bring out a good research work which will help the researcher adopt the best ways to help them understand chemistry better.

Day 2: Researcher had a discussion with students to find out if they have been taught chemical Bonding. Students agreed they have been taught chemical bonding in form one by a different teacher the previous year in form one. Researcher makes an appointment with class to prepare for a quiz the following week.

Week 2:

Day 1: the pre-intervention test was administered to students to answer. Students were given one hour to complete the work.

Day two: The intervention was instructed by using the constructivist approach. The strategy used was based on Yager‘s (cited in Kim, 2005) constructivist teaching strategy. According to this strategy, as a first step (invitation), the teacher asked students some questions at the beginning of the instruction in order to activate prior knowledge of students and promote student-student interaction and agreement before presenting the concept.

Students were asked to define some terms from the textbook that they needed to know in order to understand what we would discuss in that lesson. For example, the teacher began the instruction with a question asking what is meant by a chemical bond. After completing and discussing the vocabulary terms, our first activity was to get familiar with the periodic table. Photocopies of the period table were given out to students and they were asked to mention the electronic configuration of the various elements discussed. Students were asked to mention some atoms they know. The atoms that were mentioned were written on the board. They were then asked to give the atomic numbers of the various atoms mentioned (the atoms were limited to the first twenty elements). After students had developed some confidence with the atomic numbers and electronic configuration, they were asked to give the number of neutrons in an atom using information on their atomic numbers and masses.

Week 3:

Day One: As a second step (step 2: exploration), students were allowed to discuss the question in groups by using their previous knowledge related to atoms. The teacher created groups based on the students' grades in the previous term. Each group contained four or five students. Each group was asked to draw atomic structures for some atoms. The atoms were sodium, beryllium, potassium, chlorine, fluorine, Helium, Carbon, Neon, and Silicon.

During discussions in groups, they realized both their own and other's thoughts, shared their ideas, defended their answers and reached a consensus about the question. Meanwhile, the teacher didn't interfere with the students. They constructed their tentative answers freely. Each group gave a common answer to the teacher after discussion. In this way, the teacher had an opportunity to view the students' previous ideas. Also, the students had cognitive conflict when their ideas were not adequate to answer the question the teacher asked. This situation supported the first condition of Posner et al. (cited in Turgut and Gurbuz 2012). conceptual change model. Dissatisfaction was also promoted by the teacher in the next step. Based on their answers, he explained the concept (step 3: proposing explanations and solutions). While explaining the concept, he emphasized on students' misconceptions and why they were wrong. He presented scientifically correct explanation by using analogies and examples. Since chemical bonding is an abstract topic, he tried to give examples from daily life as much as possible. He used analogies to enhance understanding. For example, while explaining what a chemical bond was, he constructed similarities between magnets and bonds; the fact that like poles repels each other and unlike poles attracts each other is similar to the attraction and repulsion between electric charges.

Day two: Students were asked to group the elements into metals, Non-metals, semi-metals and gases. Using the Sunflower for Science (sunflower learning, 2012), students were asked to match atoms that would form ionic bonds and those that would form covalent bonds.

Borrowing books from the library was given as an example for covalent bonding; although the books are given to a person, at the same time they belong to the library. In this step, the teacher tried to accomplish Posner et al.'s conditions of intelligibility and plausibility by stressing on the students' preconceptions, making relationship between their conceptions and scientific knowledge and giving examples(cited in Turgut and Gurbuz 2012). Moreover, students saw usage of information they obtained in explaining other situations. Therefore, Posner et al.'s (cited in Turgut and Gurbuz 2012). last condition (fruitfulness) was also achieved. Before presenting each new concept, the teacher asked questions which students could answer by using their previous knowledge (step 4: taking action). Some questions were:

What is the reason that atoms bond? Why do metals and non-metals form bond? Why is table salt hard? Why does table salt conduct electricity when dissolved in water? Why is wax low melting substance? Why are metals shiny? All of the questions reflected students' misconceptions found from literature. Yager's (1991) constructivist teaching strategy was used for each question. Appendix E summarizes a sample lesson based on this strategy.

Week 4:

Day one: Revision and review of intervention lesson

Day two: The Post –intervention test was administered. The same number of questions and similar in nature as the pre-intervention was administered with same number of students.

3.7 Questionnaire

According to Baxter and Jack (2008), the questionnaire has several advantages which include facilitating data gathering, easy to test data for validity and reliability, less time consuming than interview and observation. It also preserves the anonymity and confidentiality of the respondents' reactions and answers. Hannan (2007) described questionnaires as straight forward written questions requiring an answer by ticking the appropriate box. They are very efficient ways of collecting facts. Questionnaires are also employed as devices to gather information about people's opinions, often asking respondents to indicate how strongly they agree or disagree with a statement given and that the Likert scale is a most widely used method of scaling adopted in questionnaires in the social sciences today.

Questionnaire was used for this study. The questionnaire was designed based on the objectives of the study. The questionnaire was on closed – ended questions, the closed – ended questions were used to gather specific responses from the respondents. The researcher used this data collection approach because the responses are gathered in standardised way and so they are more objective and certain. Closed –ended questions according to Cohen, Manion and Morrsion (2013) are quick to compile and straight forward to code and do not discriminate unduly on the basis of how articulate the respondents are. Again the use of questionnaires speed up the collection of information, potentially information can be collected from a large portion of a group and it is easy to analyse (Cohen, Manion & Morrsion, 2013). Data entry and tabulation can be easily done with many computer software packages like Statistical Package for Social Science (SPSS) version 22 and Microsoft Excel 2007.

3.8 Test validity and Reliability

While it has been claimed (Winter, 2000) that quantitative researchers attempt to disassociate themselves as much as possible from the research process, qualitative researchers have come to embrace their involvement and role within the research. Patton (2002) supports the notion of researcher's involvement and immersion into the research by discussing that the real world are subject to change and therefore, a qualitative researcher should be present during the changes to record an event after and before the change occurs. While the credibility in quantitative research depends on instrument construction, in qualitative research, ―the researcher is the instrument" (Patton, 2002). Thus, it seems when quantitative researchers speak of research validity and reliability, they are usually referring to a research that is credible while the credibility of a qualitative research depends on the ability and effort of the researcher.

Joppe (2000) defines reliability as the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable. Embodied in this citation is the idea of reliability or repeatability of results or observations. Although reliability and validity are treated separately in quantitative studies, these terms are not viewed separately in qualitative research.

Content (face) validity was employed in the test to measure the intended content area since a test must measure what it claims to measure, in order to be considered valid (Alhoward, 2015). In doing this the test items in the instrument were given to experts (two lecturers in the Department of Science Education, University of Education, at Winneba) to be scrutinized. It was then confirmed to be within the level of the respondents and so was permitted to administer the items.

In order to ensure reliability and effectiveness of the instrument (test items), it was pilot-tested with a SHS 2 class of forty eight students from a different school (Manso Adubia SHS) in the Amansie West District in the Ashanti Region of Ghana. This school was chosen because of easy access since it is the researcher‘s former school. Pilot-testing identified questions that respondents had difficulty understanding and those they interpreted differently than the researcher intended. Thus once a test is developed, it is either pilot tested or pre-tested with a small sample of potential respondents prior to the real respondents (Amadahe, 2002). This ensured clarity in the instructions and questions. Improving on a research through pilot-testing is likely to improve on the quality of data, the results and interpretations. After the baseline survey test, the researcher had discussions with the class on test time, clarity and understanding of the test items. These helped in modification of some of the item in the test. The reliability of the baseline survey achievement test was determined using Cronbach alpha coefficient (0.7). A figure equal to or greater than 0.7 is an acceptable reliability coefficient, an indication of test items being reliable. The same method was also used to determine reliability of the post-test items. The reliability of the pre-intervention and post-intervention test achievement items were 0.78 and 0.79 respectively. These figures being greater than 0.7 indicates that both test items were reliable.

3.9 Ethical Issues

Introductory letter was collected from the department of science Education although the researcher is currently a teacher of the school. She also spoke to some of the teachers whose classes would be used and the students involved of the aims and purpose of the study and the need for the participants to give their consents and co-operation. According to Creswell (2002), respecting of the site where the research takes place and gaining permission before entering a site is very paramount in research. The researcher assured them of confidentiality and their informed consent. According to Kelley, Clark, Brown and Sitzia, (2003), these are the most important ethical issues to adhere to when conducting a research.

3.10 Data Analysis

According to Emory and Cooper (2003) raw data obtained from a research is useless unless it is transformed for the purpose of decision making. After collecting the data, an analysis facilitates the interpretation of the result and the drawing of conclusion. The purpose of the analysis is to make meaning out of the data collected vise – a- visa the research problem at hand. Without proper analysis, the data collected would be a meaningless heap of information. This data analysis usually involves reducing the raw data into a manageable size, developing summaries and applying statistical inferences.

Students were made to write a pre-intervention test before the lessons based on constructivist learning approach was used to teach chemical bonding. Students were taken through chemical bonding concepts for three weeks. After completing the lessons on chemical bonding, students were made to respond to post-intervention test. There were two parts in each test. The first part consists of multiple choice questions. Four response options were provided as answers to the multiple choice questions (MCQs) of which one was the correct answer. The second part was theory questions for which students were required to express themselves freely by answering. Number of students on correct answer for both the pre-intervention test and post-intervention test was analysed. The analysis was done on the number of students that had correct answer for each item. The number of students on correct answers was put into percentages for the analysis and discussion. As already stated the results and analysis are done in line with the research questions posed for the study.

Finally, the data gather were coded, edited and all possible errors were corrected. The statistical tools that were used in analyzing the data were tables and percentages using software –Statistical Package for Social Science (SPSS) version 22 and Microsoft Excel 2007.

CHAPTER FOUR

RESULTS, ANALYSIS AND DISCUSSION

4.0 Overview

This chapter presents the results of the study about the effect of constructivist instructional approach on students' performance in chemical bonding. The chapter has been presented in three subheadings, each relating to answers that addressed each of the research question posed for this study.

4.1 Results and Analysis

Students were made to write a pre-intervention test before the lessons based on constructivist learning approach was used to teach chemical bonding. Students were taken through chemical bonding concepts for three weeks. After completing the lessons on chemical bonding, students were made to respond to post-intervention test. There were two parts in each test. The first part consists of multiple choice questions. Four response options were provided as answers to the multiple choice questions (MCQs) of which one was the correct answer. The second part was theory questions for which students were required to express themselves freely by answering. Number of students on correct answer for both the pre-intervention test and post-intervention test was analysed. The analysis was done on the number of students that had correct answer for each item. The number of students on correct answers was put into percentages for the analysis and discussion. As already stated the results and analysis are done in line with the research questions posed for the study.

Research question 1: What is the performance of students in the concept of chemical bonding before the use of constructivist' learning approach?

This question was posed to find students' knowledge level in the concept of chemical bonding before the use of the constructivist learning approach. This was done to enable the researcher know students' conception of chemical bonding before the introduction of the constructivist instructional approach. A pre-intervention test on chemical bonding was conducted a week after which students were given the opportunity to revise their notes on chemical bonding. The number of students on correct answer for particular multiple choice questions is presented in Figure 1.The Figure below shows the distribution of students on correct answers to each Item for the MCQ for the pre-intervention test. The number of students was then converted into percentages.

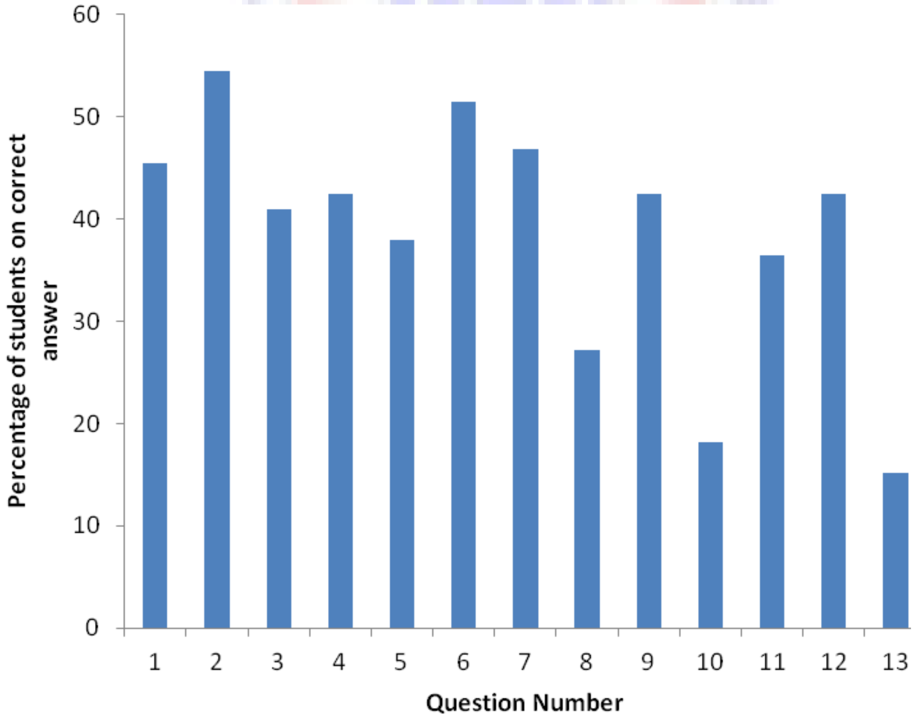

Figure 1: Distribution of students on correct answers for the Pre-intervention MCQs

From Figure 1, it can be seen that it was only Items 1, 2, 6 and 7 that had thirty students and more (≥45%) with correct answers. The rest of the items had less than 30 students (<45% of the sample) having correct answers; the Items were 3, 4, 5, 8, 9, 10, 11, 12, 13. Item 13 attracted only 10 students answering it correctly. It is also seen that out of 66 students, thirty of them had question one correct, representing 45.5 percent of the sample, they had the correct conception that negatively charged atoms attract cations. Thirty six had Item 2 correct representing 54.5 percent; they held the correct conception that the number of electrons in a single covalent bond is 2. In Item 3, students were supposed to identify that an ionic bond is the force of attraction between oppositely charged ions with 27 students obtaining correct representing 40.9 percent. For Item 4, twenty-eight of the students which represent 42.4 percent chose the correct option for the question: a covalent bond being a substance that melts at 88ºC and does not conduct electricity in either the solid state or the liquid state and that it does not dissolve very well in water but it does dissolve in non-polar solvents. Twenty five of the students had item 5(see appendix A) correct which represents 37.9 percent. Thirty four students had Item 6 correct which represents 51.5 percent, 31 had item 7 correct which represents 46.9 percent, 18 students had item 8 correct which represents 27.2 percent, 28 had item 9 correct which represent 42.4 percent, 12 students had item 10 correct which represents 18.2 percent. Twenty-four students had item 11 correct which represents 36.4 percent, 28 had item 12 correct which represents 42.4 percent with 15.2 percent of the sample that is 10 students choosing the correct option that the correct option that Diamond is very hard because it is a giant molecule which is Item 13. The mean percentage of students on correct answers in all the multiple choice questions was 38.57 percent. This value gives an indication that student‗s performance and students‗ knowledge level in the concept of chemical bonding before the use of the constructivist learning approach was low. The Figure below shows the distribution of students' on correct answer to each item for the second part of the pre-intervention test (theory).

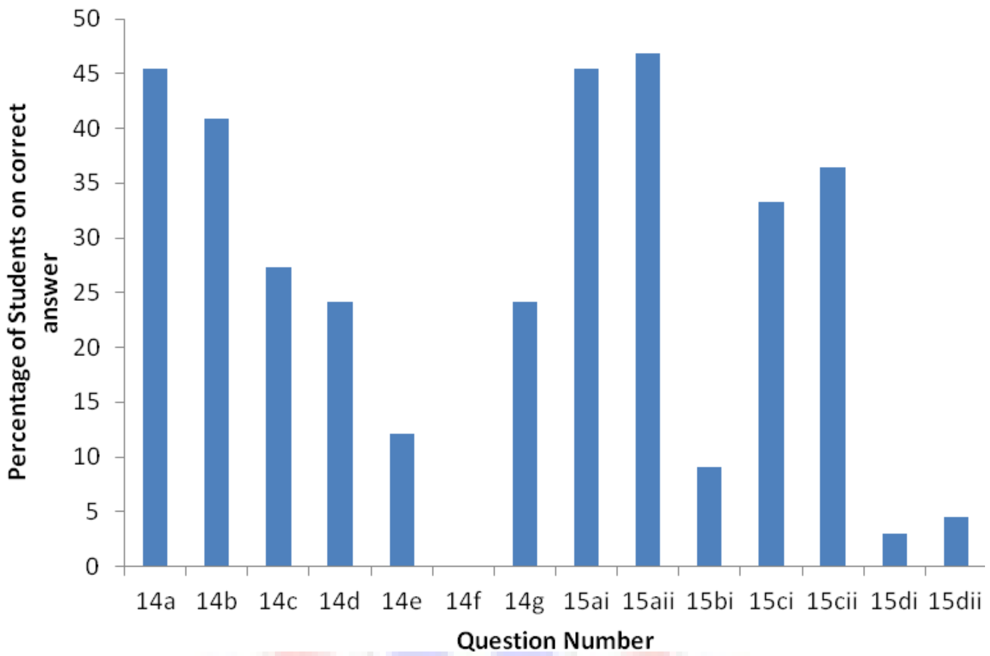

Figure 2: Distribution of Students on Correct Answers for the theory part of Pre-intervention Test

Distribution of students on correct answers for the theory part of Pre-Intervention test was lower in percentage than in the MCQs. The percentages of students on correct answer for the items were all below 50 percent for the theory section. Only questions 14a, 15ai, 15aii had a little more than 45 percent of the sample getting correct answers, the distribution of students on correct answers for the rest of the items were all below 45 percent of the students. Generally questions on the periodic groupings (Item 14b, 14c, 14 d, 14e, 14f, and 14g) appeared to be difficult for the students before the intervention. The question that had few students answering correctly was

14 e, 15 bi, 15di, and 15dii, with less than 10 students getting correct answers. None of the students got item 14f correct (see appendix A)

The mean percentage of students on correct answer was 27.13, comparing this value to the mean from the MCQs (38.6) gives a large difference. The large difference in the mean percentages appears to suggest that students had difficulty answering theory questions than MCQs. This is in line with the study of Birk and Kurtz (1999) finding after studying some misconceptions of high school students, undergraduate students as well as college and university faculty members about molecular structure and chemical bonding. They concluded that even in the faculty level, there was a gap between conceptual understanding and recall knowledge.

In general, the mean percentage of students on correct answers for the pre-intervention test for both MCQs and theory questions were lower in percentage, suggesting that few students were able to answer questions on chemical bonding before the instructions based on constructivist approach. Tan and Treagust, (1999), affirmed that most students find it difficult to understanding the concepts in chemical bonding. One possible reason is that chemical bonding is an abstract and theoretical topic (Taber, 2010). Also essential knowledge such as the particulate nature of matter, electronegativity, energy and force in which students have difficulty in understanding are necessary requirements in understanding chemical bonding. According to Taber students also hold a lot of alternative conceptions on chemical bonding as a result of this difficulty. The most common alternative conception among students was about ionic bonding, especially ionic bonding with sodium chloride (NaCl). It is therefore necessary for teachers to investigate students‘ alternative conceptions before instructions. Brandon and All suggest that a teacher makes sure she understands the students' pre-existing conceptions, and guides the activity to address them and then build on them (Brandon & All, 2010).

Research Question 2: what is the performance of students in the concept of chemical bonding after the use of constructivist' learning approach?

This research question was posed to determine whether or not students performed better after using constructivist instructional approach to teach the concept of chemical bonding. Students were guided through constructivist instructions for three weeks, after which students were tested. A change in attitude of the students was observed during the use of the constructivist learning approach in teaching chemical bonding. Most students were cooperative in answering questions and making contributions during discussions in the second and third weeks compared to the second week when the approach was started. From all indication, this change was as a result of the strategies used in the constructivist learning approach. The results were so overwhelming that one could conclude that the work was successfully executed. The Figure below is the distribution of students on correct answers for MCQs of the post-intervention test.

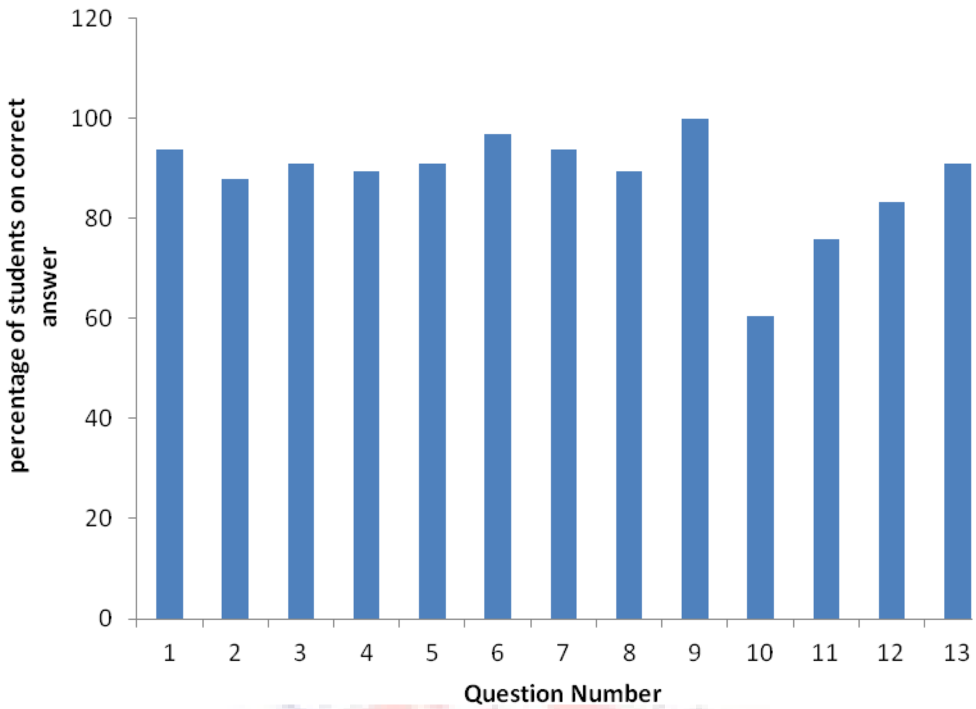

Figure 3: Distribution of students on correct answers for the Post-intervention MCQs

From Figure 3, out of 66 students 62 had Item 1 correct, representing 93.9 percent, 58 had Item 2 correct, representing 87.9 percent, 60 had Item 3 correct, representing 90.9 percent, 59 had item 4 correct, representing 89.4 percent, 60 had Item 1 correct, representing 90.4 percent, 64 had Item 5 correct, representing 90.9 percent, 64 had Item 6 correct, representing 96.9 percent, 62 had Item 7 correct, representing 93.9 percent, 59 had Item 8 correct, representing 89.4 percent, 66 had Item 9 correct, representing 100 percent, 40 had Item 10 correct, representing 60.6 percent, 50 had Item 11 correct, representing 75.8 percent, 55 had Item 12 correct, representing 83.3 percent and lastly 60 had Item 13 correct, representing 90.9 percent.

It can be seen that Items 3, 4, 5, 8, 9, 10, 11, 12, and 13 that had fewer students getting correct answers in the pre-test, now have more students getting correct answers. A clearer view of this can be seen in Figure 5. It can be seen from Figure 3 that the difference between the percentages of students' on correct responses in the pre-intervention test and the percentages of students‘ on correct responses in the post-intervention test was significant.

The Figure below shows the distribution of students on correct answers for the theory part of the post intervention test.

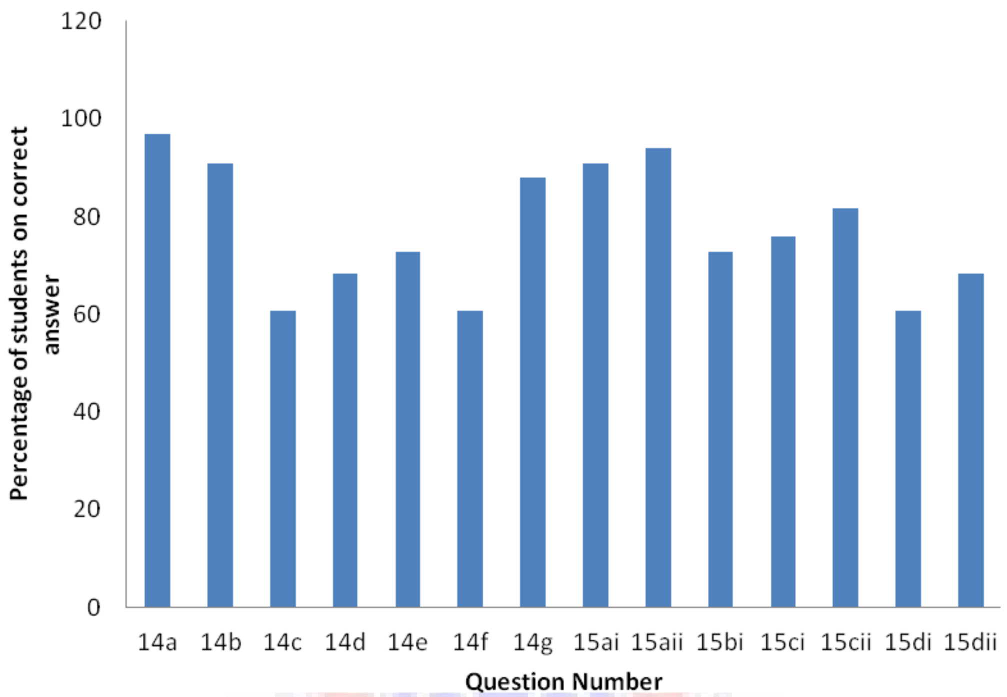

Figure 4: Distribution of Students on Correct Answers for the theory part of post intervention

From the Figure 4, it can be seen that the number of students with the correct answers for all Items has improved. Item 14a had 64 students representing 96.9 percent of students answering correctly; 14b was answered correctly by 60 students representing 90.9 percent of the students, 40 students had Item 14c correct which represents 60.6 percent of the students, 45 students had Item 14d correct which represent 68.2 percent of the sample, 48 had Item 14e correct which represents 72.7 percent. Item 14f, which none of the students had the correct answer before the intervention, now had 40 students representing 60.6 percent answering correctly. Fifty eight students representing 87.9 percent had Item 14g correct. Item 15ai had 60 students with the correct answer which represents 90.9 percent, 62 students had Item 15aii correct representing 93.9 percent, 48 had Item 15b correct which represents 72.7 percent, 50 had Item 15ci correct which represents 75.8 percent, 54 had Item 15cii correct which represents 81.8 percent, 40 had Item 15di correct which represents 60.6 percent, and lastly 45 had Item 15dii correct which represent 68.2 percent of the sample.

There was a tremendous improvement in students' performance in the post-intervention test than in the pre-intervention test. This has been summarised in Figure 1 and 2. Student's correct answers to items for both tests have been put together in the Figure below.

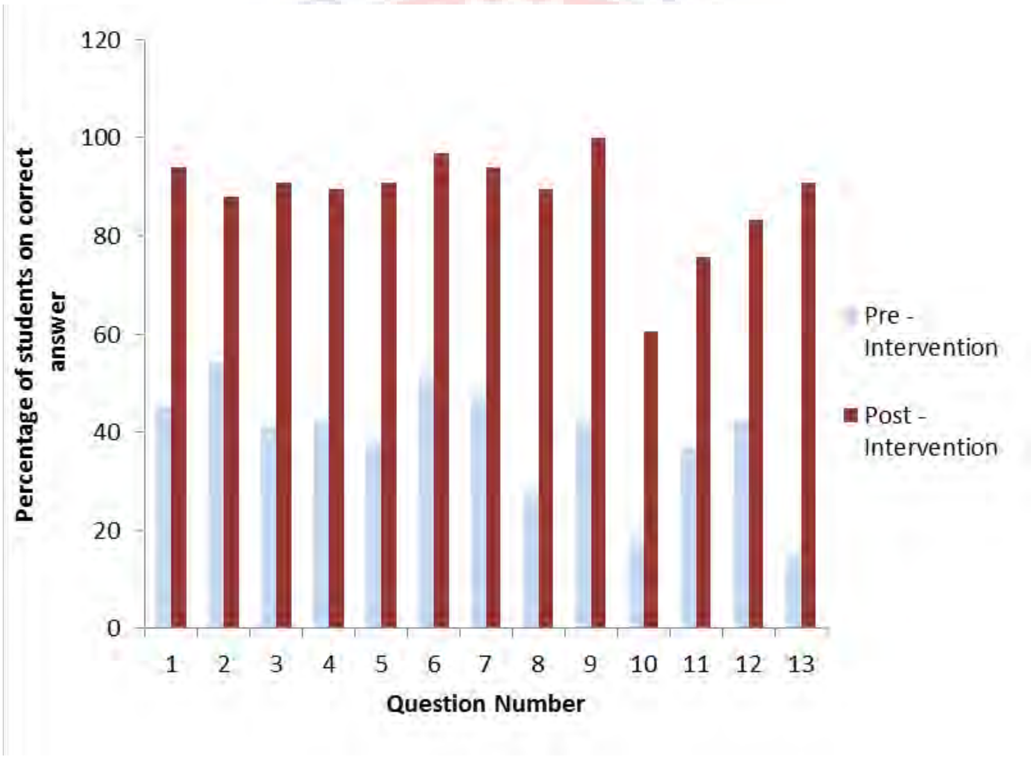

Figure 5: **Percentage of Students on Correct Answer for both Pre-Intervention and Post-Intervention for the Multiple Choice Questions**

It can be seen that there is an increase in the percentage of students on correct answers in the post-intervention for the MCQs. More students removed their misconceptions after the intervention and students‘ on correct response percentages of each Item in the post-intervention test are presented in Figure 2.

The mean percentage of students on correct answer for the pre-intervention MCQs is 38.6 percent and that of the post-intervention MCQ is 88.0. It can be observed that for each test Item in the post test, the number of students on correct answer for the multiple choices question was higher than compared to that of the pre-intervention test. Comparing the two values gives an indication that there has been an improvement in the performance of the students in the multiple choice questions. It can also be inferred that students‘ understanding and achievement on the concept of chemical bonding has improved.

The use of electron dot diagrams, the periodic table as well as the computer assisted Sunflower diagrams used to aid chemical bond formation diagrams, contributed in the success of the intervention designed. The high percentage obtained at the post-intervention stage gave enough proof that the use of the constructivist learning approach adapted in teaching chemical bonding was appropriate, valid and reliable.

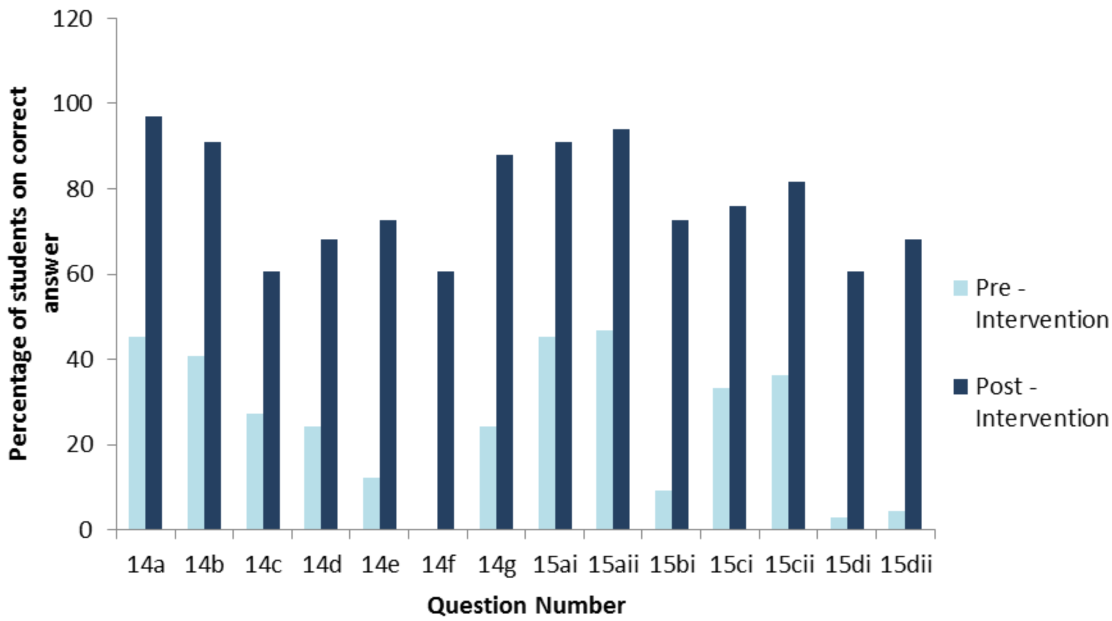

Figure 6: Percentage of Students on Correct Answer for Both Pre-Intervention and Post Intervention theory Questions

It can be seen that there was an increase in the percentage of students on correct answer in the theory part of the post-intervention test. More students removed their misconceptions after the intervention and students' on correct answer percentages of each item in the post-intervention theory test were higher as seen in Figure 1 and 2. The mean percentage of students on correct answer for the pre-intervention theory was 27.13 and that of the post-intervention theory is 83.207. The large difference of the two is an indication that there has been an improvement in the performance of the students in the theory items.

This result is in line with a research performed by Guthrie et al. in 2004, they did a comparison of three instructional approaches to compare third grade reading. The traditional approach, constructivist and collaboration activities were used. The constructivist approach resulted in better student reading comprehension, cognitive strategies, and motivation. A similar work was done by Doğru and Kalender (2007) using traditional teacher- centred approaches to those using student-centred, constructivist methods on students‘ retention of knowledge. Their initial results showed no significant difference between the two methods. However in a follow up assessment two weeks later, students who learned by constructivist methods showed better retention of knowledge than those who learned through traditional methods. In studies where constructivist approach was used, it has been shown that constructivist teaching strategies were effective in enhancing students understanding and achievement. For example, Niaz (1995) studied on dialectic constructivist framework based on cognitive conflict for freshman chemistry students. He reported that students exposed to cognitive conflict method were more successful than students studied traditionally.

Research question 3: What are the Views of Students' about the Use of Constructivist' Learning Approach to Teach Chemical Bonding?

Students were asked to respond to a questionnaire on their views about the use of constructivist learning approach in teaching chemical bonding. The questionnaires was a 5-point Likert scale ranging, from _strongly disagree‘, coded 1 to _strongly agree‘ coded 5. The mean values for all items forming each dimension were also found. This was done to give an overall picture of views of students towards the constructivist approach. Results of the response are presented below.

4.2 Students Views on the Constructivist Approach

Students views on the constructivist approach were sought through items, 9, 10, 11, 12, and 13 (see appendix C). Students‘ responses to the constructivist approach are presented in Table 1.

Table 1: Students views on the constructivist Approach in ascending Order of Mean

Item	Mean	Std. Deviation
12. I like the way chemistry was taught in my school.	2.0	1.0
1. I like the class where the teacher does all the talking and tells us all the answers	2.2	1.0
11. When I get an answer wrong in class my teacher may punish me.	2.7	1.1
30. I don‘t get appreciated when I answer correctly	3.5	1.1
3. Chemistry teachers should be willing to give students individual help	3.6	1.3
10. I don‘t like to be asked questions in class. It makes the class boring	3.6	1.3
4. When I am able to solve a problem in class, it increases my interest in class (subject)	3.6	1.2
7. I like the way chemistry was presented in these few weeks	3.7	1.1
5. I like chemistry taught in an interactive way	3.8	1.1
9. If I can ask questions and contribute in class it makes the class lively.	3.8	1.1
2. I love the participatory class it is interesting	3.9	1.4
6. When I get an answer wrong my colleagues will laugh at me	3.9	1.2
8. When I get an answer wrong in class it makes me loose interest in class participation	4.0	1.1

Scale: 1 – Strongly disagree 2 – Disagree 3 – Neutral 4 – Agree 5 – Strongly agree

The scale was interpreted as follows for easy analysis: a value less than 3 is disagreed, exactly 3 is neutral any value above 3 is agree. Majority of the students disagreed with the statement ―I like the way chemistry was taught in my school" (mean=2.0) and ―I like the class where the teacher does all the talking" (mean=2.2). Analysis of the mean for the ―when I get an answer wrong my teacher may punish me" (mean=2.3) indicates that majority of the students disagreed with the statement. Majority of them expressed interest in constructivism by agreeing to the following statements; ―If I can ask questions and contribute in class it makes the class lively" (mean=3.8), ―I love the participatory class, it is interesting" (mean=3.9), ‗I like the way chemistry was presented in these few weeks' (mean=3.7), ―I like chemistry taught in an interactive way" (mean= 3.8). Students also agreed that when they get answers wrong their interest in class participation is lost (mean=4.0), their colleagues will laugh at them (mean=3.9) and also they did not like being asked questions in class (3.6). On the other hand they agreed largely that when they are able to solve a problem in class, their interest in the lesson increases (mean=3.6).

A proportion of them also indicated their agreement with the statement ―chemistry teachers should be willing to give students individual help" (mean=3.6) and ―I don't get appreciated when I answer correctly was that of uncertainty (3.5)".

In general it can be seen that students were interested in the interactive way chemistry was taught in the constructivist instructional weeks more than the traditional strategies that were used earlier. They did not like the situation where the teacher does all the talking. They liked the interactive nature of the approach. Hand et al. (1997) found similar results, too after examining junior secondary school students' perceptions of implementation of constructivist approach to the teaching of science. It was concluded that most students liked the constructivist teaching learning approaches because of being more activity involved, having more discussion practical work, less note-taking, and having more fun and greater understanding of concepts. This result is also in line with Tynjala (1998) results. Her results showed that students in the constructivist group acquired an ability to apply knowledge and developed their thinking and communication skills.

Though they did not like to be asked questions because they were not motivated enough and that their colleagues may laugh at them or perhaps some teachers may punish them for giving wrong answers they also agreed that when they get answers correct in class it increases their interest and that their ability to ask questions and contribute in class makes the class lively. Teachers must therefore adopt motivation strategies to increase students' participation. Since the constructivist approach involves asking a lot of questions and getting answers from students, it must incorporate a reward system like that suggested by the behavioural theorist Skinner (2011) to motivate students' participation. Skinner shows that positive reinforcement strengthens behaviour by providing a consequence an individual finds rewarding. For example if your teacher gives you a toffee or a clap each time you get an answer correct you will be more likely to repeat this behaviour in the future, thus strengthening the behaviour of answering more questions.

CHAPTER FIVE

SUMMARY, CONCLUSSIONS, IMPLICATIONS AND RECOMMENDATIONS

5.0 Overview

This chapter presents the summary of the findings as well as conclusions of the study. Also recommendations for stakeholders, suggestions for further research are mentioned.

5.1 Summary

The study was an action research and was carried out with form 2A2 students of Wesley Senior High School in Konongo Municipality. The target population for the study consisted of all form two students made up of 300 students. However the sample size was 66 students from the general arts two (2A2) class. In this research, the data collection practice for this study was a diagnosis pre-intervention and post-intervention test questions within the quantitative research convention and a questionnaire under the qualitative research tradition. The research design was of action research in which mixed-methods of quantitative and qualitative methods were used to analyse data. The test was analysed using the number of students on correct answers and its converted percentages. In selecting the sample, convenience sampling a non-Probability technique and purposive sampling technique was used to select the classes that were to be used as sample for the study.

The study was guided by the following questions:

1. What is the performance of students in the concept of chemical bonding before the use of constructivist‘ learning approach?

2. What is the performance of students in the concept of chemical bonding after the use of constructivist‘ learning approach?

3. What are the views of students‘ about the use of constructivist‘ learning approach to teach chemical bonding?

All the three research questions that the research sought to answer were addressed using pre-intervention test, post-intervention test and a questionnaire.

In general terms, the study showed that students had a lower achievement level on chemical bonding before the use of the constructivist approach, but their performance also increased tremendously. It is therefore recommended that active students‘ participation is used in the teaching of chemical bonding and teachers must have in-depth knowledge to be able to use the constructivist approach for effective learning and conception of chemical bonding.

Summary of Findings

The mean percentage of students on correct answer for the pre-intervention MCQs is 38.6 percent and that of the post-intervention MCQ is 88.0. It can be observed that for each test Item in the post-intervention test, the number of students on correct answer for the multiple choices question was higher in comparison to that of the pre-intervention test. Comparing the two values gives an indication that there has been an improvement in the performance of the students in the multiple choice questions. It can also be inferred that students‘ understanding and achievement on the concept of chemical bonding has improved.

Findings from the theory part of the Test Items indicate there was an increase in the percentage of students on correct answer in the theory part of the post-intervention test. More students removed their misconceptions after the intervention and students‘

on correct answer percentages of each item in the post-intervention theory test were higher as seen in Figure 1 and 2.

The mean percentage of students on correct answer for the pre-intervention theory is 27.13 and that of the post-intervention theory is 83.207. The large difference of the two is an indication that there has been an improvement in the performance of the students in the theory items.

Majority of the students expressed interest in constructivism by agreeing to the following statements; ―If I can ask questions and contribute in class it makes the class lively" (mean=3.8), ―I love the participatory class, it is interesting" (mean=3.9), ‗I like the way chemistry was presented in these few weeks' (mean=3.7), ―I like chemistry taught in an interactive way" (mean= 3.8). Students also agreed that when they get answers wrong their interest in class participation is lost (mean=4.0), their colleagues will laugh at them (mean=3.9) and also they did not like being asked questions in class (3.6). On the other hand they agreed largely that when they are able to solve a problem in class, their interest in the lesson increases (mean=3.6).

A proportion of them also indicated their agreement with the statement ―chemistry teachers should be willing to give students individual help" (mean=3.6) and ―I don't get appreciated when I answer correctly was that of uncertainty (3.5)".

5.2 Conclusions

The following conclusions can be deduced from the results:

1. Students Performance in the concept of chemical bonding was lower before instructions in the constructivist learning approach and conception in chemical bonding was lower before constructivist learning instructions.

2. The instruction based on constructivist approach caused a significantly better acquisition of scientific conceptions related to chemical bonding and elimination of misconceptions. The findings from the pre-intervention test and post-intervention test show that students' conceptual understanding and performance had improved. This was done through the intense student-student interactions, active participation of students in the interactive lessons, maximum teacher support with the high levels of motivation. Results from this study also indicated that majority of students enjoyed the interactive lessons with the constructivist approach, and because they were motivated well to participate actively in the lessons they preferred constructivist instructional learning to the traditional instructions.
3. The instruction based on constructivist approach produced higher positive attitudes towards chemistry as a school subject.
4. Active participation of students in the teaching and learning process of chemical bonding had a contribution to the students' understanding of chemical bonding concepts and teachers must have in-depth knowledge to be able to use the constructivist approach for effective learning and conception of chemical bonding.

5.3 Implications for teaching and learning

Students should relate new information to their current cognitive structure in order for meaningful learning to occur. If students cannot link between new and existing knowledge, they fail to understand new concepts. They should be given the opportunity to express and share their ideas. The constructivist approach is important in terms of encouraging students to think about the scientific concepts and their conceptions.

Teachers should plan their instruction to facilitate conceptual change. Students' prior knowledge should be determined and how students learn scientific concepts recognised. They should make students realize their conceptions since a change in students' ideas is under their own control. The role of the teacher is to facilitate and support their thinking for conceptual change. The teachers should use effective instructional strategies to identify and eliminate misconceptions. Small group discussions are very useful and effective for conceptual change.

5.4 Recommendations and suggestions for further Research

- Further study can be conducted in different schools to provide a generalization for Ghana, especially students with higher learning skills in grade A schools achievement with the constructivist approach should be compared with those of learning abilities in grade C or D schools to see if it will be effective for both cases.
- Also students were assessed on chemistry content alone as captured within the integrated science curriculum; further studies can be carried out for different grade levels and different science courses to investigate the effectiveness of the constructivist approach.
- Chemistry teaching should favour procedural knowledge. Although declarative knowledge is important and necessary, it is not enough. If students learn how to use their knowledge, they can solve real life problems and develop complex skills. Therefore science teachers should be encouraged to

employ the use of constructivist method of teaching in the delivery of their lessons so that students can perform better.

- Curriculum, syllabus and text books should be constructed on the constructivist perspective and textbooks should be improved so that students' misconceptions can be minimized.
- Teacher education should place an emphasis on constructivism.
- Teachers should be aware of students' attitudes towards chemistry as a school subject and should seek ways to make students have positive attitudes.

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APPENDICES

APPENDIX A

Multiple Choice Questions

Pre- intervention questions.

1. Negatively charged ion attracts a(n)

A. Anion B. Cation C. neutral atom D. proton

2. How many electrons are there in a single covalent bond

A. 1 B. 2 C. 4 D. 8

3. An ionic bond is

A. The force of attraction between oppositely charged ions

B. The force of attraction between similar charged ions

C. The force of attraction between equally but oppositely charged ions

D. The force of attraction between equally but similar charged ions

4. A pure substance melts at 88°C and does not conduct electricity in either the solid state or the liquid state. It does not dissolve very well in water but it does dissolve in nonpolar solvents is most likely to be

A. a metal

B. a network solid

C. an ionic compound

D. a covalent compound

5. A compound will have an ionic structure if it is made from

A. An alkali metal with an alkali earth metal

B. A metal with one or more non-metals.

C. Metals with semimetals

D. Non-metals only

6. A type of chemical bond that is formed from the sharing of electron for an atom to attain a stable electronic configuration is called a(n)

A. covalent bond B. ionic bond

C. metallic bond D. hydrogen bond

7. Ionic compounds form

   A. a magnetic crystal

   B. an electric crystal

   C. a small structure

   D. a giant structure

8. All ions have

   A. A partially filled outer shell of protons

   B. A partially filled outer shell of electrons

   C. A full outer shell of protons

   D. A full outer shell of electrons

9. Covalent compounds

   A. Share electrons

   B. Share neutrons

   C. Share protons

   D. Share atoms

10. A non-metal in group 6 will have ion with?

   A. A charge of 1+

   B. A charge of 1-

   C. A charge of 2-

   D. A charge of 2+

11. Which of the following compounds is ionic?

A. CO_2 ***B. LiCl*** ***C.*** NH_3 ***D.*** H_2O

12. Covalent compounds

    A. Polarize electrons

    B. Exchange electrons

    C. Borrow electrons

    D. Share electrons

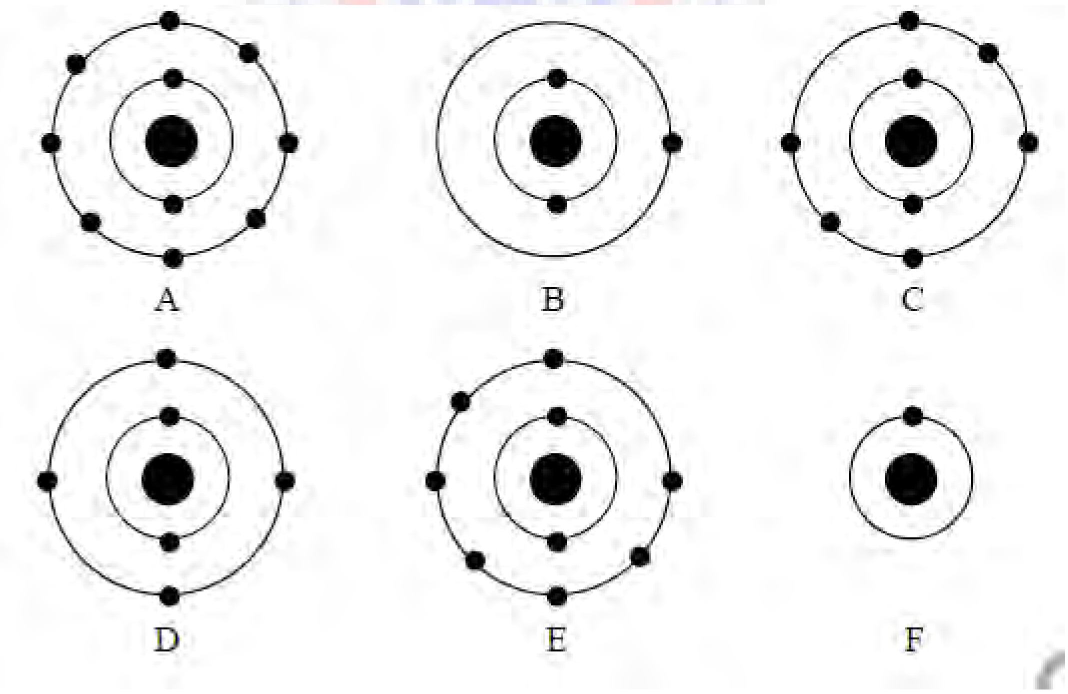
13. Diamond is very hard because it is

    A. a giant ionic lattice B. a giant molecule

    C. a transparent crystal D. a good conductor of electricity

Theory Questions

14. The diagrams below represent the electronic arrangement of different atoms and ions.



(a) Which letter(s) represents an atom of a Group I metal?

.... [1]

(b) Which letter(s) represents an atom of a Group VII non-metal?

.... [1]

(c) Which letter(s) represents an atom of a noble or inert gas?

.... [1]

(d) Which letter(s) represents an atom which is not in the second period of the Periodic Table?

.... [1]

(e) Which letter(s) represents an ion of a Group I metal?

.... [1]

(f) Which two letters represent atoms which form an ionic compound with a formula similar to Na2S?

.... [1]

(g) Which two letters represent atoms which form a molecule with a formula similar to $SiCl_4$?

.... [1]

15. Sodium chloride is often called common salt.

It can be made by reacting a small piece of hot sodium with chlorine gas.

(a) Write the electronic arrangement for an atom of:
(i) Sodium
.... [1]
(ii) Chlorine
.... [1]
(b) Use electron dot diagrams to show how KCl is formed.

(c) Write down the formulae of the ions formed by:
(i) Sodium
.... [1]
(ii) Chlorine
.... [1]
(iii) Write down the formula of sodium chloride.
.... [1]

(d) Solid sodium chloride will not conduct electricity, but when dissolved in water it will.

(i) Explain why an aqueous solution of sodium chloride conducts electricity.

....

.... [1]

(ii) In what other way could you alter the state of sodium chloride so that it will conduct electricity?

.... [1]

Marking Scheme for pre-intervention questions

Solution to pre-intervention test (multiple choice questions)

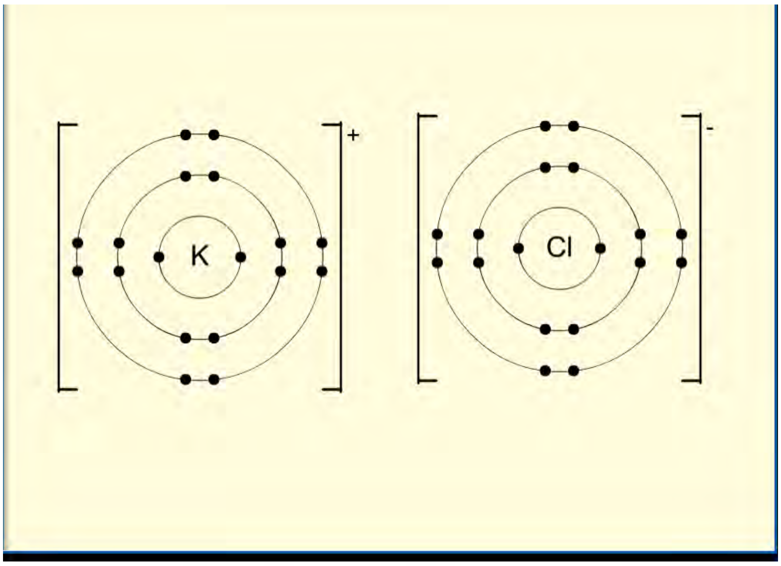
1. A
2. B
3. A
4. D
5. B
6. A
7. D
8. D
9. A
10. C
11. B
12. D
13. B

Solution to Theory Questions

14. a. B, F
    b. E
    c. A
    d. F
    e. A
    f. B_2C or F_2C / B,C or F
    g. CF_4

15. a. i) 2, 8, 1
    ii) 2, 8, 7

    b. structure of KCl



c. i) Na^+

ii) Cl^-

iii. NaCl

d. i) (it breaks into ions, positive and negative). In ionic substances the electrons are bound too tightly to be freed and flow with the current so it is the ions themselves which must flow. In a liquid the ions are able to move freely enough to carry the current. In the solid form the ions are bound into an ionic lattice by their mutual attraction and so are unable to flow.

ii) When molten

APPENDIX B

Post intervention quiz

1. Negatively charged ion attracts a (n)

   A. anion

   B. cation

   C. neutral atom

   D. proton

2. The total number of valence electrons in a molecule of CO_2 is

   A. 4

   B. 6

   C. 16

   D. 18

3. When Sodium Reacts with Chlorine, sodium will

   A. Share electrons with chlorine

   B. Swap electrons with chlorine

   C. Donate one electron to chlorine

   D. Accept one electron from chlorine

4. A pure substance does not conduct electricity in the solid state but it does dissolve in water and the resulting solution conducts electricity. The substance has a fairly high melting point. The substance is most likely to be

   A. an ionic compound

   B. a covalent compound

   C. a metal

   D. a network solid

5. A compound will have a covalent structure if it is made from

   A. An alkali metal with alkali earth metal.

   B. A metal with one or more non-metals.

C. Metals with semimetals
D. Non-metals only

6. A type of chemical bond that is formed from the attraction of an atom that has lost an electron for an atom that has gained an electron is called a(n)

B. covalent bond
C. ionic bond
D. metallic bond
E. hydrogen bond

7. NaCl is an

A. Hybrid Compound
B. covalent Compound
C. ionic Compound
D. Metallic Compound

8. Atoms take part in bond formation to

A. neutralise their charge
B. increase their charge density
C. increase their energy
D. attain a stable electronic configuration

9. Two or more atoms combine to form

A. an anion
B. an ion
C. a cation
D. a molecule

10. Na^+ combines with Cl^- to form the compound NaCl. The charge on NaCl is

A. neutral
B. positive

C. negative

D. a function of the conditions of formation

11. Which of the following compounds is covalent?

A. KCl

B. NH_3

C. LiCl

D. $MgCl_2$

12. in an ionic bond, the two elements

A. polarize electrons

B. exchange electrons

C. borrow electrons

D. share electrons

13. Graphite conducts electricity because

a. It has free electrons between its layers.

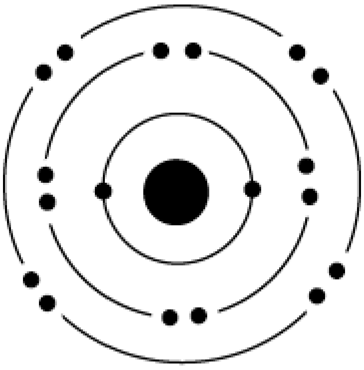
b. it has free ions between its layers

c. it has strong protons between its layers

d. it has strong neutrons between its layers

Theory Questions

14. The diagram below shows the electronic arrangement of an unknown substance.



(a) (i) In what group of the periodic table would the unknown substance be if it represented a 1+ ion?
.... [1]
(b) (i) In what group of the periodic table would the unknown substance be if it represented a 1- ion?
.... [1]
c) What would the diagram represent if it was a neutral atom?
.... [1]
(d) What would the relative atomic mass of the 1- ion be if it had 20 neutrons?
.... [1]
(e) How many neutrons would the 1+ ion have if its relative atomic mass was 39?
.... [1]
(f) What would the diagram represent if it was a 2+ ion?
.... [1]
(g)(i) How many protons would there be if the substance was a 2+ ion?
.... [1]
15. (a) Use the Periodic Table to write down the electronic arrangement of:
(i) Calcium
.... [1]
(ii) Chlorine
.... [1]
(b) If calcium is heated and put into a gas jar of chlorine a violent reaction takes place and solid calcium chloride is formed. The reaction proceeds due to the transfer of electrons.
(i) Use the electron arrangements and the idea of electron transfer to explain how the reaction between atoms of calcium and chlorine takes place.
(You should include a diagram in your answer)

....
....
....
....[4]
C. i) Write down the formulae of the ions of:
i) calcium
.... [1]
ii) chlorine form during the reaction.
....
[1] ii) Write down the formula of calcium chloride.

.... [1]

(d) i. Calcium chloride is a solid at room temperature and has a high melting point. Explain why calcium chloride has a high melting point.

....

.... [2]

(ii) A hot piece of sodium was placed in a jar of helium. No reaction took place.

Explain why helium is unreactive.

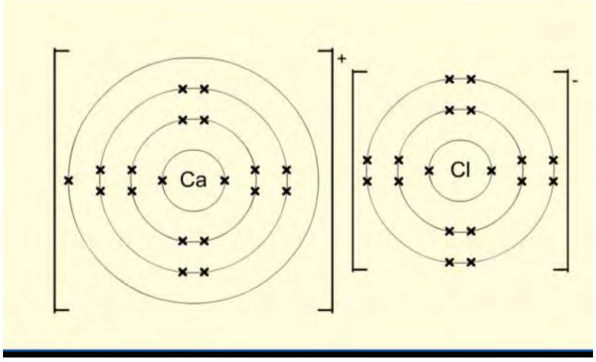
.... [1]

Marking Scheme

1) B cation (-ve ion attracts +ve ions)

2) C (16)

3) C
4) A an ionic compound
5) D
6) B (ionic Bond)
7) C (ionic compound)
8) D
9) D
10) A
11) B
12) B
13) A
    a. group 1
    b. group7
    c. Ar (Argon)
    d. 37 amu
    e. 21 neutrons
    f. Calcium
    g. 20 protons
14) a. i) 2, 8, 8, 2
    ii) 2, 8, 7
    b. i. Calcium has two (2) electrons as valence electrons and would give it out to have stable electronic arrangement like that of Ar (2, 8, and 8) and become Ca^{2+}. Chlorine can only take one out of these two electrons from Calcium. Therefore we will need (use) two (Cl) to absorb these two electrons from Calcium.
    ii. Diagram



c) i. Ca^{2+} (2, 8, 8)

ii. Cl^- (2, 8, 8)

iii. $CaCl_2$

d) i. Calcium Chloride has a high melting point because it is made up of ionic bonds. Ionic bonds are strong bonds with regular crystalline structure.

ii) It has a stable electronic configuration

APPENDIX C

UNIVERSITY OF EDUCATION, WINNEBA

FACULTY OF SCIENCE

DEPARTMENT OF SCIENCE EDUCATION

STUDENTS VIEWS ON CONSTRUCTIVIST LEARNING APPROACH

Introduction

The purpose of this questionnaire is to find out students on constructivist teaching approach. Note that this is not an examination and will not affect you; it will rather help teachers understand and develop a better approach to the teaching and learning of chemistry. Please show the extent to which you agree or disagree with each of the following statement by ticking (√) one column only for each statement.

Key: 1. strongly disagree 2. Disagree 3. Not sure 3. Agree 4. Strongly agree

S/No	Statements	1	2	3	4	5
1.	I like the class where the teacher does all the talking and tells us all the answers					
2.	I love the participatory class it is interesting					
3.	Chemistry teachers should be willing to give students individual help					
4.	When I am able to solve a problem in class, it increases my interest in class (subject)					
5.	I like chemistry taught in an interactive way					

6.	When I get an answer wrong my colleagues will laugh at me					
7.	I like the way chemistry was presented in these few weeks					
8.	When I get an answer wrong in class it makes me loose interest in class participation					
9.	If I can ask questions and contribute in class it makes the class lively.					
10.	I don't like to be asked questions in class. It makes the class boring					
11.	When I get an answer wrong in class my teacher may punish me.					
12.	I like the way chemistry was taught in my school.					
13.	I don't get appreciated when I answer correctly					

APPENDIX D

SAMPLE LESSONS BASED ON YAGER'S CONSTRUCTIVIST TEACHING STRATEGY

SAMPLE 1:

STEP 1 (INVITATION): The teacher asked a question: What do you think a chemical bond means? The purpose was to activate students' existing ideas and identify their preconceptions.

STEP 2 (EXPLORATION): The teacher created groups based on their grades in the last semester. The groups consisted of four or five students. Each group involved high, medium and low achiever students. The students discussed the question the teacher asked in the previous step in groups. During the discussion, they had opportunity to express their ideas and saw their peers' thoughts. They defended their ideas when there were different ideas in a group.

At the end of the discussion, each group was supposed to give a common answer to the teacher. For the previous question, most students thought that bonds were ―things" that holds atoms together but they could not explain exactly what the ―thing" was.

This step was also important in terms of causing students to have cognitive conflict according to Posner et al (cited in Turgut and Gurbuz 2012) conceptual change model. During discussions, students became aware of their ideas and saw some inconsistencies or gaps in their reasoning and therefore dissatisfaction occurred.

STEP 3 (PROPOSING EXPLANATIONS AND SOLUTIONS):

The teacher got the answers from each group. Based on their answers, he explained the concept. He emphasized on common misconceptions and the topics in which students had difficulty. He used analogies or examples in order to make concepts more concrete. For the question asked in step 1, after the teacher got the students‘ responses, he wanted students to explain what they meant by saying ―thing”. However, the groups could not explain it. Then, the teacher introduced bonding concept:

―In nearly all natural substances, atoms and ions exist bound to one another. Most of the substances around us are compounds rather than elements. For example, table salt, NaCl, consists of sodium and chlorine elements.

Similarly, water consists of hydrogen and oxygen elements and has a formula H_2O. At low pressure and high temperature, hydrogen and oxygen gases combine to yield water which has different property from both oxygen and hydrogen: $H_2 + 1/2\ O_2 \rightarrow H_2O$.

Compounds are formed as a result of reaction between atoms. Since the elements lose their identity during the reaction, compounds can be separated into elements by chemical methods. So, what joins the atoms to each other in a molecule? What is the "glue" that holds the molecule together?

Chemical bonding is responsible for the behaviour of substances around us. Why is table salt a hard, brittle, high melting solid that conducts electricity only when molten or dissolved in water? Why is wax low melting, non-brittle and non-conducting? Why are metals shiny and bendable substances that conduct whether molten or solid? The answers lie in the type of bonding within the substance. So what is a chemical bond? Most students think wrongly that chemical bonds are material connections simply. However, when we think scientifically, we see that there are *forces* that hold the atoms of elements together in a compound. These forces are called as ―chemical bonds”. In other words, the ―thing” between atoms you mentioned is the electrostatic forces that hold the atoms together. The type and strength of chemical bonds determine the properties of a substance.

You are familiar with the magnets. What will happen if two magnets are put closer to each other? (The teacher showed magnets to the class). We know that like poles repel and unlike poles attract each other. This is similar to the attraction and repulsion between electric charges. There are attractions between particles of two atoms that lead to chemical bonding and hold the structure together."

This step supports conceptual change described by Posner et al. as cited in Turgut and Gurbuz (2012). Since the teacher states clearly what a chemical bond is by using magnets, emphasizing interactions and stressing on students' preconceptions, the concept became intelligible and plausible to the students. In addition, the students realized that they could use this explanation for finding solutions to other questions; in this way, Posner et al.'s last condition (fruitfulness) was achieved.

STEP 4 (TAKING ACTION):

The teacher concluded that chemical bonds are electrostatic forces and asked a new question which was: What do you think why chemical bonds form? His purpose was to activate students existing knowledge, which they got in the previous steps.

Then, the students discussed this question in groups and gave a common answer to the teacher as a second step (exploration). The teacher presented the topic as a third step (proposing explanations and solutions) and as a last step (taking action) he asked a new question again.