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The Effect of Multimodal Instructional Approaches on the Performance of Students in Chemical Bonding

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Abstract

Continuous use of traditional instruction has resulted in unsatisfactory performance, misconceptions and poor attitudes towards chemical bonding for many students. This study was designed to determine the effects of multimodal instructional and traditional instructional approaches on selected colleges of education first year students' understanding of chemical bonding concept. Effect of the instruction between gender differences on understanding of chemical bonding was determined. The study took place in Offinso and Berekum Colleges of Education. Students were randomly selected into the groups. The sample of the study comprised of 120 first year students from the two colleges of education. Questionnaire interview schedule, pre and post-tests were used as the main instruments to collect data for the study. Statistical Package for the Social Sciences (SPSS), version 20.0, for windows was used to analyze the data. It was found out that 51.7% of student-teachers who participated in the study had no understanding of the concept of chemical bonding and with a lot of misconceptions and also exhibited negative attitudes towards learning the topic. The results indicated that there was statistically significant difference in performance between experimental and control groups. The experimental group performed better in post-test than control group. The result from data analysis showed that there was no statistically significant difference between male and female students. It was recommended that Offinso and Berekum colleges of education chemistry tutors especially those teaching EBS 132 should employ multimodal instructional approaches in teaching chemical bonding.

Keywords: Multimodal Instructional Approaches, Traditional Designed Instructional Approach, Experimental Group, Control group, Modes, Trends in International Mathematics and Science Study, Foundation Development Course

Background to the Study

The major problem facing science education, according to Bennett (2011) is the identification of the most effective and efficient pedagogical strategies for improving science literacy. One of the concepts in science literacy which learners always have difficulty with is chemical bonding (Coll & Treagust, 2000; Sitalakshmi, 2008). Learning chemical bonding entails learning the representational practices of abstract concepts to explain natural phenomena. The learning of this science concept is now understood as knowing how to interpret and construct the concepts of science (Norris & Phillips, 2003). Recent studies concerning science teacher education focus on content knowledge and pedagogy. The need to design instructional methods that would promote better understanding of scientific concepts is very important for the development of science education (National Research Council, 1996). The importance of this area is that there is a strong link between the students' content knowledge and the pedagogy that teachers use to teach.

Primarily, teachers' knowledge and instructional approaches have direct effects on how science literacy develops in the classroom, and this correlates with students' achievement (Tatto 2001). It is therefore reasonable to relate learning experiences of the learners to the teachers' instructional approaches. The quality of science education can be assessed by some outcome variables such as examination results. The poor performance of Ghana Junior High School students who are mostly taught by teachers from Colleges of Education in the TIMSS assessment in 2003 and 2007 (Anamuah-Mensah, Mereku, Ampiah, 2009) and number of candidates who fail in Integrated Science examinations at first and second cycle levels of education in Ghana has been a great concern of late. Large numbers of students who attend remedial classes and re-sit for examinations after completion of Junior High School and Senior High School of education are those who could not pass or had weak grades in science, it also observed that is one of the subjects students tend to dislike most. The students in the colleges are often referred to re-sit their science courses every year.

Few students choose to answer bonding questions that demands reasoning and interpreting according to Chief examiners' report of FDC 114 science course. Several researches indicated that abstract teaching of scientific concepts among others contributes to lack of interest and poor performance of students in science.

To improve science literacy and interest of students at the college level, Japanese International Cooperation Agency (JICA) project established science resource centres at some colleges such as Akrokerri and Bagabaga Colleges of Education to produce science teaching and learning material to enhance teaching of science. Ghana Association of Science Teachers (GAST) and Ghana Science Association (GSA) through annual science conferences organize workshops for tutors. The Ministry of Education, Science and Sports (MESS) was also tasked to orient individuals at all levels of the educational system to enhance the teaching and learning of science and technology (MESS, 2004). These interventions are attempts of the Government of Ghana in its Vision 2020 which identified science and technology clearly as the bases of lunching Ghana into middle income earning country and a competitor with other developing nations in the 21st century comes to pass.

Statement of the Problem

Chemical bonding is one of the key components of chemistry concepts which pose learning difficulties to students in Offinso and Berekum Colleges of Education in Ghana in integrated science and the recently introduced general chemistry. This concept helps to understand how atoms are put together for effective reaction and the production of materials. But a large number of students have difficulty in reading and writing, interpreting and comprehending bonding concepts in different representational modes. These affect critical components of science literacy (Norris & Phillips, 2003). The students' difficulties among others lie in pedagogy and the abstract nature of the topic. In teaching, basic approaches like different modal representation of the same concepts are not used in colleges of education in Ghana. Rather teachers rely on traditional teaching method such as lecture method which teacher -centered approach and pedagogical content knowledge termed as content-specific with the aim of completing the course outline giving by the affiliate university which helps students in passing their semester examinations only without grasping the actual concept. This makes students have difficulty in interpreting and comprehending concepts, or lack skills to fully articulate what they have learned from reading the literature. The purpose of introducing chemical bonding seems to have been compromised with several misconceptions at all levels of education in Ghana. This study therefore designed to determine the effect of multimodal instructional approaches on the students' understanding of chemical bonding in colleges of education in Ghana.

Purpose of the Study

The purpose of the study was to identify the causes of students' poor performance, effect of multimodal instructional approaches on students' understanding of chemical bonding concepts and the students' perceptions of teaching methods to provide opportunity for teachers to professionally develop appropriate pedagogical approaches and integrate in their teaching.

Objectives of the Study

1. identify the causes of students' difficulties during lessons on chemical bonding.
2. evaluate the effect of multimodal instructional approaches on the students' performance on chemical bonding.
3. determine the differential effects of multimodal instructional approaches on the male and female students' performance on chemical bonding.

Research Questions

To achieve the stated purpose above, the study addressed the following research questions;

1. What are the causes of the difficulty's students face during lessons on chemical bonding?
2. What is the effect of multimodal instructional approaches on the students' performance in chemical bonding?
3. What are the differential effects of multimodal instructional approaches on the male and female students' performance on chemical bonding?

Null Hypotheses

The following null hypotheses were also formulated for the study:

HO1: There is no significant mean difference between the averages mean score of students taught chemical bonding using multimodal instructional approaches and their colleagues taught with traditional instructional approach.

H02: There is no significant difference between the mean scores of male and female students who are taught chemical bonding using multimodal instructional approaches.

Significance of the Study

The findings of the study would be useful to all B.Ed. primary education students in Offinso and Berekum colleges of education in Ashanti and Ahafo regions of Ghana respectively. The outcome of this study would be helpful to science teachers and educators to realize the importance of the multimodal instructional approaches so that they can integrate it in their teaching and learning processes. It could also help teachers to recognize factors that lead to students' difficulties in their learning process. It may be useful for the in-service training of teachers at the basic school level and training institutions, to identify and use multimodal instructional approaches in the classroom. The findings of this study may also help improve the students' understanding of chemical bonding concepts. The pre-service teacher could have the ability to critically analyze and interpret chemical concepts that are put in different modes of representations in internationally acceptable standard. The study would eliminate student's misconceptions about the forces that exist in covalent bond concepts of chemical bonding

The findings would also help motivate students to be involved in active learning since instructional approaches would cater for learning differences. This study could add to the existing literature on methods of teaching science concepts and as such will serve as a source of reference for researchers who would want to carry out research on how concepts should be taught and learnt in schools. Finally, the finding may serve as source of information for Ghana Education Service, Curriculum Research and Development Division, authors of books and other science education agencies to make structural changes in the literature of science education.

Delimitations of the Study

The research was basically on the concept of chemical bonding in integrated science course outlined for colleges of education in Ghana. The study was delimited to the interaction with the first-year students in Offinso College of Education and Berekum College of Education in Ashanti and Ahafo Regions of Ghana respectively. The students in other year groups were excluded. It was limited to using five different and integrated modes of instructional approaches to teach the concept.

Limitations of the Study

Best and Kahn, (1995) limitations are conditions that are beyond the control of the researcher that place restrictions on the validity of the study. The results of the research may be influenced by the followed limitations. Some of the students were absent from lessons during the study. They were likely not to understand the concepts taught very well. Other students also kept revising their old notes and textbooks on the topics; hence the treatment may not be solely responsible for their output in the tests. These observations notwithstanding the findings of this study would provide insights into the efficacy of multimodal instructional approaches for science lessons.

Theoretical Framework of the Study

Three major theoretical frameworks informed this study. The first is transmediation, which is the transfer of information from one symbolic representation system to another (Suhor, 1984). In transmediation a student transfers key concepts and ideas from one text and creates a new text incorporating those key themes and ideas. Charles Pierce first examines this idea to deeply examine how symbols are used to create meaning and he suggested that a symbol simply does not stand for something, rather its meaning is culturally mediated (Siegel, 1995). Symbols come to be understood by the individual based on his or her experiences with the world. According to Pierce, a symbol is simply not a substitution for an object, rather a symbol tells something about the meaning of the relationship between the sign and the object. And therefore, it requires an interpret ant (Short, 2004). Students act both as interpreters and creators while they constructed these multimodal projects.

The study is also framed by current theoretical accounts of both the nature of science discourse and learning as re-representation. Both perspectives are compatible with one another in that they link theories of science as a subject to how science can be learnt effectively and also what should count as this learning. Science should be understood historically as the development and integration of multimodal discourses (Kress, Jewitt, &Tsatsarelis, 2001; Norris & Phillips, 2003; Lemke, 1998, 2004). As noted by Lemke (2003), the integration of these different modes is a key feature of the development of scientific knowledge. This is where analogy, Symbolic, realia, verbal, and graphic modes of instructions have been used individually and in coordinated ways to represent the knowledge claims of science discourse.

The Nature of Chemical Bonding

Chemical bonding is one of the key concepts in chemistry and one of the most fundamental ones that students learn. In fact, Hurst, (2002) reported that bonding is a central concept in the teaching of chemistry. A thorough understanding of it is necessary for understanding of every other topic in chemistry such as carbon compounds, proteins, polymers, acids and bases, chemical energy and thermodynamics. The concept of chemical bonding and structure, such as covalent bonds, molecules, ions, giant lattices and hydrogen bonds are highly abstract. Due to the abstract nature of bonding, it is considered by teachers, students especially teacher-trainees, and chemists to be a very complicated concept to understand (Robinson, 2003; Taber, 2001). Chemical bonding is an area in the physical sciences which understanding is developed through diverse models which learners are expected to interpret through the use of different range of symbolic representations and modes (Taber, 2001). Levy, Mamlok-Naaman, Hofstein and Taber (2010) argued that in order to fully understand these concepts, learners of chemical bonding must be familiar with mathematical and physical concepts and laws that are associated with the bonding concept such as orbital, electro-negativity, electron repulsions, and polarity. Learning about chemical bonding also allows the learner to make predictions and give explanations about physical and chemical properties of all substances.

The chemical bonds between these particles are used to explain many of the chemical and physical properties of substances and chemical phenomena (Hurst, 2002; Levy Nahum, Hofstein, Mamlok-Naaman & Bar-Dov, 2004). Since bonding is a central concept in teaching chemistry, a thorough appreciation of its nature and characteristics is necessary for the learners Chemical bonding is also explained to be what holds atoms together in molecules and crystals (Gillespie, 1997). Gillespie stated that it is one of six most important key concepts that should be included in every high school chemistry syllabus. This suggestion by Gillespie among others might have been the reasons why chemistry courses or concepts were introduced in the colleges.

The Mode of Representations of Chemical Bonding

The understanding of the topic 'Chemical structure and bonding can be developed through diverse instructional models in order to aid built on a range of physical principle. It is viewed that students are expected to interpret different symbolic representations used for explaining the concepts of chemical bonds (Taber & Coll, 2002). Evidently, Johnstone, (1991) stated that matter and its activities can be represented on three levels; the macroscopic (phenomena), microscopic (particles), and the symbolic levels (chemical language and mathematical models). According to Gabel (1996), teachers unconsciously often move from levels to another in their teaching. The problem is that they are not able to assist students to integrate these levels of which at each level concepts could be interpreted in more than one way (Tami, Avi, Rachi, & Ziva, 2004). Thus, students rather become more confused easily in the learning process. Robinson (2003) on his part has suggested that to avoid the confusion students must first be taught thoroughly to understand how to convert a symbol into the meaningful information it represents.

Scientists perform research and communicate their findings through using more than one mode of representation to one another to publish their result (Bennett, 2011). Most of these results are to solve human problems and must be communicated to learners through all senses for them to understand the findings well. Communication among scientists to understand results is very important that the argument has been made that science is impossible without language playing central role. During research presentations at professional meetings and laboratory meetings among co-workers or teachers and students, scientists use language in very specific and constructive ways. Language is used by scientists to explain, and interpret meaning from their finding, to make sense their results in the context of chemistry. The language dependency is the groundwork for fundamental sense and derived sense in science literacy. However, the process of conceptualizing and communicating scientific ideas and findings science instructors must be able to use a variety of methods (multimodal instructional strategies) to communicate for better understanding. In classroom, teachers are expected to use figures, graphs, diagrams, mathematical equations, chemical equations and even non-verbal gestures, experiment and videos illustrations when giving accounts of the scientific concepts, ideas and findings (Bennett, 2011). All these modes are used to facilitate understanding, but how come that there are difficulties in learning science? According to Bennett, all of these methods of representing ideas and concepts are different modes of representation of concepts and ideas that do not fully explain any scientific concept.

It is not surprising seeing in any professional science publication or textbook, readers confronted with figures, graphs, tables, and all manner of modal representations.

The importance of representing scientific concepts in multiple modes to gain bonding literacy means that it must necessarily be considered by science educators as well. When students encounter difficulties with learning the same ideas, concepts, and reported scientific findings that the professional researchers put in different modes they will go to their instructors for help. So, students must be exposed to the same or similar modes of concepts representations in different instructional approaches for them to appreciate and understand it (Bennett, 2011). According to Bennett, in some topics it is not possible to separate a scientific concept from its modes of representation. For that matter, for a student to understand the concept better teachers need to use multiple- modes of instructions. Most of the proposed models are represented by symbols, graphs, diagrams, etc. and cannot be communicated without them. From the chemical structure and bonding in chemistry the modes used as representations to communicate the concepts became a part of the language of science. The problem is that science students are normally faced with the challenges associated with learning the language of science along with its modes of representation. Science educators need to consider the process of student learning through multi-modal representation by developing instructional multiple modals in the same context to solve these challenges. Science education researchers also need to investigate the link between the multiple modes of representation in science and teaching by multi-modal representation strategies of learning in science literacy (Sankey, Birch & Gardiner, 2010).

Instructional Techniques in Teaching Chemical Bonding

Chemical bonding is a topic that is understood by the development of diverse models built on series of physical principles, and where learners are expected to interpret a disparate range of symbolic representations standing for the concepts (Taber & Coll, 2002). The bonding of particles results to the formation of various kinds of matter. This matter can be represented on three levels: macroscopic (physical phenomena), microscopic (particles), and symbolic representational (chemical and mathematical language) according to Johnstone (1991) and Gabel (1996). The symbolic representations play a key role of mediating between the phenomenological-descriptive level of what students can recognize, and, the abstract conceptual level of theoretical entities. For instance, H^2O could stand for both molecules and substance. But when teaching chemical bonding, teachers repeatedly and impulsively move from one level to another in their teaching without making it known to the learners. The inability to help the students integrate the levels has the possibilities of confusing them with reference to the symbol (Taber, 2009).

Modes of Instruction in Chemical Bonding

The learning of science concepts and methods entails understanding and conceptually linking multiple representation and multimodal instructions (Russell & McGuigan, 2001). Multiple representations refer to the same concept being shown in different forms such as verbal, numerical, graph and symbolic illustrations (Vaughan & Bruce, 2008). Multiple representations are used by researchers and scientist to communicate their concepts, principle and low in different forms for people to understand them. For instance, in chemical bonding, the concept is communicated to learners and among scientist by using different representations; that is using 'dash' and 'dot' illustrations, word representations, graphical representation etc. to show how bonds are formed. In the classroom, teachers assist students by using modes of instructions for them to be able to translate their understanding from one representation to another in order for them to be able to represent their knowledge. According to Vaughan and Bruce, multimodal refers to the integration of different modes within the same text to represent concepts or ideas, reasoning and finding.

Use of Multimodal Instructions to Learning Chemical Bonding

The use of multiple representations, particularly in computer-based learning environments has now been recognized as a very powerful way to facilitate understanding (Moreno, 2002). For example, when the written word fails to fully communicate- a concept, a visual representation can often provide remedy for the communication problem (Ainsworth & Van Labeke, 2002). Some simple examples of multiple representations include, using audio enhanced PowerPoint slides as mini lectures, usually using point-form text or images, interactive diagrams with accompanying transcripts and voiceovers, video presentations, interactive graphs and forms, audio explanations of concepts, and still images. In these examples, the multimedia elements (visual, aural, and interactive elements) present additional representations of the information also provided in text-based explanations. This approach caters for a range of different modal preferences and provides students with choice in how they can access key content, and thus may be considered a more inclusive response or stimulates metacognition to the needs of non-traditional learners.

Kress et al called for attention to the functional specialization to the use of different modes to communicate concepts to learners. According to them a mode may develop better understanding than another in certain directions and will therefore have greater potential for meaning-making or impose further limitations. Different modes play specific roles in the construction and representation of concepts in the classroom (Lemke 2003; Jewiit *et al*., 2001). The teacher specialty in the skill of modes of communication may make it appropriate for given relevant instructions in the classroom, as Lemke (1998) stated:

> *We can indicate modulation of speed or size, or complex relations of shape or relative position, far better than we can with words, and we can let that gesture leave a trace and become a visual-graphical representation that will sit still and let us re-examine it at our leisure. (p.3).*

Learning with multiple mode representations of concepts in the early research concentrated on the ways that presenting pictures alongside text to improve learners' memory for text comprehension (Levin, Anglin & Carney, 1987). In the recent times, the explosive increase in multi-media learning environments have widened the debate to include combinations of representations such as diagrams, equations, tables, text, graphs, animations, sound, video, and dynamic simulations (Ainsworth, 2006). Several researches attempted to discuss the importance of multiple external representations during lessons. Dienes, (1973) argued that perceptual variability of the same concepts represented in varying ways provides learners with the opportunity to build abstractions about concepts. According to cognitive flexibility theory, the ability to interpret, construct and switch between multiple perspectives of a domain is fundamental to successful learning (Spiro & Jehng, 1990). Nevertheless, study on the benefits of providing learners with more than one representation has produced mixed results. While some studies have found that learners benefit from multiple representations (Cox & Brna, 1995; Mayer & Sims, 1994; Tabachneck, Koedinger & Nathan, 1994), others do not find these as beneficial to learners (Van Someren, Reimann, Boshuizen, & de Jong, 1998; Chandler & Sweller, 1992).

Facilitating Metacognition

Sometimes teachers may try to design learning environment and teaching methods for all the different types of learning styles in class. Inevitably limitations to these approaches arise such as many students do not even realize they are favoured in one way or the other. because nothing external tells them they are any different from anyone else (DePorter, 1992 cited in Sankey, Birch, & Gardiner, 2010), It is therefore observed that when designing learning environments to cater for an array of different learning styles, it is necessary to understand students' metacognitive needs too. Apart from this, helping individual students become aware of their own preferred approach to learning needs to also be considered.

According to McLoughlin, (1999), teaching students on how to learn and how to monitor and manage their own learning styles is crucial to academic success. When students become aware of their individual strengths and weaknesses as learners, they can be more motivated to learn (Coffield, Moseley, Hall & Ecclestone, 2004). The impact of this awareness is that students can question their long-held beliefs, or behaviours, and can be taught to monitor the diverse strategies that can be used to assist them to learn on their own (Sadler-Smith, 2001). This strategy has also been shown to increase the confidence, the interest and the academic performance in terms of grades of students, by helping them to choose the most of the learning opportunities that have been designed to match their preferred modality (Coffield, et al., 2004). Students are therefore encouraged to complete some learning styles inventory forms to able them determine their most learning teaching methods, Teacher should also engage students in many teaching methods to determine the learning instructions that fit better for a class or level of learners

Differential Impact of Multimodal Instruction on Male and Female

There are differences across gender in the way students learn concepts. According to Sankey, Birch and Gardiner, (2010), male students have a multimodal learning style with no visual modes compared to their female counterparts. But the females are more evenly distributed across multimodal learning styles. Lau and Yuen (2010) indicated that females have higher preference for concrete sequential and abstract modes compared with males. However, in terms of what stimulus that is presented for learners to react to, there is growing evidence to show that differences of learning, styles in terms of gender are: socially constructed in the science among other disciplines or fields (Milgram, 2009 cited in Lau & Yuen, 2010). These learning styles of student determine the kind of different modes to use in teaching a text. For Hade (2005), the males and females are similar in learning science instead of difference in most psychological variables including mathematical ability. That is to say, the observable difference between males and females are not innate (Lau W. W. & Yuen, A. H. 2010). Thus, the basic statement wealth noting is that if the gender numerical divide is mainly due to nurture instead of nature, it is then important for educators to nurture a gender sensitive and friendly, instructional environment to engage in active participation and learning if more female or males are in class. It is also clear that there are relatively learning styles between males and females. Nonetheless, much effort has not been made into investigating the possible impact of the gender differences in multimodal instructional approaches on teaching and learning concepts. This study also aims at examining the male and the female differences in multimodal instructional approaches of understanding chemical bonding.

Research Design

In this study, the quasi-experimental design was used. It involved assigning the research subjects between two groups, a control group and an experimental group. This design permitted the two groups to be pre-tested and post-tested with different test items of the same difficulty level. The ultimate difference was that the students of Offinso College of Education who were the experimental group received the treatment. However, Berekum College of Education students did not receive the treatment since they were used as the control group. Both groups were taught by the researcher during the study. The traditional instructional approach was used to teach the students of Berekum College of Education who represented the control group, whiles multimodal instructional approach was used to teach the students of Offinso College of Education assigned as the experimental group. The lesson involved step-by-step procedures beginning from the introduction through exploration, explanation and solution, and taking action. This design was used because it allowed a number of distinct analyses and gave the researcher tools to screen out experimental and confusing variables. Also, the internal validity of the design was strong because the pre-test ensured that the groups were equivalent in achievement level. The design analyses of the various performances at each test levels are shown in Figure 1 below

Pretest Treatment Post-test Performance Difference

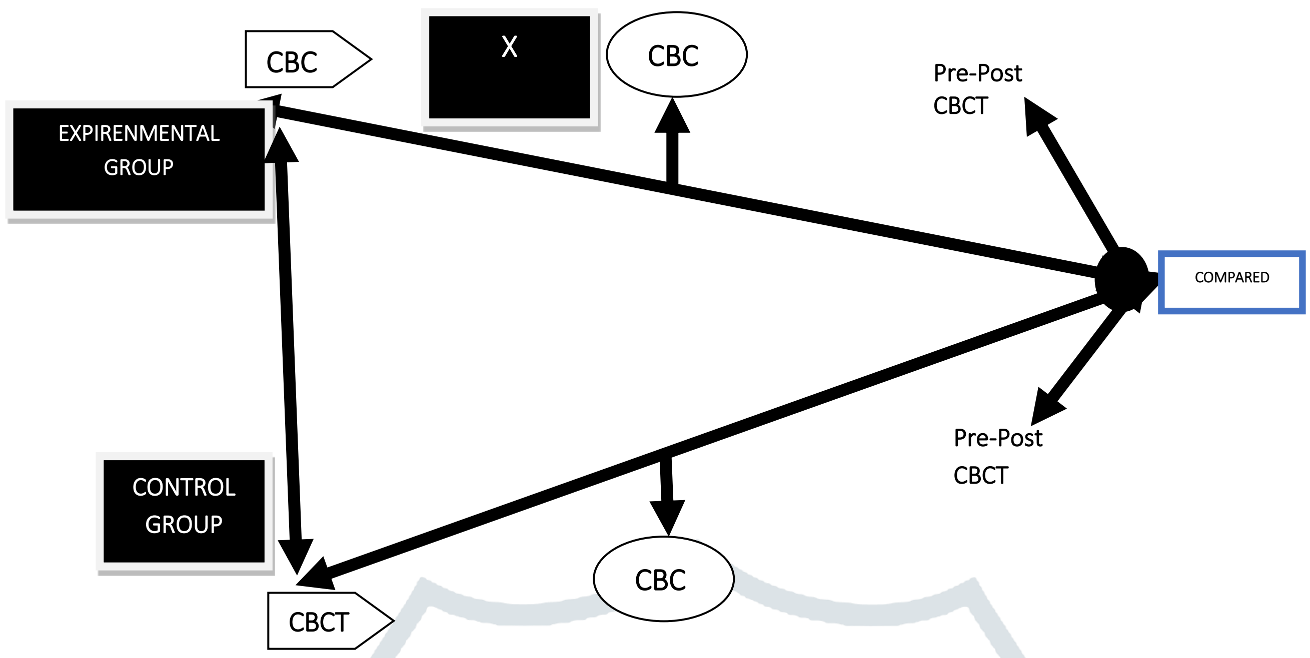


Figure 1: Pretest post-test experimental design

(CBCT: Chemical Bonding Content Test, and X; exposure to treatment)

X indicates the exposure of an experimental group to multimodal instructional approaches after the both the control and experimental groups have responded to pre-testing items. The two groups were randomly selected and designated as experimental group and control group. Only the experimental group received the treatment and also responded to the questionnaire. However, both groups took part in the post-test activity. Martyn, (2009), the design allows the researcher to compare the final post-test results between the two groups which give the researcher an idea of the overall effectiveness of the treatment. Again, it enables the researcher to find out how both groups changed from pretest to post-test, and whether only one improved, and to what extent after the lesson. If the control group showed a significant improvement, then it will inform the researcher to look for what accounted for that. The design would also allow the researcher to compare the test scores of the two pretest groups, to ensure that the randomization process was effective. Apart from evaluating the effectiveness of randomization, it would also help to determine whether the treatment group showed a significant difference. The treatment (X) used each in the experimental group is the five multimodal instructional approaches. These approaches emphasize the integration of five different modes (methods) of instructions. The modes of instructions used here were; realia, visual, analogy, symbols and verbal interaction as shown in Figure 2 below

Figure two illustrates how the five modes of instructions mentioned above are related in other to ensure effective delivery of content.

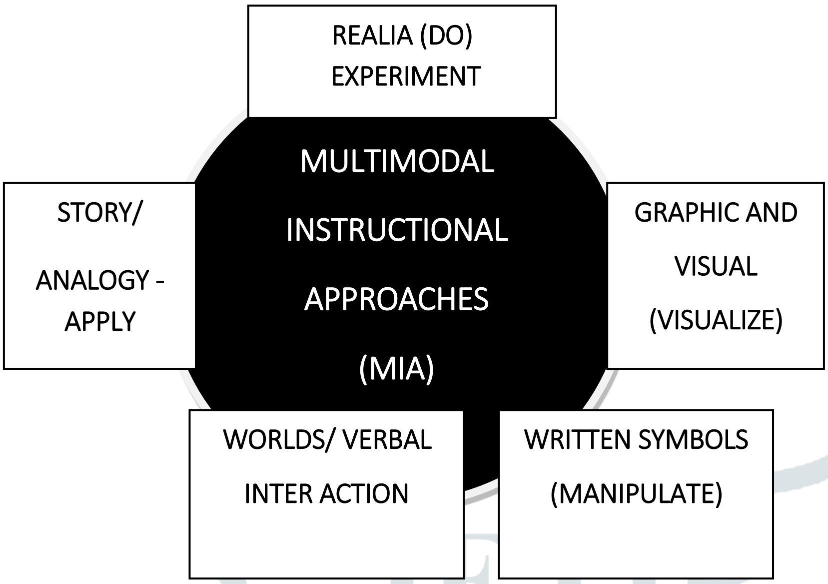


Figure 2: The five modes of instructions

This Pent-Multimodal instructional approaches Framework was an extension of the Think Board consisting of four modes introduced by Hay L. (1984). The extension includes more modes and uses words that are easy to understand by the target students. Symbol manipulation mode; this was the most predominant mode of instruction used because chemical bonding concepts are taught mostly by symbolic representations. Also, many science curricula all over the world include a large amount of work on manipulations of symbols, such as simple alphabets and numbers. However, many students find symbolic manipulations difficult and meaningless, and they fail to appreciate the power that symbols play in science thinking. Hence it was integrated with the other modes of representation to promote the understanding of bonding. Verbal interaction mode; Words are essential in communicating science ideas and in thinking about them. As -a mode of instructions, it includes word or phrases- and sentences. Students often confuse the meanings of the same word when used in everyday situations and in science. This problem becomes more severe when students learn science in foreign languages. In classroom teaching, the teachers wrote on the board the key words and phrases to be learned, ask students to read them aloud and copy them in their notebooks. The teacher explains their scientific meanings as clearly as possible to learners. Teachers explain science terms precisely and consistently. This helped many students who failed to link the spoken sounds with the written words or symbols. Students were encouraged to use the proper words when talking about bonding.

Visual and Diagram-Visualize. This mode of teaching includes diagram illustrations, charts, and computer animations. They appear in textbooks, chalkboard drawings, and computer screen displays. Diagrams come in various degrees of abstraction, and carry scientific ideas in an interesting way, and constitute a crucial mode of processing. Drawing diagrams is an important problem-solving heuristic which many scientists use.

Realia: This mode of teaching refers to the use of concrete manipulative such as concrete object. This is based on the psychological theories of Piaget and Bruner (1964). It is related to the principle of learning by doing: I hear and I forget; I see and I remember; I do and I understand. Foundation abstract chemical bonding ideas in concrete situations, students may develop the mental models that provide meaning to the abstract 'symbols which will reduce anxiety towards chemistry. The cross-over from practical activities to formal abstraction, however, is not easy (Johnson, 2004). Teachers need to work harder to facilitate this transition through careful questioning, discussion, prompting, and explanation.

Research Population

A research population is a large well-defined collection of individuals or objects having common characteristics (Castillo, 2009). According to Castillo (2009), there are two types of populations: the target population and the accessible population. The target population also known as the theoretical population refers to the group of individuals to which researchers are interested in generalizing the conclusions. Whiles the accessible population which is also known as the study population is the population which is available for the researcher and to which the researchers can apply their conclusions. The target population for this study was all first-year students of Integrated Science of 2020/2021 academic year in two colleges of education in Ghana. The first-year students were chosen because chemical bonding is studied in the first semester of first year and the students had been introduced to some concept of bonding at the Senior High School level. However, the accessible population was all first-year students in Offinso College of Education and Berekum College of Education. These institutions were chosen because they run the same programmes, which are general courses, and have the bonding teaching materials. Also, they were selected due to the convenient reached of the researcher and the willingness of the institutions to accommodate the study.

Sample and Sampling Technique

A sample is a true representative group selected from the population for observation in a study (Ary *et al*., 2002). The sample for the study was 120 first year students of Offinso and Berekum Colleges of Education in the Ashanti and Bono Regions respectively. Sixty students (30 males and 30 Females) were also randomly selected from Offinso College of Education as the experimental group and were instructed using multimodal instructional approaches. Whiles the students in Berekum College of Education were assigned as the control group and were instructed using traditional designed approach. These two schools were used in order to avoid interactions between the control group and the experimental group. Additionally, when one institution is used, the human interactions may occur as a result of students' group discussion after normal classes or during prep hours. The classes of each of the colleges were chosen due to the fact that researcher wanted a fair representation of male students and female students. Thirty students with equal number of male and female were selected from each class by randomly selecting their index numbers without the student been aware the consent of the students in both groups were duel sought.

Instrumentation

The study used both quantitative and qualitative data gathering instruments. These were questionnaire, semi-structured interview guide, and Chemical Bonding is Concept Test (CBCT). Questionnaire is used for collection of data in educational research when information is to be widely used for large number of subjects. It is also effective for getting factual information about opinion, practices and attitudes of a subject (Amedeker, 2000). The test and the students, perception scale questionnaire constituted the quantitative part of the research instruments while the interview schedule constituted the qualitative part of the research instruments.

Questionnaires

A questionnaire was designed based on the purpose of the research questions to obtain the views of learner’s perception about the use of multimodal instructional approaches. According to Hannan (2007), questionnaires are straight forward written questions which require an answer by ticking the appropriate box; an efficient way of collecting facts. They are also employed as tools to gather information about people's opinions through asking the respondents to indicate how strongly they agree or disagree with a statement given. It is done by providing respondents space in which they formulate their own responses. All the items on the questionnaire used for the study were closed-ended type. The items were Likert-type of scale. Likert-type scale was used because it is easy to construct and more reliable than-others scales (Tittle & Hill, 1967). The scale also provides the researcher the opportunity to use frequency and percentage as well as means scores to compute the data. Likert scales are often observed to give data with relatively high reliability (Gabel & Wolf, 1993). The questionnaire consisted of demography of the students and the close-ended items to demand specific responses to be expressed on a five-point Likert scale. Items on the questionnaire which were not clear to respondents were explained to them in order to elicit the right responses. A detail of the questionnaire is found in Appendix D.

Chemical Bonding Concept Test (CBCT)

A test is a tool or procedure for measuring a sample of behaviours. To measure the performance level of students in the chemical bonding questions which were developed by the researcher. The content was determined by examining literature developed according to the course outline and instructional objectives for the chemical bonding in the text unit. During the development of the test, instructional objectives of chemical bonding topic were determined to find out whether the sampled students achieved the objectives of chemical bonding and purpose of this study. The questions were reviewed by the researcher's supervisor and pilot tested. This test contained twenty content test items. Each question in the test had one correct answer and three distracters. The researcher also set questions parallel to the past questions for FDC 114 and EBS 132 examinations conducted by the Institute of Education, University of Cape Coast. An appendix B indicates the detail marking scheme of the CBCT. The test was administered twice during the study; that is before the treatment as pretest and after the treatment as post-test to the two groups as in appendix A.

Interview

Kvale, (1996) stated that interview is an interchange of views between two or more people on a topic of mutual interest, seen as central of human interaction for knowledge production emphasizes the social situation of research data. Interviews are systematic way of talking and listening to people to collect data as well as gain knowledge from individuals. The researcher used semi-structured interview schedule for the study to get insight into student's conceptual understanding of the use instructional methods. The interview was scheduled for student only. It was used to seek student's views about multimodal instructional approaches. The interview was the instrument used to gather qualitative data. The interview items are found in appendix C.

Validity of the main Instruments

Validity of a research instrument is how well measures what it is intended to measure (Patton, 2007). The test items and questionnaire were examined by experienced chemistry teachers who have taught for six years based on the cognitive levels of students and the instructional objectives outlined in the course plan for colleges of education. The instrument was vetted by the researcher's supervisor to determine the extent to which the test measures a representative sampled of the domain of tasks with respect to the chemical bonding topic. The interview items were given to the researcher's supervisor to find out if they elicit appropriate information from the participants.

Reliability of the main Instruments

Reliability concerns with the extent to which a questionnaire, test or any measurable procedure produces the same results on a repeated trail. That is, it is the consistency of score over time. To ensure reliability of the instrument, the instruments were tested using test-retest reliability method. The instruments were first administered and then re-administered on the same respondents after one week. The result of the first test and second test outcomes were compared to ascertain the reliability of instruments. The reliability of the test using Cronbach alpha reliability coefficients was calculated to be 0.72. The reliability coefficient of the pretest and post-test were calculated to be 0.76 and 0.79 respectively using Cronbach alpha reliability test.

Pilot Test

The research instruments were pilot-tested personally by the researcher at Wesley College of Education, Kumasi which was not part of the accessible population. The instruments were administered to 20 students of the college. The results were analyzed to determine the validity of the instruments. Items that needed revision were revised. This piloting process was important because it improved the content validity and reliability of the test and improved the formats.

Pre- Treatment Activity

This phase consisted of two activities which were done to ascertain the level of students' performance and understanding of chemical bonding concepts in the two colleges of education. The first activity was to interact with students to identify them by names and also revised with them some of the concepts learnt in the previous term. The purpose of this first activity was to create a cordial relationship between the researcher and the students. It also informed the researcher about the students' previous knowledge on bonding. The second phase was the administration of pre-test of CBCT items which were determine the level of students' understanding and their ability to interpret and comprehend chemical bonding concepts in chemistry. This test was conducted to help establish the basis as to whether the use of MIA could improve students' understanding of learning concepts. Besides lesson plans were prepared for the two groups. The lesson plans guided the researcher to teach the topics according to course objective and methods systematically.

Treatment of Groups: The treatment process was conducted over a four-week period. Offinso College of education was assigned as the experimental group and instructed through the use of multimodal approaches and Berekum2k 1 Data Collection Procedures. An introductory letter was taken from the Head of Science Education Department of University of Education, Winneba to seek permissions from the Principals of the two colleges to use their institutions. Data of this study was collected in four stages. The first stage was the pre-test data collected from Chemical Bonding Concept Test (CBCT). The second stage was collection of data from the post- test CBCT which was conducted after exposing experimental group and to control group to determine students' performance. The third stage was the data collected from questionnaire. The questionnaire was only administered to experimental group. The final stage was collecting data from personal interview with the experimental group. It was scheduled and conducted at the end the intervention when chemical bonding was completely taught, to obtain the students' perception about the use of multimodal instructional approaches in teaching and learning process. The questionnaire and interview administration were conducted on the same day that post-test data was collected. This was done so to allow students respond according to their feelings about the approaches. This was on the assumption that the feeling about the approach was fresh in students' mind. The interview between the researcher and the respondents were recorded with an audio device. Interviews and questionnaires were the basis for subsequent qualitative data analysis.

Method of Data Analysis

The researcher analyzed the data collected by using both quantitative and qualitative methods of data analysis. Date from questionnaire and tests were analyzed quantitatively whiles data from the interview was analyzed qualitatively. Analyses of the results obtained from the study were carried out in four (4) phases. The statistical analysis of the tests (pretest and post-test) was carried out first. The descriptive statistics such as means, mean difference, standard deviation and t-test of both experimental and control groups were computed by computer Statistical Product and Service Solutions (SPSS) version 20.0 programme. These descriptive statistics were used to summarize the general, trends in student performance. The purpose of descriptive statistics is not only to describe the data from a study but also to help find pattern within the data described and to inform inferential statistics as well. Study of central tendency indicated the overall performance of students in the groups; different groups and different academic performance levels. Inferential statistics was used to identify significant difference within the quantitative data for the purpose of answering the research questions. Inferential statistics such as students' t-test was performed at the 0.50 level with 2 tails. The inferential statistics used in this study was used for answering the quantitative aspect of the research questions as well as testing hypotheses stated earlier in the first chapter of the study.

The second stage was analysis of questionnaire data. Descriptive statistics such as frequency tables and percentages were employed to compute the results for analysis. This qualitative data analysis contributed to both descriptive and inferential interpretations from the quantitative data. Together, the results of the study provided the basis for the significance and implications of the study as well as possible future research. Qualitative data was used to analysis the student interviews and questionnaire. An in-depth qualitative analysis such as the constant comparison method was used to answer the research question on the students' perception about the multimodal instructional approaches. The qualitative data was used to assist the quantitative data in the interpretation of result.

The data collected were on the assumptions that;

a. There was no interaction between the two groups.

b. The tutor was not biased during the treatment.

c. The tests were conducted under standard conditions.

d. The participants sincerely answer the questions in the instruments.

Ethical Issues

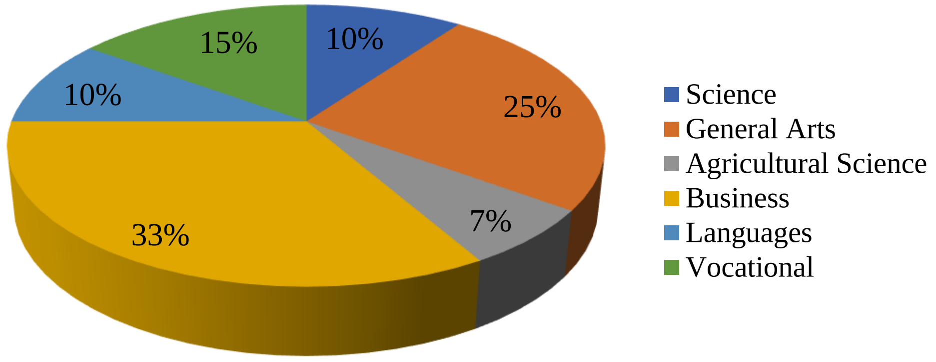
The researcher needed to protect the identity of the students and the institutions, develop a trust with them and promote the integrity of the research. During the process of data collection all the students in the class and the two groups benefit from the use of MIA. The students who were interviewed were assured of confidentiality. The researcher respected the research site by not allowing the treatments to interfere with the institution's programmes and disturb them after the study. For data analysis and interpretation, the researcher ensured the anonymity of individual students by the use of aliases and pseudonyms for individuals. The researcher also provided accurate account of the information from the data collected. Table one contains frequency and percentage distribution of sampled students and the programs they read at Senior High School level.

Table 1: Courses pursued by sampled students

Programme	**Frequency**	**Percentage**
Science	6	10.0
General Arts	15	25.0
Agricultural Science	4	6.7
Business	20	33.3
Languages	6	10.0
Vocational	9	15.0
Total	**60**	**100**

Source: Field Study, 2022

Figure three contain frequency and percentage distribution of sampled students and the programs they read at Senior High School level



The courses that the students offered at Senior High School level are 10% science, 25% Arts, 6.4% Agriculture Science, 33% of Business, 10% Languages and 15% Vocational Science

Research Question 1: What causes the difficulties students face during lessons on chemical bonding?

The findings observed from the study did reveal a number of factors that cause students' difficulties in learning chemical bonding in schools. These results were determined in relationship with the type of instructional methods used to teach chemical bonding concepts. It was observed after the pre-test scores that the students could only memorize definitions of terms rather than able to interpret and comprehend the concepts. Considering the total sampled group used for the study, the mean score (X = 7.1833) showed that the overall performance was below average performance (marks within 8-14). This was because the questions were to test students' abilities to interpret, comprehend and construct the abstract concepts which they could not do. It was also observed that during teaching of the topic that the alternative-knowledge (misconceptions) and even the teachers' misconceptions on the concept cause learning difficulties for students. When analogy was used to explain a concept, some students either became confused or misinterpreted the concept hence it interfered with the students' learning.

For instance, it was observed during the lesson that students tried to justify their answers or ideas by say "my former chemistry teacher explained it that way, and I also read it..." Again, the type of instructional method used, the way it is taught, revealed that students find it difficult in learning chemical bonding. Especially, it was indicated by students that lecture method does not cater for most of their learning differences in class. This was confirmed by the mean score differences between post-test score of control group and experimental group (mean difference= 6.650) which is shown in table 4 and as many as 13.3% of the total students scored below the average marks after they taught by TIA indicated Table 1 and Figure 3. When the students were interviewed several findings were also observed as follows;

Student interview

Male student; The male student is 23 years old and has been recognized as the best chemistry student two times at the Senior High School level in the school. He was also part of the experimental group. He believed that engaging with embodied of different modes of instruction that involved students' manipulation of symbols, video and verbal using technology were the keys to effective understanding or learning. And that physical learning instruction for chemical bonding learning should involve a range of instructional modes including 2D and 3D models as well as manipulative symbols and concrete example;

> *"I want the use of words, the use of drawings, the use of videos and computer animations, relating things learn to life situation, the use of experiment and drawings to teach a topic. Sometimes one area is not clear to me but the other will be"*

He thought using 2D and 3D models, symbol manipulation videos and verbal account to explore the concept should be involved in a chemical bonding. He also explained that engaging with different modes results in various dimensions of the concept being highlighted to him. He thought that diversity of instructional modes should be factored into the learning process, not only in chemical bonding. I think of different modes to teach science gives me a physical representation and understanding of what it is. The concepts teacher wants to teach; I can physically see it, see how it works, hold it or feel it. Drawing and illustrations, symbols illustration computer videos are pictures way of looking at a number of concepts. Words should be used to explain the concept seen videos. Illustration by using symbols to help me understand what am learning and be able to use it or explain to other people. She offered a more extended rational for the importance of teachers using multimodal instructions in learning process. He revealed that each mode of instruction provides a necessary contribution to the teaching and learning process in that engagement with each mode strengthened students' understanding of the underlying concept. From the following commentary, He seemed to value an integrated approach of instruction with the reason that it would require him to engage in an active translation across modes.

It gives me opportunity to interact with the concept in various ways, and I'm able to construct my own understanding. If am taught just one way, am able to explain the concept well, or when asked to say it in different way can do it. So, if am taught in multimodal ways, it will provide bases for me to understand in a way without weakness and my understanding will become strong. While recognizing the general value of multimodal orientation to learning, he did not necessarily prefer a highly prescriptive sequence use of multimodal instructions. He claimed that the types of modes of instruction should not necessarily follow particular order to address students' aware learning styles. But believed that the teacher needed to be aware of the learning opportunities as they emerged in class and address them through different modal explanation. He argued that it was important to explore conceptual links from different point of views. He considered that this approach was achieved by making use of different modes of instructions to develop the concept and to address learners' differences;

> *"If the concept is "how electrons are transferred" then I would expect different modes of instruction such as videos or computer animations, diagram illustrations, verbal explanation etc. but not only lecturing. Its' not about doing the same activity time and time again, but its bringing together in different context"*

As the above abstract makes clear, He thinks that focus on multimodal choices should be connected to an integrated holistic approach to concepts. In terms of supportive and productive learning environment, He thinks that a multimodal instruction focus could be helpful according to know learning style in class.

> *I think that majority of us students differ in the way we learn things; some learn by visual than others; some by listening than others; some by performing experiment or manipulation of symbols only than others. But I think majority of us learn when those situations are combined and used together. Very few of us learn one particular way only. But some of my colleagues always have difficulties with whichever mode that teachers use.*

This account also suggested that he, while there is the need to expose the learners to a range of different instructional modes some of the students are more likely to react positively to particular modes of instructions.

Female student: This student offered chemistry as an Agriculture student in the Senior High School level. She is 20 years of age. She had one of the best grades among the female students in chemistry subject. She described her main problem of learning chemical bonding to be inquiring based, including 2D and 3D models and objects and also drawing, pictorial, experimental and physical modes of instruction. She did not see multimodal as a process that needed high structured procedures but rather a necessary aspect of a highly integrated approach of teaching. To her the importance and value at using different modes was to be able to develop in students deeper understanding of concept. She also agreed that there was the need for supportive and productive learning environment to teaching chemical bonding. She saw that multimodal instructions were way to cater for variety of learning style for better understanding. She claimed there was the need for a connection between informal and formal learning studied.

> *I think multimodal ways give me a variety of ways to understand where any lime or whenever way the questions are set, I can answer them with confidence. It also serves as a reminder in my mind; I see the concept clear in mind and how it works in my daily life. I agreed that students need opportunities to revisit ideas, but it shouldn't monotonous.*

She agreed that she needed opportunity to revisit ideas, but this repetition needed to be involved with small variation so that activities do not become monotonous. She saw the need for discussing the realia or visuals guided by the lifter or peer based. It took two things that were most effective; one I would say the practical activity Used and interacting with material and actually seeing what was happening in explaining concepts. The other thing was the way we were allowed to discuss what topic was showed to us both in videos and symbols." It was effective because we were able to actually explain ideas among ourselves and swapping ideas with each other"

She considered that she was different and varied considerably in the ability to interpret and construct concepts; hence the need to be instructed with different modes to address were learning benefits gained when she or the students' diversity. According to her there her colleagues are engaged with modal diversity;

> *Some of us in a class would have benefited from symbol manipulation and view animation of how bonds are formed or verbal way of teaching. But my colleagues may find it difficult to look at letters and number and interpret what they mean. Some too may be comfortable when a teacher use analogy to explain a concept. However, 1 think for many of us students, the most id effective way to get across their ideas is to see the actual video with verbal men, the performing experiment, and use symbol illustrations to depict explanation concepts as seen in books. So, 1 don't think students in general learn in ruction.*

This means that the type of modes that a teacher wants to use, the topic, experience and ability of the students and learning preferences should not totally dictate the modes used.

She also acknowledges that translation of main meaning of concepts across different modes was easier for most students;

If you want each student to tell you what they have learned, and they are not getting it when teacher changes the question to different ways, the student easily gets it. So, the way teachers need to teach content in different ways: Teacher can use maybe analogy to lecture their students but the uses of words only are not sufficient enough to explain concept.

Research Question 2: What is the effect of multimodal instructional approaches on the students' performance on chemical bonding?

The researcher wanted find out the extent to which the MIA of teaching, the chemical bonding concept will help improve students' understanding of the concept. Table 2 and 3 present the frequencies and percentage distributions of the pre-test and post-test scores of the students in the experimental and control groups. Table 2 and figure present the frequencies and percentage distributions of the pre-test and post-test scores of the students in the control groups.

Table 2: Frequency distribution of pre-test score of students in the control group

Marks score	Frequency of Pre-test	Percentage (%)of Pre-test	Frequency of Post-test	Percentage (%)Post-test
0-7	28	46.7	8	13.3
8-14	30	53.3	47	78.4
15-20	-	-	5	8.3
Total	**60**	**100**	**60**	**100**

Source: Field Study, 2022

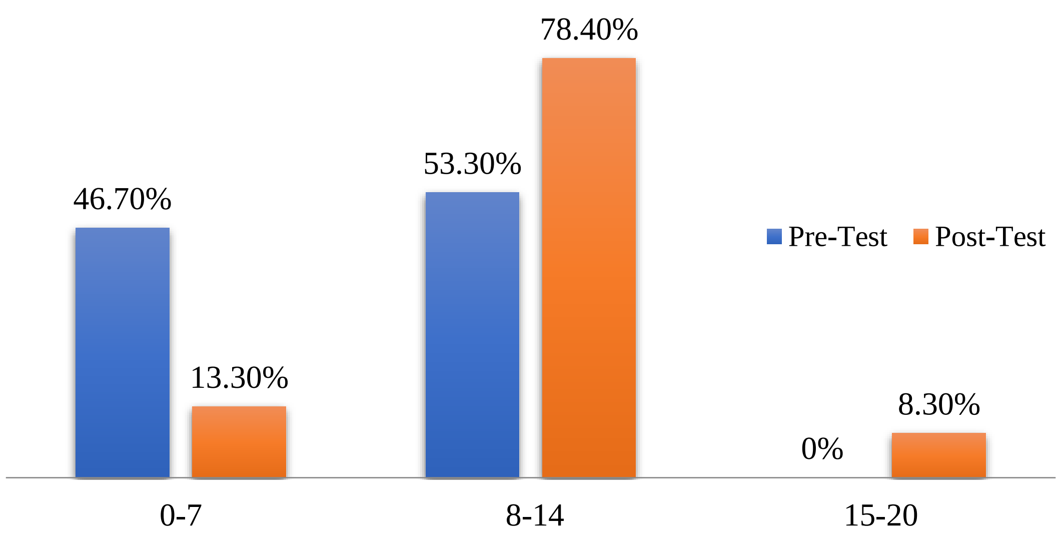


Figure 4: Frequency distribution of pre-test score of students in the control group

The result of Table 2 and Figure 4 showed that out of 60 students, 46.7% of the students scored marks within below average performance (0-7). Largely, 53.3% of the students scored marks within the average performance (8-14) in the pre-test. No student scored mark of the above average Performance in the pre-test. However, in the post-test after the student were taught by TIA, about 13.3% of the students still scored marks in the below performance level. Also, 78.4% students and 8.3% students scored marks in average performance and above performance ranges respectively, which indicates slight increase in sampled students perform. The increased in the percentages of average and above average, revealed that the TIA has positive effects on some learning of chemical bonding. Table 3 and figure 5 present the frequencies and percentage distributions of the pre-test and post-test scores of the students in the experimental groups.

Table 3: Frequency distribution of pre-test score and post-test of students in the experimental group

Marks score	Frequency of Pre-test	Percentage (%)of Pre test	Frequency of Post-test	Percentage (%) of Post-test
0-7	34	56.7	-	-
8-14	26	43.3	9	15
15-20	-	-	51	85
Total	**60**	**100**	**60**	**100**

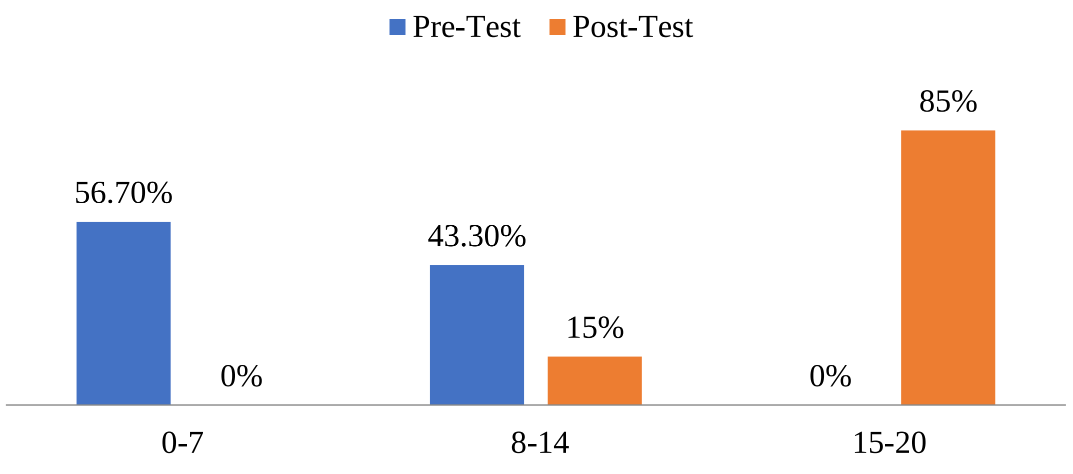


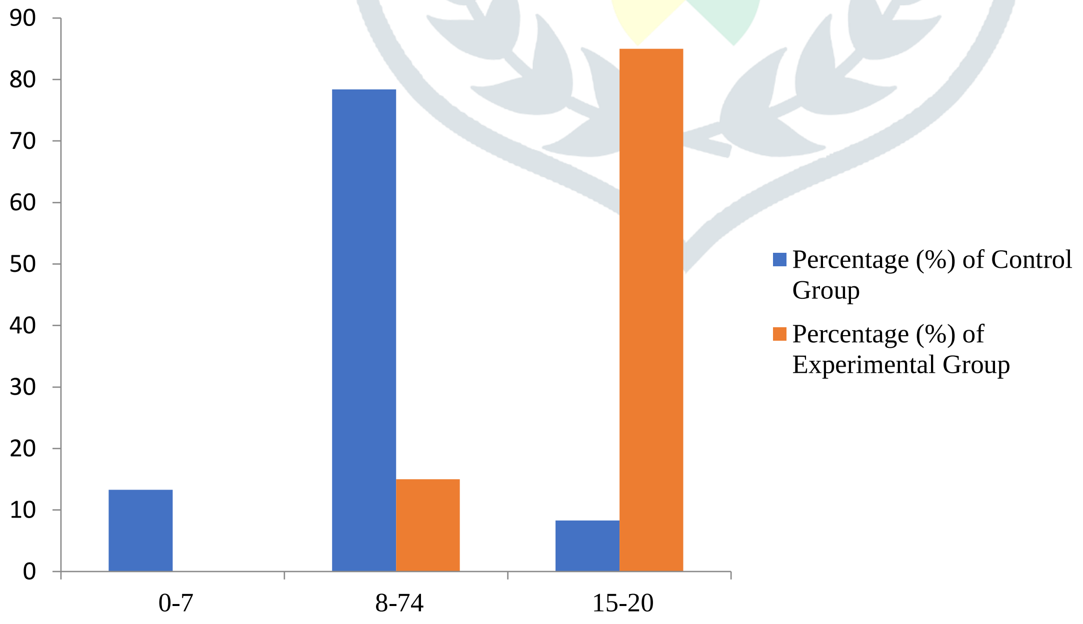
Figure 5: Frequency distribution of pre-test score of students in the experimental group

From the result of Table 3 and Figure 5, a higher number of students in the experimental group, about 56.7% scored within the below average marks in the pre-test. Also, 43.3% of the students scored mark in the average marks. No student scored marks above average performance in the pre-test. However, after the experimental groups were taught by MIA and post-test, administered, no student scored marks within below average marks. 15% of the students scored marks within the average mark range. Highly, 85% of the students scored marks in the above average performance level. These higher marks scored at the above average level and no student scoring marks in the below average suggested that MIA of teaching have a higher positive effect on the students' understanding of chemical bonding. The Table 4 shows the results of the post-test marks scores, in percentage, of students in the experimental group and the control group. The scores were to determine the performance levels of the two groups.

Table four and figure six below present percentage distribution of post-test of both the experimental group and the control group

Table 4: Percentage distribution of post-test of students of the experimental group and the control group

Marks Score	Percentage (%) of Control Group	Percentage (%) of Experimental Group
0-7	13.3	-
8-14	78.4	15
15-20	8.3	85
Total	**100**	**100**



¶ **Figure 6: Percentage distribution of post-test of students of the experimental group and the control group**

Considering the result in the Table 4 and Figure 6, whiles no student scored marks in the below average marks from the experimental group as many as 13.3% of the students scored marks in it from the control group. In the above average marks score, only 8.3% of the students from control group scored the marks while as high as 85% of the students from experimental group scored the marks. These results mean that students learn better and understand the concepts of chemical bonding when they are taught by MIA than when they are taught by TIA. The results of the analysis between pretest and post-test scores within the two groups indicated that there are significant differences of means for each group, $p < 0.05$. The extent to which there were differences in each groups pretest and post-test scores was determined. The result in table 4 revealed that the significant difference level between pretest and post-test mean score of experimental group students is three times higher than the significant difference of the pretest score and the post-test of score of the control group (X difference of experimental group= 9.967, X difference of control group = 2.983).

Research Question 3: What are the differential effects of using multimodal instructional approaches on the male and female students' performance on chemical bonding?

The additional research question in this study was to determine whether there was no significant mean difference between male and female students with respect to understanding chemical 8.6iiding concepts when they are taught by MIA. The findings indicated that there was-no significant difference of the mean between male and female students (P-value = 0.233, $p > 0.05$, showed in Table 5. The percentage distribution that showed the number of students of the male and female out of the total number of 60 was investigated as indicated in Table 5. The results from the analysis showed that the MIA of teaching was effective for both male and female students. There was no significant difference between the male and female students' performance. Hence their understanding of chemical bonding was mostly the same. Table five and figure seven below present percentage distribution of marks scored by male and female in the experimental group and the control group

Table 5: Percentage distribution of male and female in the experimental group

Marks score	Percentage(%) of Male in the Post-test	Percentage(%) of female in the Post-test
0-7	-	-
8-14	5	4
15-20	25	26

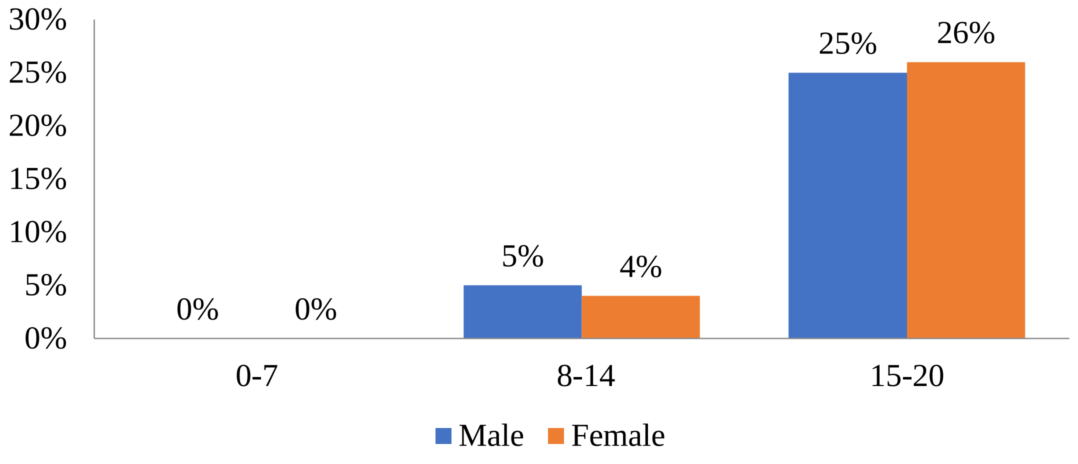


Figure 7: Percentage distribution of male and female in the experimental group

From Table 5and figure seven, none of the students from the male or the female side scored mark below average. When 5% male of experimental students scored marks in the average range, 4% of the female students also scored marks in the same range. In above average range, 25% males of the experimental students scored the marks while 26 females of the experimental students scored the marks in the range.

Hypotheses Testing

The results in table 8 below indicated the data analysis between the control and experimental groups of the pre-test mean scores differences. The result revealed that there was no significant difference before the treatment between the experimental group and the control group in terms of students understanding of the bonding (P=0.43, p>0.05), The control group had a mean score of 7.35 as compared to the experimental group. However, the mean difference (0.333) between the two groups was not statistically significant.

Table 6 showed the mean difference in performance between the control and the experimental group in the pre-test.

Table 6: Significant difference between control group and experimental group of the pre-test of students before treatment

Group Test	Means	t	df	P (2-tailed)	Mean Difference
Control Group	7.350	0.797	118	0.427	0.333
Experimental group	7.017				

Source: Field Study, 2022

$H_0$1: There is no significant difference between the mean score of students taught chemical bonding using multimodal instructional approaches and that of their colleagues taught with traditional instructional approaches.

In order to answer the question posed by hypothesis 1 stated, the student t-test data analysis was used. The analysis was based on the post-test score of both the experimental group and the control group. Table seven presented t-test (2-tail) mean score of the post-test scores of both the experimental and the control group.

Table 7. Two-sample t-test with equal variances of significant difference between control group and experimental group of the post-test score summary

Control group Means	Experimental group Means	t-test or Equality of Means			
		T	Df	p (2-tailed)	Mean Difference
10.333	16.983	-15.54	118	0.00	6.650

As a rule of thumb, the computed p-value should be less than the chosen significant level (0.05) for this study to reject the null hypothesis. Since the P-value. (0.00) in the result is less than 0.05, it could be concluded that there was a statistically significant difference between the experimental and control groups of the post-test. The students (experimental group) who were taught by MIA scored significantly high mean difference (6.65) than those taught by TIA ($X_{(MIA)}$ =16.983, $X_{(TDA)}$ =1.0.333). Again, the researcher also analyzed the data to determine the mean scores differences between the pretest and the post-test scores of the experimental group and that of the control group. The results of the analysis are indicated in the Table 10. Both results Showed that there are significant differences ($p< 0•05$, $p=0•000$) between the pretest mean score and the post-test mean score of the two groups. But the mean score difference of the experimental group was much higher (X difference 9.967) than the mean score x difference of the control group (X difference 2.983). This attested to the fact that MIA highly improved the understanding of students in learning chemical bonding. Displayed in table ten is the summary of the mean difference score within both experimental and control groups.

Table 8. Summary of mean difference between pre-test and post-test within both experimental and control groups

	Pretest mean	Post-test mean	t-test for Equality of Means	
Experimental group	7.0167	16.983	0.000	9.967
Control group	7.3500	10.333	0.000	2.983

Source: Field study, 2022

H_02: **There is no significant difference between the mean score of male and female students who are taught chemical bonding using multimodal instructional approaches**.

To answer the question posed by hypothesis 2 which stated that there is no significant difference in the performance of male and female students who have been exposed to the multimodal instructional approaches in their understanding of chemical bonding, analysis of student's t-test was run.

The summary of the results of the mean score difference between genders in both the control and experimental groups in the understanding of chemical bonding concept are shown in Table 9 below.

Table 9: Summary of mean difference between genders in the experimental group

	Male Mean	Female Mean	P(2-tailed)	Mean difference
Post-test scores	7.800	6.233	0.233	0.700
Pretest score	17.333	16.633	0.08	1.567

Source: Field Study, 2022

The findings of pretest mean scores between male and females indicated from the Table 11 that there was a significant mean different between them with regards to their understanding of chemical bonding concepts (p=0.008, p< 0.05). The mean pre- retest scores were 6.23 for females and 7.80 for males. The mean different of pretest mean scores was 1.567 indicating the extra performance of male students than female students. But the findings of post-test mean scores between both genders showed that there was no any significant mean difference between male and female students in terms of understanding chemical bonding concepts (p=0.233, p >0.05). The mean post-test scores were 17.33 for females and 16.63 for males. The results revealed the mean difference of 0.700 indicating the higher female students' performance more than male students.

Discussion

The study revealed a wide variety of difficulties that students faced during teaching of chemical bonding. Several researches revealed that students had difficulty interpreting and understanding the concept, and how the concepts are taught. Chemical bonding which is a very abstract concept requires some knowledge from other areas like forces which students are not able to fully grasp. It was observed during the lesson with the students on learning chemical bonding that they could only memorize definition of terms rather than being able to interpret and comprehend the concepts (Bennett, 2011). This confirmed the possible reason why the two groups of students performed poorly in the pre-test items. From the analysis in Table 9 the mean of the experimental group is 7.017 and that of the control group was 7.350 out of the expected score mark of 20 from each group used for the study, the mean (y=7.1833) each group. Considering the totals, it indicated that overall performance was below average performance. This was because the test items were to test their level of ability to interpret, comprehend and construct the concept of chemical bonding. This suggested that the students had difficulties in interpreting and comprehending the abstract concepts (Ainsworth, 2006; Bennett, 2011). For instance, when the students were asked to discuss the meaning of chemical bonding in groups and report their ideas, the followings conceptions were observed: bonds were seen as linkage of elastic based on shapes interlocking; bonds are formed in terms of electrons attracting to one another; chemical bonding is only formed by charged ions; ions determine the polarity of bonds etc. Most of them thought that bonds are simple connections rather than force.

It was also observed that most of the students' misconceptions and even teachers' misconception on the concept cause learning difficulties for students. When teachers do not appropriately use analogy or story to explain ideas, it sometimes interfered with students learning of concepts. It makes new scientific knowledge which is being taught not easily connects to the already existing one for better understanding. This was observed caused difficulty for students to understand the concept. During the lesson, students tried to justify the answers or ideas by saying "my formal chemistry teacher explained it that way..." So, when teaching chemical bonding concepts, teachers should focus on these misconceptions and make the scientific concepts as practical as possible. They should also use the instructional modes for students to see for themselves how the concepts work.

From the interview, students suggested chemical bonding literatures should present the concepts in multiple modes of representation to cater for every learning style of learners. If not so, it would create learning difficulties for students who study the literatures;

> *"I think that majority of us differ in the way we learn things; some learn by visual than others; some by listening than others; some by performing experiment or manipulation of symbols only than others. But I think majority of us learn when those situations are combined and used together".*

Again, the difficulty the students face in learning chemical bonding was observed to be the type of instruction used; the way the topic was taught. It was confirmed that the use traditional instructions approach where the teacher transmits that facts to the students who are passive listeners, to teach caused a difficulty for students to understand the concept. In the control group where a lecture method was used, there was significant mean difference between the students' scores in the pre-test and their post-test scores ($p=0.00$, ie $p<0.05$) in Table 8 and with mean difference of 2.98. In Table 2, 13.3% of the students still performed below average. This is an indication that these students have not been helped by the method of teaching. The way the concept was explicitly explained during the lesson to the learners would have accounted for the improved result. However, when the students are instructed by multimodal instructions, they were able to learn better. As revealed in the statistical analysis, there was a significant difference of mean between post-test scores of the experimental group and the control group of students ($p<0.05$, mean difference= 6.650). It can be concluded that multimodal instructions effectively reduce the difficulties that most of the students were confronted with in learning chemical bonding (Tytler, Waldrip & Griffiths, 2004) while TIA could not. Also, students did not find it easy learning chemical bonding when they were instructed by the traditionally instructional approach for the course. There was a very high statistical difference in percentages between those students who have difficulties in learning concepts when they are instructed with only lecture method (verbal modal) and those students who do not (1.7% strongly agree and agree whiles 81.6% students disagreed and strongly disagree showed in Table 6). The report from interviewing the students showed that they valued an integrated approach because it challenges them to engage in an active translation across modes and concepts;

"It gives me opportunity to interact with the concept in various ways and I' m able to construct my own understanding. If am taught just one way, I' m able to explain the concept well... So, if am taught in multimodal ways, it will provide bases for me to understand in a way without weakness...."

This suggests that the type of method use to teach, students' misconceptions and content representation cause difficulties. These should be critically looked at by educators in teaching chemical bonding. In learning, difficulty might not be because of the abstract nature of the concept only. The extent to which multimodal instructional approaches improve the students' understanding of chemical bonding was determined by comparing the percentage difference, the mean differences and the significant level of the performance of the experimental and control groups in the post-test. Based on the statistical analyses results displayed in Tables 4 and also in 9, it can be concluded that the instruction by using the MIA caused a significantly better acquisition of scientific con conceptions related to chemical bonding and improved learners' interest in the concept than TIA. In the Table 4, only 8.3% of the students from control group scored perform marks which indicated that their performance in chemical bonding is above average. But 85% of the students who were taught by MIA had performed above marks. These findings revealed that students who are taught using MIA are able to interpret, comprehend and construct chemical bonding concepts with devoid of misconception than using TIA to teach the concept. These results mean that students learn better and understand the concepts of chemical bonding when they are taught using MIA than when they are taught by TIA.

From the hypotheses analyses, mean scores of both experimental and control groups of students in the post-test scores indicated there was a higher score for experimental group in Tables 9 and 10. That is, there was a significant difference between the post-test mean scores (the performance) of the students instructed using multimodal instructional approach and traditional instructional approach, revealing the tendency for students to have higher test scores when they are instructed using MIA, ($p = 0.00$, $p < 0.05$). The mean difference (X difference 6.65) indicated the extent to which or how the students instructed using MIA understood chemical bonding better than those instructed by traditional approach. It was also clear from the mean difference that the levels of understanding of chemical bonding between students instructed by multimodal instruction and the traditional instruction that multimodal instructional approaches improve students' literacy in chemical bonding better. The relatively high performance of students' scores when they were instructed by MIA was due to the complacency, interest and the positive attitude towards the instructional approaches.

In the experimental group, the instructional-students interaction from the multimodal approaches was emphasized for learning. The teacher encouraged the students to ask questions, work together, explain what they saw and thought during the learning process. They used their current ideas about the concept and became ready to change with the scientifically correct explanations. The multiple modes of instructions provided the development of reflective thinking and metacognitive awareness. But students in the control group were not aware of their conceptions which were not scientific. In the group also, there was a slight interaction between the teacher and the students; students listened to their teacher, studied their literature materials and compiled their own notes. The reason why the students in the control group were not so successful as compared to those in the experimental group might be attributed to the fact that they were not given the opportunity to think about the concepts, ask questions to clear their doubts. For that matter, they continued to hold wrong conceptions which were not scientific on chemical bond.

Meaningful learning occurs if students are challenged by instructions to think about the concept and ask question for a situation for better understanding. The high result of the mean difference from the Table 9 and 10 confirmed the fact that using MIA creates learning environment that allows learners to easily learn concepts to better improve their chemical bonding literacy especially for lower-achieving students (Fadel, 2008; Mayer, 2003). This is also confirmed from the students' interview that the use of MIA would engage students in an active translation across modes of representation address their learning differences and make them able to interpret and construct the concept according to the scientific principles. The study therefore supports the argument that multimodal instructions improve students' competency in chemical bonding concepts. It could be concluded that students instructed through instruction based on the use of multimodal approaches had more positive attitudes toward chemical bonding than students taught by traditional designed instruction. Most students taught said chemical bonding was a difficult concept to learn and did not want to study it. In the MIA, students were actively involved in the learning process. This might have caused students in the experimental group to have more positive attitudes.

The third research question in this study was to investigate whether there was a significant mean difference between male and female students with respect to understanding chemical bonding concepts.

When the students were instructed using MIA the results indicated in the Table 11 that there was no significant difference of the mean between male and female students (P-value = 0.233, $p > 0.05$). Again, it was established that there was no significant interaction between gender difference and treatment in terms of understanding chemical bonding concepts. This meant that, there was no significant difference in performance of understanding the concept between male and female students who were instructed by multimodal instructional approaches and participated in the post-test items. The reason why no significant difference was found in this study might be due to the fact that the multimodal instructions approach used to instruct concept had catered for the learning differences of both male and female students in the classroom. This situation might also have positive effect on their attitudes toward chemical bonding. The fact that there was a significant mean difference between male and female students from the finding in Table 11 in the pretest scores, has informed the teaching technique used as treatment to examine the effect of it in catering for gender abilities to learn chemical bonding (P -value = 0.008, $p < 0.05$). The significant difference arose from the fact that male students' mean scores was 7.800 whiles female students' mean scores is 6.233, indicating that male students relatively understood chemical bonding more than female at initial stage. However, since there was no significant difference in their mean scores after treatment, but with female having higher post-test mean score (mean score for female= 17.333 whiles mean score for male = 16.633) then it can be concluded that females were at the better side in the understanding of chemical bonding. The females are therefore more evenly distributed across multimodal learning techniques.

Another purpose of the present study was to determine the perception of students learning chemical bonding through the use of multimodal instructional approaches. The findings indicated that almost all the students who participated in the experimental class learnt and understood chemical bonding concept. Catering for differences in students' learning experiences and outcomes for better understanding, developing motivation for positive attitude towards the concept, creating challenging and comfortable learning environment, ability to interpret and comprehend, use of traditional approaches where students are passive listeners, and use of up to five multimodal instructional approaches were areas that were investigated to determine effect of the approach of teaching. However, the data collected from the questionnaire (see appendix D) and confirmed that students' learning styles in class, ability to understand chemical bonding as well as to interpret and comprehend and being motivated to learn the concept among others were made possible by the MIA.

The data in table 6 revealed that 91.6% of the students understood the concept through the use of multimodal instructional techniques. With regard to gender, more male students (48.4%) said they understood the concept as against 43.4% female students. This therefore confirmed the results of the mean scores of male and female students (male =17.33, female = 16.63) in terms of performance in the CBCT. For understanding, the learning outcome would be better instructed by MIA in the learning face of students because it caters for their learning styles (Sankey, Birch, & Gardiner, 2010).

Also, it was observed that students were motivated when they were instructed using MIA to learn chemical bonding. The result on motivation revealed that 91.6% students also think they were motivated to learn the concept while only 6.7% of students did not by disagreeing to that. It is clear from the result more female students (5.0%) were not colleagues' score in the CBCT from table 5.3. Nevertheless, 95.0% of the students said they were more comfortable in the class when the concept was instructed in different modes. This supports the report that using different modes of instructions in an integrated form creates learning environments that cater for learning styles of students making then feel comfortable and perform better (Omrod, 2008). It also confirmed the qualitative analysis in the interview of students. Multimodal learning environments allow for active participation in a lesson and critical thinking development.

Also, the questionnaire sought to determine views of the students on the use of five different multimodal instructions in the teaching and learning of chemical bonding. The results showed that 85.7% of the students were very comfortable and understood better the concept when they are instructed by multimodal instructions while 4.7% of the students disagreed. It could be concluded that students who were instructed through multimodal instructions preferred that they were taught chemistry concepts especially chemical bonding by using the multimodal instructional approaches. Some of the reasons that were given by the student during the interview are that; it catered for learners learning style, it made concept not easily forgotten, it increased the interest of learning chemical bonding concepts, it demystified the perception that the concept is difficult to learn and it helped to do away with misconceptions about the concept. Generally, most students saw chemical bonding as a difficult area in chemistry to learn and do not want to study or choose to answer questions on it when they are not compelled. The multimodal instructional approaches focused on practically explaining the concepts and students' ideas, encourage student to think about situations and ask questions, and share their ideas. These students were actively and passionately involved in the teaching and learning process. These factors would have made the students of the experimental group to have high positive attitudes and high performance in the Chemical bonding test. In conclusion, this study revealed that students had difficulty in understanding chemical bonding concepts. The use of multimodal instructional approaches results in deeper conceptual understanding of chemical bonding.

The causes of students' difficulty in understanding chemical bonding

From the interviews conducted, every student mentioned that the chemical bonding is a difficult concept to study. The factors such as the abstract nature of the concept, the verbal teaching technique, the use of some analogies to explain the concept and the use of inappropriate symbolic representations of concepts were identified to have caused learning difficulties. The researcher observed during the treatment that students have the misconception that force of attraction is only occurs in ionic bond but not in covalent and metallic bonds. It was also found out that the teacher's inability to explain the concept well contributes to students' inability to grasp the concepts correctly. The students could only memorized definitions of terms rather than able to interpret and comprehend the actual meaning of the concepts.

Performance of students taught using MIA and T1A

The statistical analysis of the pre-test of both the experimental and the control groups showed that there was no statistically significant difference in the performance between the two groups at the beginning of the study as shown in Table 8. The results revealed that the performance of the experimental and the control groups were comparable on their initial understanding of the chemical bonding concepts. But the statistical analysis of the post-test of the experimental and control groups in Tables 4 and 9 indicated clearly that there was statistically significant difference in the performance between the experimental group and the control group. The experimental group performed far better than the control group in the post-test (8.5%). There was significant improvement in the performance of students in the experimental group over the control group after the treatment. This means that students who were taught using MIA could interpret and comprehend more of the scientific chemical bonding concepts in the study than those who were taught using TIA.

Performance between male and female students who were taught using MIA

The findings of pretest mean scores between male and females indicated from the table 11 that there was a significant mean different between them with regards to their understanding of chemical bonding concepts. The female performed better than their male counterparts before the treatment. However, the performance of the post-test mean score between both genders showed that there was no significant difference between male and female students mean scores in terms of understanding of chemical bonding concepts. The mean post-test scores were 17.33 for female and 16.63 for males. The mean difference of 0.700 indicated the higher female students' performance than male students.

Conclusion

Multimodal instructional approaches which integrating different pedagogy instructions (Vaughan & Bruce, 2008) as means of improving learning outcomes in a classroom is widely acknowledged in journals and other educational research work (Dolin, 2001; Russell &McGuigan; 2001). The introduction of the multimodal instructional approaches produced a significant improvement in students' learning and understanding of concepts in the chemical bonding as compared to the commonly instructional technique, traditionally instructional approach. Students' abilities to interpret and comprehend the concept were hugged when they were taught using multimodal instructional approaches. However, it was revealed that traditional instructional approach which was characterized by verbal instructional approach was noticed to be the cause of the difficulty students faced in learning chemical bonding. It can be concluded that multimodal instructional approaches which is guided by child-centered approach greatly improved the understanding of chemical bonding. It helps approach students properly interpret and comprehend concepts and caters for learning difference in classroom. It also motivates activate mental challenge and critical thinking, make students feel comfortable and develop their interest to learn and understand chemical students bonding.

Implications for Classroom Teaching

Primarily, teachers' instructional approaches have direct effects on the learners' understanding during lessons. This correlates with students' achievement (Tatto, 2001). The findings of the study indicated that multimodal instructional approaches had a direct impact for improving methods of teaching and learning and students' academic performance. There was a strong link between the students' content knowledge and the pedagogy that researcher used to teach the experimental group. This approach is also likely to improve the students' understanding in other concepts in science courses. Each five modes of instructional approaches could be used to cater for students learning style for them to feel comfortable in the classroom. The method of instruction used in the study would also motivates and challenge students to critically think about the concept in the learning process.

Recommendations

1. The governing councils and academic boards of Offinso and Berekum colleges of education should make adjustments in their academic calendars to organise capacity building workshops for science tutors in their colleges on the use of multimodal approaches in teaching since the method has proved to be effective.
2. Berekum and Offinso colleges of education should focus on learner's alternative knowledge (misconceptions) because it was observed that the students' conceptions which are not scientific do cause learning difficulties.
3. Ministry of Education, Curriculum Research Development Division, University of Cape Coast, University of Education, Winneba and other agencies should make some structural changes in the discipline of science education in schools that will encourage the use of multimodal instructional approaches in the training of science teachers.
4. The Ghana Education Service and Ghana Association of Science Teachers and other interested agencies should regularly and periodically organize in-service training for science teachers on modes of instructions and students' alternative concepts in chemical bonding.
5. Institutions or authors or books interested in getting relevant pedagogy for particular concepts should include MIA as teaching method for chemical bonding.

6. Science tutors should take steps to correct misconceptions in science because it leads to students' inability to grasp chemical bonding concepts.

Suggestion for the Further Studies

1. This study indicated the need for further research in the construction of concept representation; and the design of professional learning programs to support teacher understanding of how to maximize learning opportunities and students learning styles.
2. Similar study can be carried out for different levels of education in Offinso and Berekum municipalities in different science topics to investigate the effectiveness of multimodal instructional approaches on
3. Further study is encouraged on integrating less or more modal instructional approaches to determine its impact on academic performance and understanding of concepts
4. A larger sample size could be used to conduct and replicate this study in different schools to provide a generalization of its effect for pedagogy development.
5. Further research may be carried out to investigate the understanding and the perceptions of science tutors in Offinso and Berekum colleges of education on the use of multimodal teaching techniques.

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