UNIVERSITY OF EDUCATION, WINNEBA

A STUDY OF EFFECT OF MULTIMODAL INSTRUCTIONAL APPROACHES ON STUDENTS' PERFORMANCE IN INTEGRATED SCIENCE.

JOSHUA KWABENA OWIREDU

AUGUST, 2015

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Thesis in the Department of SCIENCE EDUCATION, faculty of SCIENCE EDUCATION, submitted to the School of Graduate Studies, University of Education, Winneba in partial fulfilment of the requirements for the award of the Master of Philosophy (Science Education) degree.

AUGUST, 2015

DECLARATION

STUDENT'S DECLARATION

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

SIGNATURE: ……………………………………………….

DATE: ………………………………………………………

SUPERVISORS' DECLARATION

We hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines on supervision of dissertation as laid down by the University of Education, Winneba.

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ACKNOWLEDGEMENTS

I humbly acknowledge with thanks the Almighty God for His grace, favour, love and strength to do this research.

I also owe a depth of gratitude to my supervisors, Dr. Ishmael K. Anderson and Dr. E. K Oppong for their immense support and contributions towards the successful completion of this work. I would sincerely like to express my heartfelt gratitude to you both, for your precious time, patience, many in-depth constructive criticisms and valuable suggestions which have immensely contributed to the success of this study. God richly bless you, Sirs.

I am most grateful to all lecturers at the Department of Science Education, UEW, especially: Prof. Mawuadem Amedeker, Prof. John K. Eminah, and Dr. Thomas Tachie – Young. I cannot forget Dr. Ernest Ngman-Wara, Dr. Joseph Nana Annan, Dr. Yaw Ameyaw and Dr. Kojo D. Taale whose tuition and great thoughts have contributed in no small measure in conducting this research.

Special thanks go to colleague fellow students, Science Tutors and the SHS One Home Economics students of the Winneba Senior High School for their great support in providing the needed information for this research work. I also owe a depth of gratitude to Mrs. Nelly Sakyi-Hagan of Winneba Senior High School and Mr Bawa Mbage of Dambai College of Education for your assistance.

Last but not least I acknowledge the sacrifices my wife and children made in allowing me to leave them alone at home to work on this thesis.

DEDICATION

This thesis is dedicated to Caleb Opoku Owiredu and Chris Opare Owiredu (children), Mrs. Diana Aduamah Owiredu (wife), Madam Susuana Afua Antwi (mother) and Mr. Michael Kwesi Mintah (father).

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ABSTRACT

The study took place in Winneba Senior High School. The study involved a whole class of first year Home Economics One students in Winneba Senior High School, Winneba, selected through purposive and convenience sampling technique, totalling forty (40) students (thirty-nine female and one male). Test, questionnaire and interview were the main instrument used to collect data for the study. The researcher developed Multimodal Instructional Approaches to teach some selected topics in integrated science for five weeks. The topics were relative atomic mass and relative molecular mass, mole as a unit, measurements of concentrations and preparation of standard solution dilution and dilution factor. The students wrote a series of five pre-intervention tests on the selected topics before each lesson after which the students were taught using the Multimodal Instructional Approaches. The approaches involve teaching using the video mode, aural mode, read or write mode and finally kinesthetic mode. The students then wrote a similar test but different in content as a post intervention-test. Statistical Product and Social Science (SPSS), version 20.0, for windows and Richard Hake normalized gain were used to analyze the data. The findings from the average normalized gain of the post intervention and pre-intervention test scores showed a gain of 0.77, indicating effectiveness of the multimodal instructional approaches on the students' performance. Furthermore, a greater percentage of students had a positive perception about multimodal instructional approaches to teaching and learning. The study recommends the use of multimodal instructional approach in teaching Integrated Science lessons at Winneba Senior High School. This could help the students have better understanding of scientific concepts.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter outlines the reasons that prompted the researcher to undertake the study, the problems that the researcher observed about students' difficulties in understanding concepts in integrated science, the purpose of the study and the educational significance of the study. The structure of this chapter also includes the research questions to be answered to achieve the objectives of the study. It also contains the limitations and delimitation of the study. The chapter concludes with the presentation of the operational definitions used in the study as well as the description of the organization of the research report.

1.1 Background to the Study

Avotri, Owusu-Darko, Eghan and Ocansey (2000) as cited in Anderson (2006) indicated that in a fast advancing and changing technological world, science has become the backbone of development. The importance of science and technology for the development of Ghana in this age of Information Communication Technology (ICT) and globalization cannot be underestimated. It is in the light of this that the country needs to realize its dependency on science education.

Science education is the cultivation and the disciplining of the mind (Akpan, 1992). The disciplining and the cultivation involve the faculties of an individual to utilize science for improving his or her life as well as to cope with an increasingly technological world. Akpan (1992) further observed that science education helps students to pursue science academically and professionally and for dealing responsibly with science related social issues. However, the ideas that underpin one's approach to science teaching are likely to be influenced by one's understanding of what science is and the reasons for teaching science (Erinosho, 2009). The teaching styles and pedagogic approaches should change significantly to reflect modern methods (Kress, 2007).

Despite the growing importance of science and technology in all realms of life in any society, students continue to show ambivalence toward the study of science education (Anderson, 2006). According to Anamuah-Mensah (2004) there may be many reasons for this situation of students' failure and ambivalence in science education. Anamuah-Mensah considers over-dependence of the chalk-and-talk instructional approach as a major cause for students' disinterest and failures in science learning. Other uncreative and traditional methods of teaching and learning in the schools as indicated by Anamuah-Mensah (2004) such as textbook dependent, examination-oriented teaching, learning by rote memorization, lack of science practical in most schools and even where they are done, they are designed in cookbook manner to confirm known answers as well as the use of de-contextualised curricula. This approach of teaching is not different from Winneba Senior High School.

As examined already the limitations of using traditional method of teaching, this study, therefore, aims to investigate the effect of Multimodal Instructional Approaches (MIA) on students' performance. Multimodal Instructional Approaches of teaching refer to the integration of different modes within the same text or topic to represent scientific ideas, reasoning, and findings in order for understanding of it by learners (Vaughan & Bruce, 2008). Students appear to respond to information differently (Fleming, 1997). Student learning may be classified according to the sensory modalities by which one prefers to take in information. According to Fleming (1997), these sensory modalities are classified into four modes which are visual, aural, read or write and finally Kinesthetic. These four modes of instruction have been abbreviated as VARK Multimodal Instructional Approaches.

Researchers have identified the following as some of the benefits of using Multimodal Instructional Approaches in the classroom:

i. It deepens understanding of scientific knowledge and makes thinking flexible (Fleming, 1997)
ii. It accurately translates a concept from one system to another (Lesh, Post, & Behr, 1987).

It is against this background that the study was designed to determine the influence of the use of Multimodal Instructional Approaches on the performance of students on the following selected topics. The topics covered were relative atomic mass and relative molecular mass, amount of substance and Avogadro's constant. Other topics covered included measurements of concentration, the preparation of standard solution, and dilution of solution and dilution factors.

The following topics were focussed because first year Home Economics one students of Winneba Senior High School performance in those topics were very low and they showed disinterest in those selected topics.

1.2 Statement of the Problem

Lack of proper understanding of the selected topics is a major contributing factor for abysmal performance in integrated science. The students' difficulties in understanding these selected topics among others lie in cognitive load. This is because cognitive load is a factor to students learning (Sweller, 1994). In teaching, different modal of re-representation of the same concepts are not used in Winneba Senior High School. Cognitive load is the total amount of mental activity imposed on working memory in an instance of time (Sweller, 1994). Sweller explained that when lessons are presented in diverse ways they do reduce the cognitive load. The cognitive load on students might explain why they tend to give explanations to scientific phenomena or concepts using alternative conceptions which are not in line with accepted scientific facts.

Again, Maduabam (1995) observed that students' performance in the WAEC science paper is very low and poor, recording the poorest result annually since 1960 (as cited in Eminah, 2012). This situation is always confirmed by Chief Examiner's Report notably among them is chief examiners' report of WASSCE integrated science paper. (Chief Examiner, 2014). According to the report, students lack understanding of scientific concepts.

Additionally, this might have explained why Ghanaian students' at the international level did not do well. Ghana placed 42nd out of 42 countries which partook in the Trends in International Mathematics and Science Study (TIMSS) in the year 2011 assessment of science and mathematics education. (Martin, Mullis, Foy, & Stanco, 2012). Martin, Mullis, Foy, and Stanco explained that the performance of Ghanaian pupils in the 2011 TIMSS was abysmally low. Ghana's mean score of 306 was significantly lower than the international mean of 505. According to the report, among the eighth grade participating countries, only Ghana had many low performing pupils, with a percentage of students with achievement too low for estimation between 15 and 25 percent (Martin, Mullis, Foy, & Stanco, 2012). In line with this, the study sought to research into the extent to which multimodal learning would reduce students' cognitive load thereby enhancing the performance of students in Integrated Science.

1.3 Purpose of the Study

The purpose of this study was to improve the performance of students in some selected topics in integrated science after students had been taught using Multimodal Instructional Approaches.

1.4 Objectives of the Study

The objectives of the study were to determine:

i. the performance level of students in some selected topics in integrated science before the use of MIA.

ii. the performance level of students in some selected topics in integrated science after the use of MIA.

iii. the perceptions of students on the use of Multimodal Instructional Approaches during integrated science lessons.

1.5 Research Questions

This study was guided by the following research questions:

i. What is the performance level of students in some selected topics in integrated science before the use of MIA?

ii. What is the performance level of students in some selected topics in integrated science after the use of MIA?

iii. What are students' perceptions of the use of Multimodal Instructional Approaches for teaching in integrated science?

1.6 Significance of the Study

Rutherford (1985) noted that the continued progress of the developed countries in respect of economy, security, global status and attractiveness to human society would continue to be dependent on science education. The findings of the study would then be useful to all the stakeholders in Science Education.

The outcome of this study would be first of all helpful to students offering integrated science as a core subject to get better understanding of those selected topics. Secondly, it could also help colleagues' teachers to understand that Multimodal Instructional Approaches (MIA) is likely to improve students understanding as compared to traditional teaching approach such as textbook dependent and chalk- and -talk instructional approach. Finally, the finding would be of help to Curriculum Research and Development Division (CRDD) of the Ministry of Education (MOE) with information on the positive effect of using multimodal instructional approach (MIA).

1.7 Delimitations

Dusick (2011) stated that delimitations are the characteristics selected by the researcher to define the boundaries of the study. To Dusick (2011) delimitation involves the researcher making conscious exclusionary and inclusionary decision regarding the sample, the variable studied, the theoretical perspective, the instrument, etc.

In the light of this, the following delimitations would help reviewers to delineate the boundaries of the study, so that they could understand the focus of the research:

i. This study is restricted to mole concept topics in the SHS integrated science syllabus.

ii. Therefore the performance of students is in only mole concept topics but not in the other topics in the integrated science.

iii. The phrase multimodal approach to teaching connotes varieties of strategies or approaches. Some of which are interactive software that assist learning process (Hall, Huhges, & Filbert, 2000; Evmenova, Jeff, Rider, & Warren, 2006). Others include listening to lecturing and storytelling (Misko, 1999). The modes of instruction used were visual, aural, read or write, and kinesthetic. These four modes have been abbreviated as VARK Multimodal Instructional Approaches (Fleming, 1997).

1.8 Limitation of the Study

According to Best and Kahn (1989), limitations are conditions beyond the control of the researcher that will place restrictions on the validity of the study. Like all other studies, this study is not without limitations. One of the major limitations of the study was that the study considered only the views of first year Home Economics students of Winneba Senior High School and this might not reveal a general picture about how the mole concept is taught at the school.

In order to strengthen internal validity of the study, the researcher used a variety of data collection methods including questionnaire, interviews, and tests. However, each method may have limitations such as respondents misunderstanding of a question or failure to answer all the questions. Even though the interviews were intended to gain in depth understanding of respondents' understanding and experiences related to the teaching and learning of the mole concept, participants may have tended to give responses consistent with their perceptions of the researcher's expectations.

Again, because the study is a case study using action research approach, findings may not be generalized to other schools in the country.

1.9 Definitions of Terms

In this section, definitions of terms are provided including explanations where necessary. In doing so, cognisance is taken of the scope and context of the research.

Concept: Idea underlying a class of things, general notion.

Modes: These are stimuli and methods that are used to explain concepts during the teaching and learning process.

Multimodal: Is an attempt to translate varieties of modes of representation into a systematic and practical technique for teaching. It allows instructional elements to be presented in more than one sensory mode (Yoong, 1999).

Multimodal Instructional Approaches: The integration of different stimulus modes within the same text to represent scientific ideas, reasoning, and findings (Chen & Fu, 2003).

Situated cognition: Is a theory that posits that knowing is inseparable from doing by arguing that all knowledge is situated in activity bound to social, cultural and physical contexts (Gee, 2005).

Transmediation: it is the process of translating meanings from one sign system into another such as pictorial representation (Siegel, 1995).

Trends in International Mathematics and Science Study: Is a series of international assessment which takes place every four years and provides data about trends in mathematics and science achievement over time.

1.10 Abbreviations

ERIC: - Educational Resources Information Centre

CTGV- Cognition and Technology Group at Vanderbilt

MEST: - Ministry of Education Science and Technology

MIA: - Multimodal Instructional Approaches

SHS: - Senior High School

TIA: - Traditional Instructional Approach

TIMSS: - Trends in International Mathematics and Science Study

VARK: - Visual Aural Read or write and Kinesthetic

WAEC: - West African Examination Council

WASSCE: - West African Senior School Certificate Examination

WSHS: - Winneba Senior High School

1.11 Organization of the Study

The research report was categorized into five chapters. Chapter one deals with the background to the study, statement of the problem, purpose of study, research questions, educational significance of the study, delimitation of the study, limitation of the study, definition of operational terms and abbreviations, and finally the organization of the study. Chapter two covers review of the relevant literature on the study, whilst Chapter three focuses on the methodology. The methodology is made up of the design of the study, population, sampling and sampling techniques used, instrument and data collection procedure as well as the procedure for analyzing the data. Chapters four presents the results and discussions of main findings of the study. Chapter five contains the summary of the main findings, the conclusion, recommendations and suggestions for further studies on the problem area.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

The chapter focuses on literature related to various aspects of the study. It entails what other researchers and educationists have indicated about the teaching and learning of mole concept using Multimodal Instructional Approaches. The review was done based on theoretical and empirical research done in the concepts of teaching and learning.

For this study, the theoretical framework was based on transmediation, situated cognition and representation of learning whiles the empirical review was organised under the following subheadings:

1. Empirical Framework of the Study
2. The concept of cognitive load theory
3. The nature of Multimodal Instructional Approaches
4. Multimodal representations of concepts
5. Use of multimodal instructions
6. Using Multimodal Instructional Approaches to teach the mole concept
7. Motivations and barriers of Multimodal Instructional Approaches
8. Perception of using Multimodal Instructional Approaches
9. Summary

2.1 Theoretical Framework of the Study

The theoretical framework on which Multimodal Instructional Approaches is based affects not only the way in which information is communicated to the student, but also the way in which the student makes sense and constructs new knowledge from the information which is presented. Three major theoretical frameworks informed this study. The first is transmediation, which is the transfer of information from one symbolic representation system to another (Siegel, 1995). In transmediation a student transfers key concepts and ideas from one text and creates a new text incorporating those key themes and ideas (Akintunde, 2007). 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). It might be seen that symbols come to be understood by the individual based on his or her experiences with the world. However, according to Siegel, 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.

The second theoretical framework of this study is the situated cognition. Situated cognition is a theory that posits that knowing is inseparable from doing and that Gee argued that all knowledge is situated in activity bound to social, cultural and physical contexts (Gee, 2005). A research team located at the Learning Technology Center at Vanderbilt University helped established some practical guidelines for integrating technology based on constructivist principles. This team, known as the Cognition and Technology Group at Vanderbilt (CTGV), proposed an instructional approach based on concepts introduced by Brown, Collins and Duguid (1989). The CTGV hypothesised that teaching without a direct relationship to children's personal experience often resulted in their acquiring what Whitehead referred to as "inert knowledge". That is, students never actually applied the knowledge they had learned because they could not see its relationship to problems they encountered. It was further noted that inert knowledge is "knowledge that can usually be recalled when people are explicitly asked to do so, but is not used spontaneously in problem solving even though it is relevant" (CTGV, 1990, p. 2).

Brown *et al*. (1989) suggested that teachers could prevent the problem of inert knowledge by situating cognition in the context of what they called authentic experiences and practical apprenticeships – activities. Inert knowledge in a situated cognition is considered important by learners because they emulated the behaviour of experts (adults) in the area. In this way, students see the link between school learning and real-life activities. The CTGV felt that "teachers can meet the criteria for situated cognition by anchoring instruction in highly visual problem-solving environments" (CTGV, 1991a, p. 2).

Like Vygotsky (1989), the CTGV believes that learning is most meaningful to students when it builds on experiences they have already had. Students are also more likely to remember knowledge that they build or "generate" themselves, rather than that which they simply receive passively (CTGV, 1991b). It is in this direction that the researcher employed Multimodal Instructional Approaches to help students generate their own knowledge and apply it to their everyday life. The CTGV proposed that the best way of providing instruction that would meet all the required criteria was to present it as videodisc-based scenarios posing interesting but difficult problems for students to solve.

The educational implication is that, lessons are to be designed to build on children's existing knowledge in a way that would emphasize knowledge transfer to real-life situations.

The final theoretical framework is learning as representation (Cowan & Albers, 2006). The representation theory is based on constructivist principles, in which a learner actively constructs an internal representation of knowledge by interacting with the material to be learned (Keegan, 1990). 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 learning. Science should be understood historically as the development and integration of multimodal discourses (Lemke, 1998; Jewitt, Kress, Ogborn, & Tsatsarelis, 2001; Norris & Phillips, 2003; Lemke, 2003, 2004). As noted by Lemke (2003), the integration of these different modes is a key feature of the development of scientific knowledge. Based on these studies, visual, aural, read or write and kinesthetic modes of instructions have been used individually and in coordinated ways to represent the knowledge claims of science discourse.

2.2 Empirical Framework of the Study

A search in science literature shows that several researches have been conducted on multimodal learning. In a study carried out with a sample of undergraduate students studying at the University of Southern Queensland (USQ) by Sankey, Birch and Gardiner, (2010), it was found that only four out of the sixty participants preferred to be instructed using aural mode. The majority of the students appreciated multimodal instructional approaches. The authors connected the improvement in the scores students received between the pre-intervention test and post-intervention test, the qualitative data clearly indicated that students perceived learning resources with additional representations of content assisted their comprehension, understanding and retention of content. The additional representations also made content more interesting and enjoyable to them. In particular, students expressed a strong preference for a combination of learning resources and options. According to Sankey, *et al* (2010), given these findings, the importance of improving student progression and retention, and engendering a joy of learning, leading to life-long learning, educators should be encouraged to continue to explore the use of multimodal instructions.

To further understand the interaction between the senses and how we can capitalize upon this phenomenon in our classrooms, Mayer (2005) demonstrated the advantages of including as many senses as possible in the learning process. The writer in experiments that undoubtedly exemplify this point involves three groups of people. One group receives information delivered via one sense (hearing), another, the same information from another sense (sight), and the third group the same information as a combination of the first two senses. The results consistently confirm that multisensory groups always do better than the unisensory groups. According to Mayer (2005), they have superior and more accurate recall and have better resolution, which lasts longer. He further indicated that the benefits were not just confined to a combination of sight and sound. When touch is combined with visual information, recognition learning leaps by almost 30%, as compared with touch alone (Mayer, 2005).

Bawa (2014) on his part conducted a study that was designed to determine the differential effects of multimodal instructional and traditional instructional approaches of selected colleges of education first year students' understanding of chemical bonding concept. The study took place in Dambai and Jasikan Colleges of Education. Students were randomly selected into the groups. The sample of the study comprised of 120 first year teacher trainees from the two colleges of education. Interview, questionnaire and pre and post-tests were used as the main instrument to collect data for the study. It was found that there was a significant difference in performance between experimental and control groups. The experimental group performed better in post-test than control group.

There is an evolutionary rationale for why multisensory situations are effective and successful in capturing our attention. In East African home, ancestors were encountering a multisensory world and were already champions at experiencing it. It is the same in the classroom. The more the learning environment is optimized, the more multisensory the environment becomes. But the opposite is true; learning is less effective in a unisensory environment (Mayer, 2005).

From the literature reviewed, a lot of research has gone into how to effectively instruct using multimodal approaches. But from the several researches, which have been considered, conducted, none of it has investigated the effectiveness of the Multimodal Instructional Approaches in teaching of the mole concept. Researchers who have used the approach never used four multimodal approaches or tested it at the secondary level in Ghana. So, clearly more research is needed in this direction. The researcher therefore deemed it necessary to investigate the effect of Multimodal Instructional Approaches on students' performance in some selected topics in integrated science at Winneba Senior High School.

2.3 Cognitive Load Theory

Cognitive load theory (CLT) is a theory of instruction that addresses directly the limitations of Working Memory (Sweller, 1994). Cognitive load theory suggests that learning happens best when instructional materials align with human cognitive architecture (Sweller, van Merrienboer, & Pass, 1998). Thus, by simultaneously considering the structure of information and the cognitive architecture that allows learners to process that information. Cognitive load theorists have been able to generate a unique variety of new and sometimes counterintuitive instructional designs and procedures (Paas, Renkl, & Sweller, 2004). In many ways, this focus on information and cognitive structures as well as the ultimate goal of generating new and efficient instructional techniques has distinguished CLT from many other cognitive theories (Sweller & Chandler, 1991). This is not to say that all other theories have failed to consider the interaction between external instructional presentation and internal cognitive structures and function. Certainly Gagne's theory, among others, was sensitive to the idea that if learning is to occur, instructors must deliberately arrange the external and internal conditions of learning (Gagne, Wager, Golas, & Keller, 2005). However, it seems that more than any other, CLT has focused on understanding this interaction from a theoretical perspective and then has applied that understanding to the development of instructional methods.

2.4 The Nature of Multimodal Instructional Approaches

Teachers sometimes tend to focus on resources and students' learning styles rather than on modal diversity, and also confusing modes and resources. For example, according to Vaughan and Bruce (2008), some teachers perceive a specimen from nature to be a representational mode in itself. Vaughan and Bruce also indicated that teachers tend to think that different learning styles dictate the type of many different modes that should be used for the same topic on the assumption that particular modes worked better for some students than others. In this view, teaching is mainly about matching the right modes to a specific learning style of each individual, and that learners' engagement of one mode of representation is not sufficient for learning a concept. Volkmann and Abell (2003) suggested that teachers had not considered assessing systematically the kind, range, and sequence of modes and their effects on learning scientific concepts. Various studies have addressed students' learning through different representational modals in the classroom at the basic and senior high school levels (Dolin, 2001; Russell & McGuigan, 2001). Some of these include the use of analogies for learning science (Coll & Treagust, 2000), the role of scientific modals in learning science (Treagust, Chittleborough & Mamiala, 2002) and the perception of teachers in the use of multimodal representation of concept (Vaughan & Bruce, 2008). Several of the studies tried to explain how teaching and learning should be done for students to be able to better understand and interpret scientific principles and concepts in the classroom.

Teaching and learning in science involves understanding and conceptually linking multimodal representations in the classroom (Ainsworth, 1999; Dolin, 2001; Russell &

McGuigan, 2001). Multiple instructional representations of concepts refers to the same concept being shown in different forms, including verbal, graphic, numerical, and embodied modes, as well as repeated teachers' representations of the same concept to learners. For instance, teachers can represent a topic such as preparation of standard solution, a topic on mole concept using 3-dimension, then in 2-dimension, such that students can appreciation the content. When teachers translate the understanding of a particular concept from one mode to another, or refine a past understanding using the same mode, they are engaged in representing the knowledge known as multimode representation.

Multimodal representation of teaching refers to the integration of different modes within the same text or topic to represent scientific ideas, reasoning, and findings in order for understanding of it by learners (Vaughan & Bruce, 2008). There are a diversity of possible representational modes; verbal (oral presentations, guest speakers), graphic and visual (Internet, computer simulations, videos, posters, diagrams, tables, charts, smart board presentation), written (worksheets, menus, texts, project assignments, scripts, pamphlets, concept maps), numerical (mathematics), embodied (role-play, class presentation), and three-dimensional modes (models, experiments). This variety of modes is used as resources to promote interest in topics or cater for individual differences in learning styles, rather than as different representations of science methods, concepts, and symbols.

There are several classifications of modes that have been proposed to aid learning of science concepts. These classifications are broadly agreed and categorized into the forms which include the categories such as descriptive (verbal, graphic, tabular), experimental, mathematical, figurative (pictorial, analogous, and metaphoric), symbolic and kinesthetic or embodied gestural understandings or representations of the same concept or process. It is also confirmed in literature that students need to develop an understanding of different modes, rather than relying on particular modes for specific topics, if they are to develop a strong and better understanding of both science concepts and how they can be represented (Saul, 2004). Dolin (2001) perceived that some representational modes in learning are not used the teaching strategies. Confirming improving learning through re-representing the same concepts, Nuthall (1999) stated that students need more than two experiences in order to develop long-term knowledge of a concept.

Varied representations of the same concept is essential due to the fact that particular modes have different strengths and weaknesses in terms of precision, clarity, and associative meaning, and that teachers and learners need to understand these aspects of representations. According to Lemke (2004), running verbal texts would make no sense to learners without the integrated mathematical equations. Hence Lemke pointed out that modal interdependence is typically a key feature of scientific explanations in classroom. Dolin (2001) also observed that some representational modes in learning has not been utilized and should be effectively included in the classroom practices. It means that representational modes may be identified but the important thing is that how it is incorporated into classroom practices for learner to understand a topic. Teachers can enhance learning through re-representing the same concept in different modes. Children in the process of learning require three or more different experiences such as concrete, video, illustration or abstract experiences to be able to establish long-term knowledge of a concept (Nuthall, 1999). When children are taken through these experiences in the same text it puts them in a better position mentally to generate varying representation of a concept. In using Multimodal Instructional Approaches, Russell and McGuigan (2001) reported that students need to generate different representations of a concept and recode the representations in various modes. This helps them to refine and make more explicit their understanding of a particular concept. In their classroom teaching and learning process, both teachers and students produce various representations of particular concepts, and knowledge construction was seen as the process of making and transforming these different representational modes. Some other researchers claim that some modes may be more convenient and supportive of student learning than other modes. For instance, Gobert and Clement (1999) indicated that a student can draw to learn effectively, where the visual media used affords specific advantages over the textual media.

It is suggested that teaching and learning practices should incorporate the use of accepted representations as well as student-generated multimodal representations for learning topics. For example, students can learn about preparation of standard solution through engagement with 3D objects, concept maps, diagrams, verbal accounts, role-play, computer animations and CD-Rom illustrations such as video presentation. Multimodal representation for learning topics is used for the students to understand, integrate, reconstruct and explain these modes through their own learning styles to show that proper learning has taking place. In fact, learning science did not always involve (a) systematic focus on conceptually linking multiple representations within all topics and (b) building on students' own representations of topics through guided exposure to, and interaction with, teacher-presented representational options (Hazari, 2004). It has been seen that presenting material in a variety of modes may encourage students to develop a more versatile approach to their learning findings in the field of cognitive science (Yeşildağ & Günel, 2013).

Hazari suggested that multiple intelligences and mental abilities do not exist as yes-no entities but within a continuum which the mind blends into the manner in which it responds to and learns from the external environment and instructional stimuli. Conceptually, this suggests a framework for a multimodal instructional design that relies on a variety of pedagogical techniques, deliveries, and media (Picciano, 2009). The effective and systematic use of multiple modes in teaching a topic can make student learn the mole concept with ease. Klein (2003) supported the view that the most effective use of different representational modes in learning science is to seek to match particular modes to specific preferred students learning styles. Students sometimes feel more comfortable and perform better when learning in environments that cater for their prime learning styles (Cronin, 2009). While there is recognition that the exposure to diverse modes can promote student interest in a topic and cater for individual differences and learning styles, there is also more interest area such as how students make sense of science concepts and methods across modes (Vaughan & Bruce, 2008). From a pedagogical perspective it is assumed that students' engagement with, and integration of diverse representational modes enhances learning by encouraging them to make explicit their knowledge of underlying science concepts.

Current research works have focused on teachers and students using diagrams to construct and give explanations to scientific concepts (Ainsworth & Iacovides, 2005) and understanding concepts through multiple modes representations in different topics (Parnafes, 2005; Tytler, Peterson & Prain, 2006), and the role of visualization in textual interpretation (Florax & Ploetzner, 2005). Instead of putting emphasize on a particular representation or one classroom instructional approach, this study focused on the effect of the use of Multimodal Instructional Approaches of re-representing the same concept for effective learning of mole concept rather than trying to identify an exemplary representation or mode which authorized as proven to provide an accelerated key to better learning, the research work was interested in how students appreciate re-representing of the same concepts in different modes.

Multimodal representations of topics on mole concept are consistent with conceptualists' approaches to learning science. This is to involve learners more instead of only emphasizing on the restricted representational forms which are found in textbooks or the usual chalkboard illustration practices. The recent research findings have explained the need to study Multimodal Instructional Approaches. Tytler, Waldrip and Griffiths (2004) and Tytler (2003) indicated that mostly, students learn effectively in science and engage more on the subjects when they are challenged to develop meaningful understandings. Tytler suggested that effective learning occurs where individual learners' learning needs and preferences are catered for or when a range of assessment tasks are used or the nature of science depicts its social, personal, and technological dimensions. Tytler (2003) claimed that effective learning occurs when links are made between class programmes and local or broad community which the wide relevance and social implications of science. In short, the explicit focus on learners' engagement with interpreting and representing concepts in different modes through multimodal approach in classroom promotes students' learning.

2.5 Multimodal Representations of Concepts

One of the key factors that influence teaching and learning process in science identified by many researchers and writers in recent times is mode representations factor. It is so because science is not solitary endeavour, its participants have to communicate with one another on a regular basis and to the learners in order to contribute to development or explain the natural phenomenon.

Scientists perform research and communicate their findings using more than one modes of representation to one another to publish their result (Bennett, 2011). Bennett explained that 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. The writer further opined that 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 science. 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. Just as scientists represent ideas and discoveries in modes to communicate with others; it is the same way that science students learning about those ideas and discoveries use the same forms of representation to understand nature. Once students are inducted into these forms of communication they must be helped to be fluent in them if they are to be successful in the science classroom (Lemke, 2000).

The importance of representing scientific concepts in multiple modes to gain literacy means that it must necessarily be considered by science educators as well (Zywno, 2003). Zywno explained that 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, for 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 and diagrams and cannot be communicated without them (Bennett, 2011). From the mole concept, 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 multimodal 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 multimodal representation strategies of learning in science literacy (Sankey, Birch & Gardiner, 2010).

2.6 The Use of Multimodal Instruction

In recent times, attention has been focused on learning with more than one representation and methods, stemming from the fact that two representations are better than one (Ainsworth, 2006). This strategy is used for the purpose of overcoming students' difficulties previously pointed out. The multimodal instructional strategy, one of the instructional strategies, makes students interpret and analyse concepts such as mole concept in diverse forms to meet the fast evolving science literacy. It appears complex integrated science concepts are being discovered daily, yet the same instructional approach of teaching is still being used every day. Discussion on the instructional strategies skills indicated that teachers are required to develop understanding of the processes involved in building up inert knowledge which goes beyond the traditional discursive practices are important in this era (Ainsworth, 2006). Driver, Newton and Osborne (1999) conducted a study on the importance of building up inert knowledge by stating that to understand the symbolic world of science it is necessary for students to have experiences which are not only with finished products, but also with meaning-making processes based on the use of words, diagrams and realia, stemming from the scientific culture. Kress, Ogborn, Martins and McGillicuddy (1998) could not put it better than stating that we: "We have tried to go further, and to look at all the activity of the classroom – talk, gesture, pictures, graphs, and tables, experimenting, doing demonstrations – as a ways of making meanings" (p. 42).

The study of how different instructional approaches were being used in the teaching and learning of scientific content in the classroom has been fertile field of research. Quite a number of articles on the instructions have been published in the science educational literature (Kress *et al*. 1998; Jewitt & Scott 2002; Roth 2002; Piccinini 2003; Lemke, 2003). These authors questioned the supremacy of verbal language (mode) that features mostly in teaching and learning process. They explained that other languages mediate the construction of knowledge in the classroom and that these other languages (ways of presenting concepts) are worthy of research.

Lemke (1998) called attention to the beginning and integration of different languages (multiple modes) used in communication during science teaching and learning. Lemke explained that verbal instructions (lecture) are always accompanied by gestures and facial expressions, and that written languages are accompanied by pictures, tables and graphs. According to Lemke, attention has to be paid to the visual instructions that always accompany with verbal language and written languages to bring about a holistic approach of learning mole concept.

Research has also exposed that significant increases in learning can be accomplished through the well-versed use of integrated visual and verbal multimodal learning (Fadel, 2008). Students may feel more comfortable and perform better when they are provided with learning environments that cater for their predominant learning style (Omrod, 2008; Cronin, 2009). It is also observed that teaching concepts in multimodal instructions can encourage students to develop a versatile approach to their learning (Hazari, 2004). Multimodal learning environments allow instructional elements to be presented in more than one sensory mode. Sequentially, materials that are presented in a variety of modes may lead learners to recognize that it is easier to learn and improve attention, thus resulting to improved learning performance especially for lower-achieving students (Chen & Fu, 2003; Zywno, 2003). Mayer (2003) argued that students learn more deeply from a combination of words and pictures than from words alone, Mayer described this as 'multimedia effect'. The importance of using multimodal learning environment cannot be understated. According to Shah and Freedman cited in Sankey, Birch and Gardiner (2010), benefits of using visualizations in learning environments include promoting learning by providing an external representation of the information. It also include a deeper processing of information and maintaining learner attention by making the information more attractive and motivating, hence making complex information easier to comprehend. Fadel

(2008) stated that "students engaged in learning that incorporates multimodal designs, on average, outperform students who learn using traditional approach with single modes" (p. 13).

Picciano (2009) also identified the benefit of multimodal designs as allowing students to experience learning in ways that they are mostly comfortable and also challenges them to experience and learn in other ways as well. As a result, students can become more self-directed, interacting with the various elements in these environments. So, depending upon their chief learning style, students may self-select the learning object or representation that best suits their modal preference (Doolittle, McNeill, Terry & Scheer, 2005). This is explained by some researchers as different modes of instruction might be most favourable for different people because different modes of presentation exploit the specific perceptual and cognitive strengths of different individuals (Pashler, McDaniel, Rohrer, & Bjork, 2008).

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 multimodal 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 a 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. Jewitt, Kress, Ogborn and Tsatsarelis (2001) 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 (Jewitt *et al*. 2001; Lemke, 2003). 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 that ‘‘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; Spiro & Jehng, 1990; Jewitt, Kress, Ogborn & Tsatsarelis, 2001; Lemke, 2003). 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 (Mayer & Sims, 1994; Tabachneck, Koedinger, & Nathan, 1994; Cox & Brna, 1995), others fail to find these benefits to learners (Chandler & Sweller, 1992; Van Someren, Reimann, Boshuizen, & de Jong, 1998).

2.7 Using Multimodal Instructional Approaches to teach

The question that science education research must then answer is: how is Multimodal Instructional Approaches of concept representation connected to learning mole concept? In answering this question, science education researchers must begin to look at how teachers, students and scientists are able to integrate and coordinate the multiple modes of representation in their investigation and conceptualization processes (Bennett, 2011). Every science literature presents concepts in a mixture of modes working together as one comprehensible, coherent language (Jewitt, Kress, Ogborn, & Tsatsarelis, 2001). For students learning integrated science, multiple modes instructional approach of concepts representation can place a high demand on their cognitive processes. This is also confirmed by Lemke (2000) in stating that to be able to use a scientific idea and to understand it in the way that scientists do is to be able to integrated the verbal, mathematical and graphical aspects, applying whichever is most appropriate in the moment and freely translating back and forth among them. Lemke continued to indicate the ability for teachers to use and manipulate different modal and modes for students to translate the concepts across is the hallmark of student understanding of science concepts instead of rote learning or memorization of the end product in literatures.

However, exposure of students to multimodal instruction will let them understand the limitations and implications of each mode that is used, point to the development of the student‘s understanding of mole concept (Jewitt, Kress, Ogborn, & Tsatsarelis, 2001). It is a fact that the introduction of several modes, each being unique in their own way, to communicate a concept solves all learning problems. There are the possibilities that the modes used to represent the concept will be needless or insufficient to capture a complete meaning or the specific meaning intended by the writer (Jewitt *et al.* 2001). Kress, Jewitt, Ogborn and Tsatsarelis explained that most concepts demand more than one thought or mode of instruction. Also many scientific equations, symbols, and theories, in mole concept have complex relationship which cannot be taught and summarized with just one mode. For that matter, if teachers and students are to entirely articulate the concept for assessment both local and international then more than one mode of instruction will be required.

Multimodal instructional representation of concepts in science covers the entire educational experience that science students can participate in the learning process (diSessa, 2004). According to diSessa, teachers should be able to integrate a number of modes during teaching to develop a rational understanding of scientific concepts in students. The writer further opined that sometimes, teachers teaching preparation of standard solution in which different modes are used to express the knowledge to learners, help them constitute new knowledge which is coherent with those modes. During a science class, teacher might use the didactic mode in teaching a concept such as the mole but show a diagram of illustration on the chalkboard and pictures compounds in their textbook or charts, or video illustrating a relationship between the variables. Hence within that short time in the lesson students are able to override a number of different modes of instructions almost simultaneously into a single unified concept for better understanding. Sometimes there is the demand of many different types of modes to represent concepts that the students are required to follow in a context but the students may have any difficulty in assimilating the information from particular mode to another, then it is likely that they will develop either a partial or flawed interpretation of that concept. When students are able to gain the competency to follow multiple modes in their correct purpose, it may invent an important learning landmark for the student (diSessa, 2004). In some cases a student might not understand a concept properly through the use of particular modal. The student in mind will be deeply investigating other modal options to understand that concept. Therefore when different instructional approaches of representations are used at that point the student through the mental investigation may find relationship that can be compared to the his or her schema, resulting to actively learning abound the concept in a way such as forming new or stronger connections within or between concepts (Prain & Waldrip, 2006).

According to Prain and Waldrip, students may be faced with a particular diagram illustration processes and pictures which are so different from what they have seen before a multimode can make them to reconsider their prior conceptions of the topic. When students are given opportunities or cue through instructions to reconsider their prior conceptions, they are likely to form new connections that add to their previous experiences that will allow them to think and communicate about the content more clearly (Vaughan & Bruce, 2008). According to Vaughan Bruce, the interpretation and translation of concepts by students can occur in two ways; first of all, the teaching approach used by the teachers and then secondly, the ability of the student to learn. During lesson presentation, students are expected to listen, ask questions to clear their doubts or difficulties and give responses to questions in order to express their understanding of the science concepts. Mentally, students compare multimodal representation approach to be able to articulate their ideas and understanding of the concept and translate it into a new form to give positive response. Students may face difficulties when teachers consider the important aspect of the content and use a mode that seem not to be most appropriate and convenient to them in order to effectively communicate their ideas as well. The students will have difficulty to completely express the entire scope of their conceptions with only one mode of representation or instructions at a time (Waldrip, Prain & Carolan, 2006). Waldrip, Prain and Carolan stated that the more complex a concept, the more wording or multiple modes of instructions the teachers will have to use in order to fully express concepts.

This knowledge establishment of a science concept using Multimodal Instructional Approaches is the critical point on which multiple modes of representation intersect.

Teachers must not only insist that students understand and interpret content within a modal representation but must also be able to use multiple modes of teaching to enable students translate between modes when synthesizing a written composition. However, students who are not familiar with any conceptual link between the modes do not translate their understanding across different types of modal representation (Vaughan & Bruce, 2008). It is obvious from the above-mentioned studies that learners who are able to recognize the conceptual link between different modes of the same concept are able to articulate their understanding of the science concept. Equally, teachers according to the study do not teach their students about clear conceptual connections across the modes or use them significantly as an assessment strategy. Hence little links between multiple modes were made than probably could have if more of the teachers' scaffolding had been provided.

Proper communication in science using modal representation involves that the teachers and students have a good grasp of the rhetorical task and the strategies needed to satisfy it. It appears at the SHS level, majority of students fail to communicate clearly and consistently in class using interpretations diagrams and equation on mole concepts. This is because they often give ambiguous definitions and terms. This ambiguity in communication may causes problems among the students when they try to find out meanings among their peers concerning the meaning of concepts. Mostly students relied totally on previous examples scaffold by the teachers and are often found not having appreciably increased in their understanding of the mole concept content as a base of interpreting the equations (Bennett, 2011). This finding is troubled with the inclusion of multimodal representations as a part of classroom curriculum. Bennett explained that just exposing students to multi-modal representation rhetorical tasks may not be a sufficient bridge to reach the level of scientific literacy expected by scientists. There is an interesting distinction why students and scientists interpret graphs differently. Students are mostly motivated to answer questions related to the graphs based upon an external motivation of doing well in examination whereas the scientists depends on personal knowledge from actual investigations in science that come from internal motivation (Bennett, 2011). The differences in motivation are found to be important because the students approach solving the graphical problems in an analytical approach that are not related to the concepts in the course whereas the scientists are applying their knowledge from experience in legitimate inquiries in the content domain and therefore provide more interpretations of the graph that are grounded in science content knowledge.

Also students are motivated to learn when they are involved in concepts through representations and re-representation than the use of traditional method (Vaughan & Bruce, 2008). The repetition as an intervention used does not only allow for additional time on task but practice with the content and practice with the modes of representation. This discovery supports the work of multi-modal representation that focused on the assessments of which modes are to be used in conjunction with representing the original concept. According to diSessa (2004) students are found to perform better in science when they understand that there is no single modal representation that explains the entire concept. These students are to be encouraged to only include modal representations that were clear, unambiguous, gave minimal but sufficient information, and are comprehensive to its rhetorical purpose.

However, Bennett (2011) stated that students who do not perform well lack an adequate understanding of when and where to use certain modes to clearly communicate their understanding. These students who struggle with the concepts and rhetorical tasks needed more practice and scaffolding of teaching method from teachers to be competent in that area. This competence could also be interpreted to mean that students who have a greater repertoire of modal representation are more fluent in the language of their science (Bennett, 2011). That is, students with a broad range of representational competence are able to read and write science more accurately and sufficiently. In fact, the students with profound multi-modal representational knowledge of science concepts are more literate in science and teachers with adequate Multimodal Instructional Approaches of concept representation are competent teachers (Bennett, 2011).

2.8 Motivation and Barriers to Multimodal Instructional Approaches

Despite the many pedagogical benefits associated with the adoption and integration of educational technology, Jacobsen, Clifford and Friesen (2002) found that both philosophical and pedagogical barriers to innovation exist when teachers shift from information transmission to designing technology. According to Jones and Kelly (2003), the need to adapt one's teaching style and redesign course content has presented a major barrier for some teachers. Covington, Petherbridge and Egan Warren (2005) identified some of these barriers as the entrenched instructional practices, lack of clarity about the benefits of technology, lack of willingness to take risks, and the need for more rigorous course planning has deterred some teachers from changing from familiar instructional practices.

Indeed, the successful integration of Multimodal Instructional Approaches requires an adjustment of pedagogy to allow for active participation, authentic tasks, collaborative learning, and individualised feedback (Knowlton, 2002). According to Rockwell, Schauer, Fritz and Marx (1999), teachers need to alter teaching styles and develop new skills when they integrate technology into their program and they need to understand the relationship between learning, interactivity and technology. Hence, in adopting and integrating educational technology, there is a need for training in this different instructional design (Eastman & Owens Swift, 2001; Hazari, 2004).

Some teachers have also expressed pedagogical concerns, in terms of what impact multimodal instructions will have on students' learning, and others have expressed a lack of confidence in the benefits for students (Ebersole & Vorndam, 2003; McAlpine & Gandell, 2003). Thus, Munoz (1993) stressed the importance of being ethical in the use of multimodal instructions and warns that teachers should resist the seductive force of technology to replace enhanced technology. Other teachers have reacted to students' concerns to the shift from printed to electronically-delivered materials (Daugherty & Funke 1998; McPhail & Birch, 2004). Student resistance may arise due to a variety of factors including the lack of access to the required hardware and software and lack of computing skills (Jones & Kelley, 2003; McPhail & Birch, 2004). Moreover, fear of the negative impact on student evaluations if the technology does not work or is not accepted by students is a major deterrent for teachers (McCorkle, Alexander & Reardon, 2001). Hence it is proposed that pedagogical barriers including: the need to adapt one's teaching style, the need develop new skills and redesign course content; the need for more rigorous course planning; the need to deviate from entrenched instructional practices; the need to adjust pedagogy to allow for active participation, authentic tasks, collaborative learning, and individualised feedback; lack of confidence in the benefits for student learning; concerns about the quality of the course; and perceptions that the value of educational technology may vary across subject domains inhibit academics' adoption and integration of Multimodal Instructional Approaches.

2.9 Perception of using Multimodal Instructional Approaches

According to Sankey, Birch and Gardiner (2010), students perceived learning resources with additional modal representations of content, assist them in their comprehension, understanding and retention of content. It also makes lesson more interesting and enjoyable. In particular, students expressed a strong preference for a combination of learning options use in class. Given these findings, it is important for improving student progressive and retentive memories through causing a joy of learning, leading to life-long learning. They therefore suggested that educators and researchers should be encouraged to continue to explore the use of educational technology and modes for developing multiple representations of content. They also viewed that audio and video enhanced smart board presentations and interactive diagrams with transcripts and audio, in particular, were valued by learners in engaging students through multimodal learning environments. However, the study of Sankey *et al*. (2010) did not indicate perception of the use of Multimodal Instructional Approaches on learners' abilities to interpret and comprehend diverse concept representations to avoid various misconceptions in learning science today. There are students who are multimodal learners and they normally learn across a range of conditions such as aural, visual and kinesthetic. The literature have also indicated that multimodal learning may be of greater benefit to lower-achieving learners, while higher achieving learners perform well regardless of how the content is presented, this may be one factor that explains the lack of impact of multiple representations of content on learning performance (Zywno, 2003).

Teachers face considerable challenges in focusing on multimodal instructions in learning in science. Catering for differences in students' learning experiences and outcomes, developing appropriate assessment methods, and providing effective timely scaffolding for different learner needs entailed a range of complex implementation issues according to Vaughan and Bruce (2008). However, in their study it is confirmed that teachers developed similar practices and viewpoints in relation to the value of focusing on multimodal instructions to enhance student learning. The focus on this approach caters very effectively for student diversity and has the potential to promote deeper learning. Vaughan and Bruce explained that the focusing of this approach is not open to a tightly structured sequential approach but required flexibility in responding to emerging learning opportunities and diverse student needs, capabilities, and curiosities. The approach also provides opportunities to revisit concepts which are crucial to enhancing student learning. Its translational process enabled students multiple pathways for conceptual clarification. However, the effective scaffolding is crucial to enabling students to cope with the increased demands of translation work.

It is observed that there are complexities in choosing appropriate modes to enhance learning for students with different capabilities because of the differences within individual representational modes. These differences in using modal options influenced the views on effective assessment. In a study of students perceptions in using multi-modal representations to support student learning in science, Waldrip, Prain and Carolan, (2006) noted that this focus could promote deeper learning, but it is not easily accommodated within a tightly structured sequential learning process. Therefore, teachers needed to be flexible to use different modal instructions to be able to emerge learning opportunities and diverse student needs and capabilities.

Students also needed to be familiar with the nature of the representational conventions in different modes in order to represent and translate concepts across modes. From this research works, it is obvious that the concentration is on the modal representations of concepts. But little is said about the modal instructions to enhance better learning. The modal focus is perceived as challenging the students to develop meaningful understandings and as catering for individual learning needs, preferences, and skills (Vaughan & Bruce, 2008). But it is to be noted that this focus could entail a broad range of assessment tasks, where links could be made between the classroom program and the local and broader community. Findings seemed to suggest that a cross-modal focus provides a generative framework for developing effective teaching and learning to positive perceptions of teaching methods.

2.10 Summary

The literature review showed a discrepancy between what is termed as scientific knowledge and students' knowledge in mole concept. This difference was observed to be due to, among others, the methodologies used to instruct learning process. Mole concept is highly abstract in nature, therefore it is considered by integrated science teachers and learners as very complicated concept to understand (Robinson, 2003; Taber, 2001). Diverse modes of concept representations are used to explain and interpret the process of mole concept. Disperse essential importance from several literature and multiple modes or representations of mole concept, learners still think it is a very complex and difficult concept to be understood. It is therefore necessary to consider the instructional approach that can be used to teach the topic.

However, Bennett (2011) argued that learners' difficulties to interpret and construct a concept depend on human learning process such as instructional approach and the intrinsic nature of the content. Both the nature of the scientific models and the way topic is taught contributes to students' learning difficulties (Levy, Mamlok-Naaman, Hofstein, & Taber, 2010). When the right instructional approach is not used, it creates learning difficulties. But Multimodal Instructional Approaches (MIA), in some contexts, significantly influence learning multimode representations in curriculum materials. However, there still remains a considerable amount of research to identify how and to what extent can the approach improve a student's metacognition and science literacy is a matter of concern (Yore & Treagust, 2006). Also, identification of effective scaffolding teaching strategies that will give students timely knowledge on how to interpret and construct multiple scientific concepts such as mole concept is needed (Vaughan & Bruce, 2008).

In recent times, the use of pedagogical content knowledge which teachers are supposed to have is the knowledge of a particular topic, problem, how to organization issues, and represent them. They are to adapt in their methodologies to suit diverse interest and abilities of learners. This approach over simplifies ideas, not in line with up-to-date scientific knowledge, and failed to develop conceptual understanding (Kind, 2009). It is used at the expense of a professional capability such as providing suitable platform for future learning. Multimodal representations of concepts are what scientists used to communicate ideas and findings among themselves can be best explained through using multimodal instructions (Bennett, 2011). It is because a particular mode and modal approach does not fully explain any scientific concept. When learners face difficulties in learning representational modes, they consult teachers who need to use multiple modal instructional strategies to help them out. Apart from using multimodal approach in the same topic, there is the need to investigate the link between the multiple modes of representation in science and teaching by Multimodal Instructional Approaches of learning science literacy (Sankey, Birch, & Gardiner, 2010).But the problem found from the research works is that teachers often attempt to use multiple resources for teaching and learning rather than on modal diversity for teaching in class.

Again, there are research works on how effective a teaching method such as only verbal modes, or combination of two instructional modes have impact on learning (Sankey, *et al*., 2010). But there has not been research on the effect of four multimodal instructions on students' understanding of concepts. Teaching and learning in science should involve the understanding and conceptual link between multiple representations in curriculum materials and multimodal representation of the same context (Dolin, 2001; Russel & McGuigan, 2001). Multiple instructional representations are showing the same concept in different form such as verbal, graphical and chemical equations in the curriculum material. Multimodal Instructional Approaches involve the integration of different modes within the same topic to present scientific concepts for greater learner comprehension. Multimodal engages learner in more than one sensory mode to make learning easier, improve attention and performance especially for low-achiever (Chen & Fu, 2003). Diverse modal promotes learners' interest and cater for individual learning styles, and enable students interpret concept and construct ideas in different modes for effective communication (Saul, 2004). Nuthall, (1999) indicated that students need more than two experiences in order to develop long-term knowledge of a concept. However, some modal representation of concepts is not utilized and must be effectively included in the classroom practice. The reason is that students engage in learning that incorporates multimodal designs on average outperform students who learn using traditional approaches with single modes (Fadel, 2008).

From the literature reviewed, a lot of research has gone into how to effectively instruct the mole concept. But from the several researches, which have been considered, conducted, none of it has investigated the effectiveness of the Multimodal Instructional Approaches in teaching of the mole concept. Researchers who have used the approach never used four multimodal approaches or tested it at the secondary level in Ghana. So, clearly more research is needed in this direction. The researcher therefore deemed it necessary to investigate the effect of Multimodal Instructional Approaches on students' performance in some selected topics in integrated science at Winneba Senior High School.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

The research methodology is a set of systematic plans for conducting a study so as to get the most valid findings (Kannae, 2002). According to Anderson (2006), the quality of any research methodology hinges on gathering relevant information that would be used to solve or investigate a stated problem.

This chapter provides description of the methodology employed in the study which includes the research design, population, sample and sampling techniques. The structure of this chapter also includes instrumentation, validity and reliability of the instrument. Pre-intervention stage, intervention stage and post intervention stage are part of this chapter. The chapter concludes with data collection procedure and methods employed to analyse the data collected as well as ethical issues that were ensured.

3.1 Research Design

According to Amedahe (2002) , research design is a plan or blueprint that specifies how data relating to a given problem should be collected and analysed. In this study, case study was the design conducted using an action approach. The essentials of action research design follow a characteristic cycle whereby initially an exploratory stance is adopted (Labaree, 2011). The exploratory stance helps the researcher to learn and to understand the problem under investigation so that some form of interventional strategy is carried out, and the cycle process repeats, continuing until an implementable solution is achieved.

Figure 1 shows the cyclical approach of action research model as described by Gerald (1983).

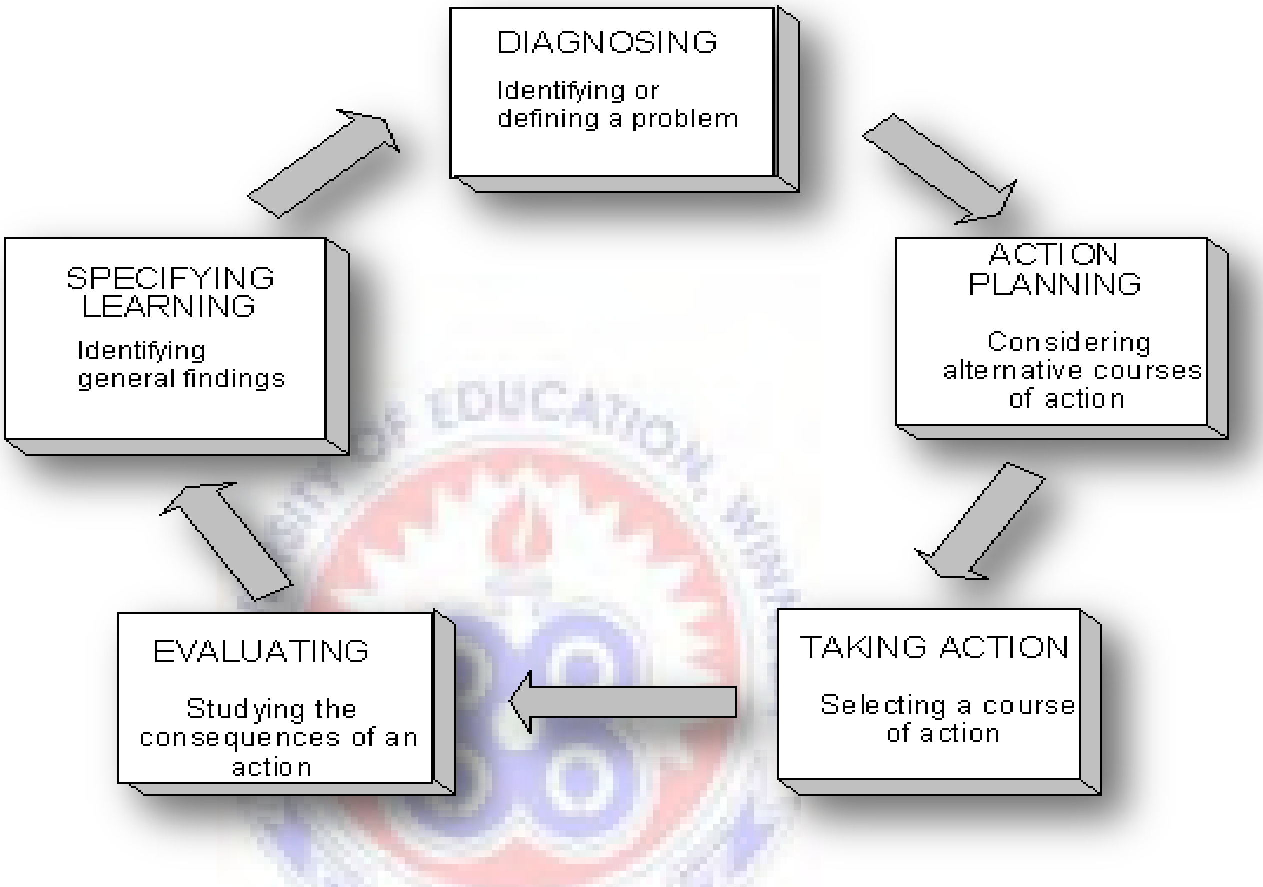

Figure 1. Cyclical action research model

The design of this study followed he cyclical action research mode. This design was in three phases. The first phase was problem identification and lesson notes preparation. The second phase was the development of the Multimodal Instructional Approaches and the intervention undertaken. The final phase was data collection, data coding and data analysis. In the first phase, the researcher prepared lesson notes and taught a total of five lessons.

At the second phase, the researcher developed a strategy to help improve the performance of students using multi modal instructional approach. This approach emphasises the integration of four different modes (methods) of instruction. The modes of instruction used were visual, aural, read or write and kinesthetic interaction as shown in Figure 2.

Each mode is associated with a predominant action verb, such as visualize, listen, read or write, and manipulate. These four modes of instruction have been abbreviated as VARK Multimodal Instructional Approaches.

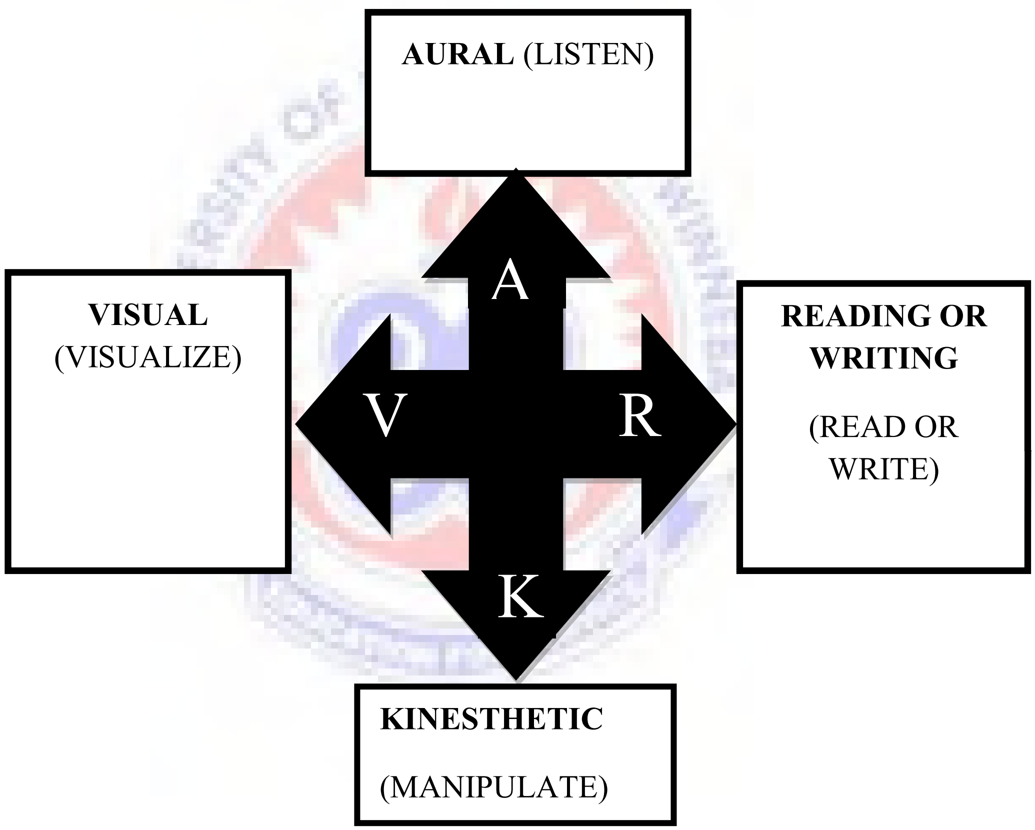

Figure 2. Framework of VARK Multimodal Instructional Approaches

Visual mode: This mode of teaching includes videos, diagram, illustrations, charts, and computer animations. Diagrams come in various degrees of abstraction, and carry scientific ideas in an interesting ways, and constitute a crucial mode of processing. Visual mode is an important problem solving heuristic which many scientists use.

Aural mode: Sounds are essential in communicating scientific ideas and in thinking about them. In classroom teaching, the researcher 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 researcher then explains their scientific meanings as clearly as possible to learners. This helped many students who failed to link the spoken sounds with the written words or symbols. Students were encouraged to use the terminologies associated with the selected topics.

Reading or writing mode: This was the most predominant mode of instruction used because lessons on mole concept involve a lot of representations. Many students find symbolic manipulations difficult and meaningless, and they fail to appreciate the power that symbols play in science thinking. However, it was integrated with the other modes of representation to promote the understanding of mole concept.

Kinesthetic: This mode of teaching refers to the use of concrete manipulative such as concrete objects. This is based on the psychological theories of Piaget and Brunner (1964). Piaget and Brunner explain that lessons are half taught when concrete objects are used. Students may develop the mental models that provide meaning to the abstract symbols which will reduce anxiety towards integrated science.

At the final phase, the researcher analysed the data collected using both quantitative and qualitative methods of data analysis. According to Johnson and Onwuegbuie (2004), mixed methods research involves combining a single study techniques, methods, approaches and language of both quantitative and qualitative traditions. Burns and Groove (1993) defined quantitative research as a formal, objective and systematic process to describe and test relationship and examine cause and effect interactions among variable using mathematical means or statistical analysis of data. Qualitative research on the other hand seeks to discover the meaning that participants attach to their behaviour, how they interpret situation and what their perspectives are on particular issues (Measor & Woods, 1984).

Mixed methods approach is more than simply collecting and analyzing either qualitative or quantitative data; it also involves the use of both approaches in tandem so that the overall strength of a study is greater than either qualitative or quantitative research (Creswell & Plano-Clark, 2007).

3.2 Research Population

The population of this study was all first year students offering Integrated Science as a course at Winneba Senior High School. The first year students were chosen due to the following reasons:

1. They were free from any external examination stress as they were not an examination class and as such were more likely to provide information devoid of facade.

2. They were not so much exposed to the traditional instructional approach of learning as the second and third year students in the school, Winneba Senior High School, therefore likely to appreciate the new approach.
3. Most of the selected topics on mole concept are taught in the first year as indicated by the integrated science syllabus than in the second and third year (Integrated science syllabus, 2007).

3.3 Sample and Sampling Technique

Considering some factors such as finance, time and accessibility, it is practically impossible to access information from a target population. It becomes appropriate therefore, to measure from a smaller group of the target population. This is done in such a way that the information obtained is representative of the total population under study. This smaller group from the target population represents a sample, which is always addressed by the study (Anderson, 2006). Anderson explains that one always addresses only a sample. The sample selected for this study was first year Home Economics1 class of forty (40) students, consisting of thirty-nine females and one male.

Purposive sampling technique was used to select the sample for the study. Purposive sampling is a form of non-probability sampling in which decisions concerning the individuals to be included in the sample are taken by the researcher, based on a variety of criteria. According to Bernard (2002) the variety of criteria includes may include specialist knowledge of the research issues, or capacity and willingness to participate in the research. Makhado also explained that purposive sampling enable the researcher to select information rich cases as this would help the researcher to address the purpose of the research (Makhado, 2002). In addition to the reasons mentioned above, the researcher wanted first year Home Economics 1 class to acquire the skills and knowledge in mole concept hence purposive sampling was appropriate. Again, this the class the researcher personally teaches.

3.4 Instrumentation

In the present study, three instruments were used to collect data. These comprised self constructed tests items, questionnaires and interview schedule. The self constructed test items were used to collect data during the pre-intervention test and the post-intervention test about students' knowledge in mole concepts. The main instruments were self constructed tests items and questionnaires. The interview schedule was used to triangulate students' responses on the questionnaire.

The test items were designed by the researcher and were formulated to cover key concepts of the selected topics on mole concept. The questionnaire was also employed as a tool to gather information about students' perceptions on the use of Multimodal Instructional Approaches in the teaching of mole concepts. The interview schedule was finally used to triangulate students' responses on the questionnaire.

3.4.1 Pre-intervention test and Post-intervention test

A total of five pre-intervention test and five post-intervention test sessions were designed by the researcher to measure the performance level of students in the study on five selected aspects of the mole concept. The contents of the tests were formulated based on the scheme of work and instructional objectives of those five selected topics. In each of the pre-intervention test and post-intervention test sessions, students were tested on ten (10) multiple choice questions and five (5) short answer type. The questions were carefully reviewed by the researcher's supervisors in order to make inputs and corrections on face validity. Before each topic was taught, a pre-intervention test was conducted to determine the initial level of students' knowledge in that topic; the post-intervention test was then administered to students after the treatment. The items formulated for the pre-intervention test were different in content, but similar in format from the items in the post-intervention test. Each question of the multiple choice question in the test had one correct answer and three distracters.

Appendices B, C, D, E and F show the various pre-intervention test items of the instrument whist Appendices G, H, I, J and K show the test items for the post-intervention test.

3.4.2 Questionnaires

A questionnaire is an effective way for getting factual information about opinion, practices and attitudes of a subject (Amedeker, 2000). A questionnaire was designed to gather information about the perceptions of students on the use of Multimodal Instructional Approaches in the teaching of those selected topics. 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.

The questionnaire consisted of two main sections. Section one of the instrument was used to gather information on the demography of students. Students were required to provide information on their gender. The other section of the questionnaire consisted of close-ended items which students were required to respond to them on a five point Likert-type scale. A Likert- scale was adopted 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. As corroborated by Gabel and Wolf (1993), Likert scales usually provide data with relatively high reliability.

The questionnaire also comprised fifteen (15) items which bothered on the views students held about the use of Multimodal Instructional Approaches in classroom instruction. The students were asked to indicate the extent of agreement or otherwise with each item on a 5-point Likert scale. The item mean response score (IMRS) of the responses with respect to each item was calculated and the corresponding standard deviation computed to provide an idea of the extent of agreement in each item. A detailed questionnaire is found in Appendix L.

3.4.3 Interview Schedule

The researcher used the semi-structured interview schedule for the study to triangulate the students' responses on the questionnaire. According to Borg, Gall and Gall (1993), interview can be fully structured, semi-structured or unstructured. For this study, it was obvious that using fully structured interview schedule was inappropriate. This is because such schedules are designed to be followed in a rigid manner. Undoubtedly, this would result in the loss of vital information, which could be volunteered by interviewees without the use of such structure. Unstructured interviews have been proposed to be most appropriate for qualitative research because they provide volunteered information, as the interviewee is more relaxed. The interview was scheduled for students only. It was also used to interact with students to seek their views about the use of Multimodal Instructional Approaches. The respondents' voices were recorded with a recorder and later transcribed. The interview schedule is found in Appendix M.

3.5 Validity of the Instruments

Validity of a research instrument is how well it measures what it is intended to measure (Patton, 2007). The instruments were looked at in terms of its face and content validity. Anastasi (1988) describes face validity as the validity that pertains to whether the test "looks valid'' to the examinees who take it, the administrative personnel who decide on its use and other technically untrained observers. In order to ensure face validity, the research instruments were given to colleagues, experienced integrated science teachers from Winneba Senior High School and lecturers from University of Education, Winneba, Department of Science Education to check spellings of words and grammatical functionality of the instruments. Necessary and constructive corrections and suggestions made were taken into consideration.

With regard to content validity, Zeller (1988) stated that content validity involves specifying the domain of the content. The researcher also consulted the Integrated Science syllabus, textbooks, senior integrated science teachers, fellow graduate students to ascertain the content validity of the instrument. This was to help the researcher develop the instruments in line with the curriculum requirement. Again, the test items, questionnaire and the interview schedule were examined by the researcher's supervisors to determine the extent to which the instruments measures a representative sampled of the domain of tasks with respect to the selected topics.

3.6 Reliability of the Instruments

Reliability concerns with the extent to which a questionnaire, test or any measurable procedure produces the same results on a repeated trails (Joppe, 2000). That is, it is the consistency of score over time. For this study, to ensure reliability of the instrument, the instruments were tested using test–retest reliability method. Test-retest reliability is best used for the things that are stable over time, such as intelligence (Rosenthal & Rosnow, 1991).

The researcher determined the reliability of the instruments used for the study. The first year Home Economics two students were made to respond to the same items after answering them for the first time under the same conditions within a week (see appendix

P). The two classes shares similar characteristics in terms of subject studied and performance. The internal consistency of the instrument was determined using the Statistical Package for Social Science (SPSS), version 20.0 for windows (SPSS Inc., 2007). With this the Cronbach coefficient alpha which measures reliability was used. The reliability coefficients of these two (2) instruments are summarised and presented in the Table 1.

Table 1. The Reliability Coefficients of the Two (2) Research Instruments

Type of the Instrument	Reliability coefficient
1. Test	
i. Pre-intervention test	0.78
ii. Post-intervention test	0.83
2. Students' Questionnaire	0.79

According to Borg, Gall and Gall (1993), coefficient of reliability values above 0.75 are considered reliable. Therefore, the above reliability estimates gave an indication that the instruments were substantially reliable.

3.7 Pre- Intervention Activity

This phase consisted of two activities which were done to ascertain the level of students' performance and knowledge of the selected topics. The first activity was to interact with students to identify them by names and also revised with them the previous lessons. The purpose of this first activity was to create a cordial relationship between the researcher and the students. The interaction also informed the researcher about the students' previous knowledge of those selected topics. The second phase was the administration of pre-intervention test after the students had been told to read on those selected topics. The pre-intervention test result for each student was recorded on the Students' Pre/Post-Test Results form (Appendix N). The pre-intervention tests were done to determine the level of students' performance and the ability to interpret and comprehend the selected topics in integrated science. This test was conducted to help establish the basis as to whether the use of Multimodal Instructional Approaches (MIA) could improve students' performance in the concepts.

3.8 The Intervention

The treatment process was conducted over a period of five weeks. Lesson plans were prepared (see Appendices G, H, I, J and K). The lesson plan guided the researcher to teach the selected topics according to lesson objectives and the methodology. The students were taught for one hour, twenty (20) minutes session per a week. The topics covered were relative atomic mass and relative molecular mass, amount of substance and Avogadro's constant. Other topics covered included measurements of concentration, the preparation of standard solution, and dilution of solution and dilution factors.

The strategy used for the treatment was based on VARK Multimodal Instructional Approaches consisting of four modes of instruction introduced by Fleming (1997) in the constructivist teaching approach. In the first step, the researcher asked student some questions at the beginning of the instruction in order to activate the prior relevant knowledge of the students and to promote student-centred interaction and agreement. For example, the researcher began the instruction with a question such as 'What is a standard solution?' The second step involved the exploration of students' knowledge. The students were allowed to discuss the questions among themselves in groups of four using their relevant previous knowledge. During the discussion, the students became conscious of their own and others' thoughts. They shared their ideas, sometimes, defended their answers until consensus was reached about the solution to the question without the interference of the researcher. The groups constructed their tentative answers freely and submitted a common answer to the researcher after the discussion. Based on the answers, the researcher used VARK Multimodal Instructional Approaches to explain to students what a standard solution was and how to prepare a standard solution from a given concentration. While explaining the topics, the researcher emphasized on students' misconceptions and why they were wrong. Before ending the lesson of those selected topics, the researcher summarized the lesson learnt and asked students questions which they did not ask and help them to solve questions which they could not answer.

3.9 Post –Intervention Activities

The researcher concluded the lessons by asking the students to solve the evaluation exercises as post intervention test. This also served as motivation to students. The questionnaire and interview were administered to the students after the last intervention lesson.

3.10 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 headmistress of Winneba

Senior High School (See Appendix S). Data for this study were collected in four stages. The first stage was the pre-intervention tests data collected from those selected topics. The second stage was the collection of data from the post-intervention tests which was conducted after exposing the students to the Multimodal Instructional Approaches. The third stage was the data collected from the responses to the questionnaire. The final stage was data gathered from personal interview with the students. The interview was scheduled and conducted at the end of the intervention. The questionnaire and interview were administered on the same day that last post-intervention test data was collected. This was done to allow students to respond according to their feelings about the Multimodal Instructional Approaches. This was on the assumption that the feeling about this approach would be fresh in students' mind.

3.11 Method of Data Analysis

The researcher analysed the data collected using both quantitative and qualitative methods of data analysis. According to Johnson and Onwuegbuie (2004), mixed methods research involves combining a single study techniques, methods, approaches and language of both quantitative and qualitative traditions. Burns and Groove (1993) define quantitative research as a formal, objective and systematic process to describe and test relationship and examine cause and effect interactions among variable using mathematical means or statistical analysis of data. Qualitative research on the other hand seeks to discover the meaning that participants attach to their behaviour, how they interpret situation and what their perspectives are on particular issues (Measor & Woods, 1984). Mixed methods approach is more than simply collecting and analyzing either qualitative or quantitative data; it also involves the use of both approaches in tandem so that the overall strength of a study is greater than either qualitative or quantitative research (Creswell & Plano-Clark, 2007).

In order to gather the quantitative data, a series of pre-intervention tests and post-intervention test were conducted to assess student performances before and after the intervention, so as to check the effective gain in students' performance. Researchers have developed a variety of tools to perform the average effectiveness of approaches in enhancing performance. One of such tools most commonly associated with the work of Richard Hake is called the normalised gain (< g >) (Hake, 1998). Since its introduction, the normalized gain has been widely used in assessing students' performance in pre-intervention test and post intervention test (Bao, 2006). According to Hake, the normalized gain is the ratio of the difference in mean scores between post intervention test and pre-intervention test to the difference in maximum score of the test to that of the pre-intervention test (Hake, 1998). It was mathematically presented as

$$\frac{\textbf{Post intervention test mean score} - \textbf{pre-intervention test mean score}}{\textbf{maximum score of the test} - \textbf{pre-intervention test mean score}}$$

The three test scores (maximum, pre-intervention test and post intervention test) could be defined for an individual students or as an average measures for a sample. In this study, the average normalized gain for the entire class was calculated to express the effectiveness of Multimodal Instructional Approaches or otherwise. Using the gain score, Hake classified interactive lesson and traditional lecture methods into one of three groups:

High gain; < g > greater than 0.7

Medium gain; < g > between 0.3 and 0.7

Low gain; < g > less than 0.3 (Hake, 1998).

Hake concluded that instruction that is based on traditional instructional approach usually has a low gain < g > less than 0.3. However, instruction that depend on moderately or highly used of interactive engagement approaches usually have medium gain (between 0.3 and 0.7) and high gain (< g > greater than 0.7). The statistical analysis of the tests (pre-intervention test and post-intervention test) was carried out first. The descriptive statistics such as means, mean difference and standard deviation of both pre-intervention test and post intervention test were computed by using Statistical Package for the Social Sciences (SPSS) version 20.0 programme. The normalized gains < g > of each lesson were computed to check the effectiveness of the intervention. These descriptive statistics were also used to summarize the general trends in student performance. The purpose of descriptive statistics was not only to describe the data from a study but also to help find pattern within the data described. Study of central tendency indicated the overall performance of the students.

The second stage was the analysis of the questionnaire data. Descriptive statistics such as frequency and percentages were used to compute the results of the study. The qualitative data analysis contributed to descriptive 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. The qualitative data was used to complement the quantitative data in the interpretation of result. The data collected were based on the following assumptions that:

a. The researcher was not biased during the treatment.

b. The tests were conducted under standard conditions.

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

3.12 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 students who were interviewed were assured of confidentiality. The researcher respected the research site by not allowing the treatments to interfere with the school'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 pseudonyms for individuals. The researcher also provided accurate account of the information from the data collected.

3.12 Summary

First year Home Economics One class of the Winneba Senior High School is a highly feminine class and considered the least performing class of form one was chosen as the sample for the study. To help improve the students' performance in integrated science, an intervention was provided by the researcher. The researcher developed Multimodal Instructional Approaches to teach some selected topics in integrated science for five weeks. Some of the topics treated were relative atomic mass and relative molecular mass, mole as a unit, measurements of concentrations and preparation of standard solution dilution and dilution factor. A mixed method approach was used as the study required both quantitative and qualitative data. With the aid of the pre-intervention test and post test and a questionnaire the quantitative data was obtained while an interview provided the qualitative data. Data obtained from the study was then subjected to analysis at the end of the intervention.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The purpose of this chapter is to present the results, findings and the discussions of the findings in order to determine the effect of Multimodal Instructional Approaches on students' performance in some selected topics on mole concept at Winneba Senior High School. The results, finding and discussion were presented in reference to the research questions. The research questions were formulated in order to determine whether the student would perform well in those selected topics or not when they were taught using Multimodal Instructional Approaches (MIA). It was also to determine students' perceptions on the use of Multimodal Instructional Approaches in integrated science. Additionally, it presents the demographic description of the participants of the study.

4.1 Demographic Description of Respondents

Demographic description may be referred to as how people are classified into groups using common characteristics such as race, gender, income level and age. According to Lee and Schuele (2010) demographic information provides data regarding research participants and it is necessary for the determination of whether the individuals in a particular study are a representative sample of the target population for generalization purposes. The number of sample in the study was forty (40) first year Home Economics one students of Winneba Senior High School. The profile of the respondents in this study in terms of gender is in Table 2.

Table 2: Gender of Respondent

Gender	No. of Students	Percentage
Male	1	2.5
Female	39	97.5
Total	**40**	**100**

The first years Home Economics 1 class is a female dominated class. Out of the total of 40 students, 39 (97.5%) were girls while only 1 (2.5 %) was a boy. The enrolment of boys has always been low ever since the introduction of Home Economics as a course into the second cycle educational system of Ghana (Awumbila, 2001). In the Ghanaian culture, certain roles are specifically done by females. For example, kitchen related jobs like cooking and food management among family members at home are organised by the women in the families (Nukunya, 1998). Nukunya explained that since cooking of food and home management form part of Home Economics programme, most Ghanaians have misconstrued the programme to be for only females. Males involved in this course are usually belittled in Ghanaian society, and this been the major reasons why most males shy away from the Home Economics programme and it has become female dominated one (Awumbila, 2001).

4.2 Analysis of Data

In this section, data obtained from students' pre-intervention test scores and post intervention test scores, normalized gain, questionnaire on students' perception about

Multimodal Instructional Approaches and the interview schedule were analysed in reference to the research questions.

Research question 1: What is the performance level of students in those selected topics in integrated science before the use of Multimodal Instructional Approaches?

This question sought to determine the performance level of the students before the intervention. The mean scores for all the lessons were determined, as indicated in Table 3.

Table 3: Pre-intervention Test Scores

Topic test	N	Mean Score Values (Std. Error)	SD	Variance
RMM	40	2.60 (0.202)	1.28	1.63
AC	40	2.75 (0.272)	1.72	2.96
CONC.	40	2.93 (0.285)	1.80	3.25
PSS.	40	3.25(0.217)	1.37	1.89
D &DF	40	3.40(0.359)	2.27	5.17
Overall Average	**40**	**2.99 (0.267)**	**1.69**	**2.98**

RMM- Relative molecular mass, **AC**- Avogadro's Constant **CONC**. Concentration, **PSS**- Preparation of Standard solution, **D &DF**- Dilution and Dilution factor.

Table 3 shows students' mean scores, the standard error which is in parenthesis and standard deviation (SD). Table 3 also shows the variance in the pre-intervention test score for each lesson.

From the Table 3, all the mean score values of the pre-intervention test fell below the average score of 5. Considering the overall mean score value of 2.99 for the pre-intervention test, it could be seen that the overall performance of the students was poor.

The findings observed from the scores did reveal a number of factors which do cause students' difficulties in learning the selected topics. It appears that most of the students could only memorize definitions of terms rather than the ability to interpret and comprehend the concepts. This was because most of the questions tested students' abilities to interpret, comprehend and construct concepts which most of the students could not do. This might have been one of the reasons why they performed poorly. It was also observed that during the marking of the pre-intervention test for those selected topics, students tend to give explanations to concepts using alternative conceptions which were not in line with the accepted scientific facts (see Appendix Q). Again, it might be seen that the single mode of instruction alone did not cater for most of their learning style in class. This is likely to be the one of the reasons why they recorded low overall mean score mark.

Research Question 2: What is the performance level of students in some selected topics in integrated science after the use of Multimodal Instructional Approaches?

This question sought to find out if Multimodal Instructional Approaches are likely to have any impact on students' performance in those selected topics. Students were given test after the intervention, which is termed as post-intervention test. This test was given to students to enable the researcher to determine students' performance after students had gone through the selected topics using multimodal instruction. The mean scores obtained by the students in this test are reported in Table 4. The table also shows the standard deviations (SD), standard errors (SE) and the variance in the post-intervention test score for each lesson.

Table 4: Post-intervention Test Scores.

Topic test	N	Mean score values	SD	SE	Variance
RMM	40	7.75	2.67	0.42	7.12
AC	40	8.35	1.96	0.31	3.82
CONC	40	8.50	1.83	0.29	3.33
PSS	40	8.60	1.37	0.22	1.89
D&DF	40	8.78	1.31	0.21	1.72
Overall Average	**40**	**8.40**	**1.83**	**0.29**	**3.57**

Considering the results in Table 4, it is evident that the overall mean score value of the post intervention test was above the average mark of 5. Additionally, the overall mean score value of the post-intervention test (8.40) was higher than the overall mean score of the pre-intervention test (2.99). This suggests an improvement in performance of the students after the intervention.

The students' mean scores for the pre- intervention test and post intervention test for each lesson were analysed based on Hake normalized gain theory. According to Hake, the normalized gain is the ratio of the difference in mean scores between post intervention test and pre- intervention test to the difference in maximum score of the test to that of the pre-intervention test (Hake, 1998). It was mathematically presented as

Post intervention test mean score − pre− intervention test mean scoremaximum score of the test − pre−intervention test mean score

As already stated in chapter three, Hake classified the normalized gain into one of the three groups:

High gain; < g > greater than 0.7

Medium gain; < g > between 0.3 and 0.7

Low gain; < g > less than 0.3 (Hake, 1998).

The results presented in Tables 3 and 4 were used to calculate the normalized gain for each lesson. Table 5 shows the normalized gains (Hake gain) for the all the lessons

Table 5. Hake Gain (g) Values for the Lessons

Topic test	N	Mean Pre-intervention	Mean post- intervention	Hake Gain	SD
RMM	40	2.60	7.75	0.70	0.36
AC	40	2.75	8.35	0.77	0.36
CONC	40	2.93	8.50	0.79	0.36
PSS	40	3.35	8.60	0.79	0.36
D&DF	40	3.40	8.78	0.82	0.36
Overall Average	**40**	**2.99**	**8.40**	**0.77**	**0.36**

The normalized gain (g) for the first lesson after the intervention recorded a medium gain of 0.7, which indicates that the lesson was effective. The second and the third lessons also recorded higher mean scores in the post intervention tests and had in Hake gains of 0.75 and 0.77 respectively. Again, the last two lessons also saw a rise in their normalized gains value of 0.80 and 0.81. This shows that the last two lessons thus the fourth and fifth lessons recorded very high gains (Hake, 1998).

The findings based on the normalized gains had revealed that the Multimodal Instructional Approaches deepened understanding of scientific knowledge of students and made thinking flexible to students (Fleming, 1997) Again, the approach accurately translated a concept from one mode to another which enabled students to grasp the concept being taught easily (Lesh, Post & Behr, 1987).

Additionally, to determine whether the difference in students' mean scores for the pre-intervention tests and post-intervention tests were statistically significant, an independent-sample t-test was used to analyse the five lessons. Table 6 shows the significant differences between the pre- intervention and post-intervention test scores of the five lessons.

Table 6: Differences in Mean Scores between the Pre- and Post-intervention Tests for the Lessons

Lessons	Pre-intervention mean	Post intervention mean	Mean difference	significant difference
RMM	2.60	7.75	5.15	0.00
AC	2.75	8.35	5.25	0.00
CONC	2.93	8.50	5.60	0.00
PSS	3.35	8.60	5.68	0.00
D&DF	3.40	8.78	5.38	0.00

Significant level at $p < 0.05$

Independent-sample t-test analysis (Appendix O) showed that the differences in the mean scores of the students' mean for the pre-intervention test and that of mean post-intervention test were statistically significant for all the five lessons with p- values of less than 0.05. These p-values indicate that the student had a better knowledge in those selected topics after they had been exposed to the use of multimodal instruction approach than before.

Research Question 3: What are students' perceptions of the use of Multimodal Instructional Approaches in lesson presentation?

This research question was meant to seek the views of students about Multimodal Instructional Approaches (MIA) in lesson presentation. The questions were answered using a five-point Likert scale ranging from 'Strongly Agree to Strongly Disagree. The responses of the students were analysed using a descriptive statistics such as frequency and percentage. All the responses from individual students about their views concerning the use of Multimodal Instructional Approaches (MIA) to teach those selected topics were analysed. Table 7 shows the results of the number of students and extent to which they agreed on each item in the questionnaire. The Likert scale used were SA=Strongly Agree (1), A=Agree (2), NS=Not Sure (3), DA=Disagree (4), SD=Strongly Disagree (5). The mean value and the standard deviation (STD) on this scale for each questionnaire item were determined. The percentage of student on each agreement level is presented with each number of students in parenthesis.

Table 7. Perception of Students about the Use of Multimodal Instructional Approaches (MIA) in Teaching Some Selected Topics

		Count in percentages (%)						
S/N	**ITEM**	**SA** **1**	**A** **2**	**NS** **3**	**DA** **4**	**SD** **5**	**Mean**	**STD**
1.	MIA has helped me to improve my performance in the selected topics.	(39) 97.5	(1) 2.5	-	-	-	1.03	0.16
2.	MIA motivated me to learn topics such as preparations of standard solution easily.	(40) 100	-	-	-	-	1.00	0.00
3.	My interest was aroused and sustained when taught the same concept in different modes of instruction.	(36) 90.0	(4) 10.0	-	-	-	1.10	0.30
4.	MIA helped me to conceptualize mole concept.	(13) 32.5	(25) 62.5	(2) 5.0	-	-	1.73	0.55

5. I learnt better when taught in a single mode approach especially in verbal mode.	-	-	(3) 7.5	(7) 17.5	(30) 75.0	4.68	0.61
6. I learnt better when my science teacher teaches with graphic and visual modes such as computer simulations, video, charts and smart board presentations.	(39) 97.5	(1) 2.5	-	-	-	1.08	0.47
7. I worked well with other students in during group work in class.	(24) 60	(16) 40	-	-	-	1.40	0.50
8. I prefer to be instructed using VARK multimodal instruction approach during integrated science lessons.	(24) 60	(15) 37.5	(1) 2.5	-	-	1.43	0.55
9. I developed positive social attitude and communication skills as a result of Multimodal Instructional Approaches.	(23) 57.5	(15) 37.5	(2) 5.0	-	-	1.48	0.60
10. I developed my process skills such as manipulation, observation, reporting and drawing during multimodal instructions.	(27) 67.5	(12) 30.0	(1) 2.5	-	-	1.38	0.63
11. I cooperated with other students during group discussion.	(20) 50.0	(14) 35.0	(6) 15.0	-	-	1.65	0.73
12. I was actively engaged during multimodal instructional lessons.	(24) 60.0	(13) 32.5	(3) 7.5	-	-	1.48	0.64
13. MIA made some scientific concepts real and easier to understand.	(28) 70.0	(10) 25.0	(1) 2.5	(1) 2.5	-	1.38	0.67
14. MIA catered for my learning styles in class.	(33) 82.5	(7) 17.5	-	-	-	1.18	0.38
15. I look forward to (eagerly anticipate) the next lesson because of multimodal instruction.	(27) 67.5	(13) 32.5	-	-	-	1.32	0.47

Values in parentheses represent the number of students. N=40

As seen in the Table 7, forty (40) students gave their responses about the effect of Multimodal Instructional Approaches in lesson presentation to the questionnaire. In item 1, students were to respond to whether or not Multimodal Instructional Approaches (MIA) of teaching improves their knowledge in the selected topics on mole concepts. According to the students' response, 97.5 % of them strongly agreed and 2.5 % only agreed that the Multimodal Instructional Approaches did improve their knowledge in the topics. Thus all the students were in agreement with the statement. In terms of whether MIA motivated students to learn or not, it was observed that all the students strongly agreed that it did motivate them.

The next item was to find out whether the students interest were aroused and sustained during the lesson when a concept was taught in different modes of instruction 90.0% and 10% of the students strongly agreed and agreed respectively that their interest were aroused and sustained with that instructional approach. None of the students was in disagreement with that item. This might imply that all the students liked the use of Multimodal Instructional Approaches in teaching those topics on mole concept

For item 4, the students who strongly agreed and only agreed were 13 and 25 (32.5% and 62.5%) respectively, suggesting that 95.0% of the students could now conceptualize mole concept without difficulties when Multimodal Instructional Approaches was used. Therefore, only 5% of the students could not conceptualise the mole concept when Multimodal Instructional Approaches was used in the teaching process. However, when item 5 sought to find out whether using only verbal mode of instruction to teach helped them to learn, the response trend changed from strongly agree to strongly disagree. This is because none of the students strongly agreed that the use of only verbal mode of instruction helped them to learn. However, 7.5% of the students were not sure, while 17.5% and 75% students disagreed and strongly disagreed respectively. This implies that 92.5% of the students totally had disinterest in the use of only verbal instructional mode approach to the teaching of the concept. It is suggested that verbal mode of instruction could be one of the causes of students' difficulties in understanding mole concept with regard to those selected topics.

Students were asked to indicate whether or not they learnt better when teachers used visual modes such as video, computer animations and smart board presentation in teaching as indicated in item 6 of Table 7. The majority of the students indicated that they learnt better with 97.5% and 2.5% of them strongly agreeing and only agreeing respectively, that they learnt better visual modes were used. All the respondents agreed with the statement that they worked well with other students in small group during Multimodal Instructional Approaches (MIA) as demanded in item 7. Item 8 elicited students' preference levels in the use of VARK Multimodal Instructional Approaches. VARK is an abbreviation which stands for Visual, Aural, Read or write and Kinesthetic. The results showed that 24 (60%) students strongly preferred VARK and another 15 (37.5%) of them just preferred the use of VARK. However, only one student did not prefer the use of the VARK Multimodal Instructional Approaches during lesson.

Again, 57.5% and 37.5% of the students strongly agreed and agreed respectively that Multimodal Instructional Approaches (MIA) developed in them positive social attitude and communication skills as they had responded to item 9. Most of the students agreed that MIA developed in them process skills such as interpretation, observation and manipulation skills as requested in item 10. This is because 97.5% of the students were in agreement. Table7 clearly shows that most of the students would like to co-operate with other students during group discussion.

Item 12 sought to find out engagement level of students in multimodal instructional lessons. With respect to the response to this item, 60% of the students strongly agreed that they engaged during lessons that involve multimodal instruction and 32.5% of the students only agreed. The students who indicated that MIA made some scientific concepts easier were 30 (95%). A high proportion (82.5%) of the students strongly agreed that the use of Multimodal Instructional Approaches during teaching and learning catered for their various learning styles in the classroom. This is because all the students agreed to the statement that they felt their learning styles were catered for during multimodal instructional lessons. It is evident from Table 7, that 100% of the respondents agreed to the statement that they were eagerly anticipating the next lesson to be delivered in Multimodal Instructional Approaches.

4.3 The Result of the Interview

The interview responses were used to triangulate and to seek further clarification of the responses provided by the students to the various items in the questionnaire. In all seven students were interviewed. The questions in the interview schedule were formulated based on the items of the questionnaire. The respondents' responses were recorded verbatim and later transcribed. The following were some of the views expressed by students during the interview.

Researcher: Do you think engaging with different modes of instruction resulted in improved performance?

Respondent A:

> *My performance was improved because concerning the video, if you watch the video you remember all what happened and be able to write something but the read or write only, you may forget what was said.*

Respondent B:

> *Because of watching the video and laboratory work ... I understood what was taught more than you standing in front of the class teaching me without showing us anything.*

Respondent C:

> *Sir, this is because when lesson becomes theoretical... students become confused. When you are taught in class and you have a view of it and practice it, it made me solve any question that I was asked*

Researcher: Which of the Multimodal Instructional Approaches do you learn best with? Give reason(s)

Respondent D:

Sir, the video, this is because.....me like this, when I watched video and movies I can easily capture something.

Respondent E:

Sir, the video, to me, I like watching video, and when I watch the video I put something in my mind so may be one day when I am sitting down there and they give us test, I will say this is it or that that I watched from the video, so I will able to remember something and write about it.

Respondent F:

It is video, this is because for the video, when I see it, I remember.

Researcher: In your own view, how do Multimodal Instructional Approaches promotes active learning?

Respondent G:

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 not able to explain the concept well…So, if am taught in multimodal ways, it will provide bases for me to understand in preferred way without weakness.

Respondent A:

Sir, because when video, audio, read or write and laboratory work is also added to it makes understanding clearer.

Respondent *C*:

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.

Respondent A:

Sir, I wish every teacher teaches me with this approach. This is because I understand better.

4.4 Detailed Findings of the Study

The study set out to find the effect of Multimodal Instructional Approaches on the performance of SHS One Home Economics students in some selected topics on the mole concept. In the earlier part of this chapter, results were mainly presented and analysed based on the specific research questions with brief comments on them. In this part, however, the key findings of the study are presented in line with the research questions set to guide the study.

Research Question One: What is the performance level of students in some selected topics in integrated science before the use of Multimodal Instructional Approaches?

This question sought to determine the performance level of the students before the intervention. The mean scores obtained were between 2.60 and 3.40. With respect to the results, it was observed that before the implementation of the intervention test, students could only memorize definition of terms but were unable to interpret, comprehend and translate the concepts studied into solving problems (see appendix Q). Majority of the students misconstrued the mole as mass instead of being a specific number of particles of a substance.

Research Question Two: What is the performance level of students in some selected topics in integrated science after the use of Multimodal Instructional Approaches?

This question was about the influence of Multimodal Instructional Approaches on the students' performance in those selected topics. It was revealed that generally, there was a vast improvement in the performance of students in selected concepts after the intervention was implemented. The mean scores ranged from 7.75 to 8.78. Thus the exposure to the Multimodal Instructional Approaches might have contributed tremendously to boost the understanding of students. Statistically, there existed a significant difference in the mean scores of students in the pre-intervention tests and the post-intervention tests, which corroborated the fact that the Multimodal Instructional Approaches had a positive influence on students' performance. Again, the average normalized gain was 0.77 which signifies a higher gain for effectiveness in lessons.

Research Question Three

What are students' perceptions of the use of Multimodal Instructional Approaches in lesson presentation?

Finally, the Research Question 3 demanded the perception of students about the use of multimodal instruction in teaching those selected topics. The results from their responses showed that most of the students had positive views about the use of the Multimodal Instructional Approaches in classroom instruction. Generally the students indicated that the

MIA helped them to improve their understanding and subsequently their performance in tests based on the selected topics. Majority of the students also revealed unequivocally that the MIA motivated them to easily understand topics such as preparation of standard solutions and dilution of solutions.

There was a clear indication that the students' interest were aroused and sustained when taught the same concept in different modes of instruction. It was also revealed that the approach helped students to conceptualize the mole concept. Interestingly, none of the students preferred the use of the single mode of instruction such as verbal mode.

Moreover, it was found that students learnt better when the science teacher teaches with graphics and visual modes. The responses further revealed that most students worked well with other students during group work. Majority of students indicated that they preferred to be instructed using the VARK Multimodal Instructional Approaches. Additionally, almost all students developed a positive social attitude and communication skills as a result of the use of the Multimodal Instructional Approaches. It was observed during the intervention stage that the students preferred to cooperate with other students during group discussions.

It was also found that students were actively engaged in lessons when the multimodal approach was implemented. Students asserted that the MIA made the understanding of scientific concepts easier. It came out from the responses that MIA catered for their learning style in the lesson. Majority of the students anticipated the next lesson would be presented using Multimodal Instructional Approaches.

Furthermore, the report from interviewing the students showed that they valued multimodal approach because it enables them to translate concepts form one mode to another such as visual mode to kinesthetic mode. A report of a student about translating concept from one mode to another is indicated below:

> *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 not able to explain the concept well…So, if am taught in multimodal ways, it will provide bases for me to understand in preferred way without weakness.*

Additionally, students suggested that teachers should present the concepts in multiple modes of representation to cater for every learning style of learners. This was highlighted by a student in saying that:

> *Sir, I wish every teacher teaches me with this approach. This is because I understand better.*

In conclusion, this study revealed that the use of Multimodal Instructional Approaches resulted in improve performance in the concepts.

4.5 Discussion of Findings

The findings of the study were discussed in line with the three research questions that were formulated.

Research Question One: What is the performance level of students in some selected topics in integrated science before the use of Multimodal Instructional Approaches?

Table 3 revealed that before the implementation of the intervention students could only memorize definition of terms but were unable to interpret, comprehend and translate the □=2.985) showed that the general performance was below average. Anamuah-Mensah (2004) indicated that textbook dependent and learning by rote memorization in most schools resulted in unsatisfactory performance and poor attitude towards integrated science. This could have been one of the possible reasons why students performed poorly in the pre-intervention test. They might have memorized without deep understanding of the concepts. Before the use of Multimodal Instructional Approaches, it appears students were mostly taught in traditional mode of instruction. This is because a study by Ainsworth (2006) revealed that developing understanding of inert knowledge through Multimodal Instructional Approaches (MIA) goes beyond the traditional mode of instruction. Fadel (2008) also stated that students engaged in learning that incorporates multimodal designs, on average, outperform students who learn using traditional approaches with single modes.

Research Question Two: What is the performance level of students in some selected topics in integrated science after the use of Multimodal Instructional Approaches?

This question was meant to determine the performance level of students in some selected topics in integrated science after they have been taught using Multimodal Instructional Approaches. The results in Table 4 and 5 show a better performance with an overall Hake's gain of 0.77 which was very effective. From Table 5, it was recognized that the difference in students' pre-intervention tests and the post-intervention tests scores was statistically significant. This implies that using the Multimodal Instructional Approaches to teach improved the performance of the students after the intervention. The key explanation to their improved performance could also be due to their active participation in the lessons and the highly interactive nature of the lessons as a result of the use of Multimodal Instructional Approaches in teaching.

Again, lessons of this nature where students' sources of stimulus were varied breaks monotony in the lesson and makes class lively. According to Jewitt, Kress, Ogborn and Tsatsarelis (2001), this approach catered for a range of different modal preferences and provides students with a choice on how they can access key content, and thus may be considered a more inclusive response or stimulates metacognition to the needs of learners. These results reaffirm the findings of a study of Russell and McGuigan (2001) that students need to generate different representations of a concept and recode the representations in various modes. Multimodal Instructional Approaches might have helped them to refine and make more explicit their understanding of a particular concept. This is because Russell and McGuigan explained that active engagement of students in lessons which is effective enhances students' performance and improve attitudes than the conventional classroom instruction. These results are also in congruent with Picciano (2009) who also identified the benefits of multimodal designs as allowing students to experience learning in ways that they are mostly comfortable with and also challenges them to experience and learn in other ways as well. According to Russell and McGuigan (2001) and Picciano (2009) Multimodal Instructional Approaches allows students to concentrate on the physical meaning of abstract concepts, hence, obtaining an in-depth understanding of the theory. All these attributes of Multimodal Instructional Approaches may have contributed to better understanding of concept leading to a high performance. These findings have significant implications on the approach to teaching since they suggest that incorporating varied instruction into Integrated Science courses may be a valuable tool for improving the performance of students.

Research Question Three: What are students' perceptions of the use of Multimodal Instructional Approaches in lesson presentation?

Perceptions of the students were sought about the use of multimodal instruction approach in teaching. Their responses showed that the students' perceived multimodal instructional as having a positive effect on the teaching process. In that they all preferred to be taught in Multimodal Instructional Approaches, since no student preferred the use of a single mode of instruction such as verbal mode. Additionally, the responses to the questionnaire item that sought to determine the preference level of the students on the use of VARK multimodal instructions in the teaching of the selected topics showed that 97.5% of the students preferred to be instructed in multimodal instructions while only 2.5% of the students were unable to make up their mind. This may imply that students preferred to be taught integrated science concepts especially in those selected topics, using the Multimodal Instructional Approaches.

Some of the views expressed by the students during the interview sessions were that the Multimodal Instructional Approaches catered for students' learning styles, it made concept more comprehensible and increased their interest in learning the selected topics. It appears some students held the perception that integrated science is difficult to learn may be removed through the use of Multimodal Instructional Approaches, as well as the misconceptions about the concepts. Among the findings of a study by Nuthall (1999), found that children in the process of learning required three or more different experiences such as concrete, video, illustration or abstract experiences to be able to establish long-term knowledge of a concept. Nuthall explained that when children are taken through these experiences in the same text it puts them in a better position mentally to generate varying representation of a concept.

Furthermore, the report from interviewing the students showed that they valued multimodal approach because it enables them to translate concepts form one mode to another such as visual mode to kinesthetic mode. The students indicated that the Multimodal Instructional Approaches enabled them to construct their own understanding of concepts.

In a similar vein, a study conducted by Yeşildağ and Günel (2013) with 80 Sophomore College students in Turkey within two identical sections of introductory modern physics course in the 2007/2008 spring semester, revealed that at the end of the instructional stage, through survey and semi- structured interviews, students were asked to evaluate the value of the multimodal instructional implementations in the learning of concepts. A report of a student about the implementation of multimodal instruction indicated that:

After completing the assignment there were things changed in my reading. I feel like I am trying to associate things (text, formula, picture, diagrams etc.) given within the written material. Also, I realized that reading is a joyful *activity since you tends to make connection among the things.*

These responses of students were in consonance with the findings of another study by Sankey, Birch, and Gardiner (2010) and Zywno (2003), who agreed that multimodal instruction, well organized in the classroom settings, can increase learners' knowledge and make them focus on learning tasks. Fadel (2008) has also shown that significant increases in learning can be accomplished through the well-versed use of integrated visual and verbal multimodal learning. Again, students may feel more comfortable and perform better when they are provided with learning environments that cater for their predominant learning style (Omrod, 2008; Cronin, 2009).

In conclusion, the findings of this study complement current research on maximizing the effectiveness of designed representational environments by focusing on the need to take into account the diversity of learner background knowledge, expectations, preferences, and interpretive skills (Dolin, 2001; Russell & McGuigan, 2001). The procedures that students use in constructing their own multimodal representations, and the developmental pattern to these procedures (diSessa, 2004), provide insight into design features that could be explored in effective teaching representations.

4.6 Summary

Data from the various research instruments used for the study was subjected to an analysis for evidence of changes in students' performances and perception. The results obtained from the analyses indicated that there had been significant improvements in the students' performance after they had been exposed to the intervention. Also revealed was the positive perception of students toward teaching using Multimodal Instructional Approaches. Generally, the students preferred to be instructed using MIA instead of the traditional instructional approach (TIA) for teaching the concept.

The next chapter of the study is the final chapter which discusses the summary, conclusions drawn and recommendations made from all the four preceding chapters.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter presents the summary of the findings, implication of the findings for teaching science and conclusions. The chapter also includes recommendations and suggestions based on the findings of the study.

5.1 Summary of the Study

The main purpose of this study was to investigate the effect of Multimodal Instructional Approaches (MIA) on first year Home Economics 1(one) students' performance in some selected topics in integrated science. An action research method was the design for this study. The researcher designed the multimodal approach to teach the selected topics. The students were assessed before and after each lesson and the scores recorded as pre-intervention test and post-intervention test scores respectively. An average Hake's normalized gain showed a gain of 0.77, which was an indication of the effectiveness of the lessons.

The effect of MIA on students' performance was also confirmed by the Independent-Sample t-test analysis, which showed that the differences in mean scores of students' overall mean score for the pre-intervention test and that of the post-intervention test were statistically significant for all the five lessons with p- values less than 0.05. Again, the perception of students about the use of multimodal instruction in teaching those selected topics showed that almost all the students had positive views about the use of the

Multimodal Instructional Approaches in classroom instruction. Moreover, it catered for individual learning styles and also motivated them to learn the concept.

The researcher also observed that integrating different modes of instruction, such as visual, aural, read or write and kinaesthetic (VARK) does not follow specific order or sequence. The mode of instructions could be in any order based on the concept confronted with. However, the results indicated that students did not prefer to be instructed by verbal mode of instruction.

5.2 Summary of the Main Findings of the Study

This section of the study focuses on the summary of the major findings. Firstly, it deals with the summary of differences in performance of students before and after their exposure to Multimodal Instructional Approaches. Secondly, the summary of students' perceptions of Multimodal Instructional Approaches on teaching and learning was discussed. The results of the study are summarized and presented in line with the research questions.

1. *Is there any difference in performance of students before and after the use of Multimodal Instructional Approaches?*

The overall performance of the students in the post-intervention tests was significantly better than that of the pre-intervention tests. The average Hake normalized gain was about 0.77 (Table 5) showing a higher gain and effectiveness of lessons resulting in promoting higher knowledge acquisition in the concepts.

2. *What are the perceptions of students about the use of Multimodal Instructional Approaches on lesson presentation?*

The perceptions of students about the use of MIA were ascertained when students were asked to provide their responses to the various items in the questionnaire and the results are presented in Table 6. The responses revealed that students generally had better perceptions of the use of the Multimodal Instructional Approaches (MIA) in the teaching of the concepts. Students indicated that the use of MIA in teaching made them have better understanding and improved their knowledge in mole concepts.

5.3 Conclusion

The introduction of the Multimodal Instructional Approaches produced a significant improvement in students' learning and understanding of concepts in the selected topics on mole concept as compared to the traditionally instructional approach. Students' abilities to interpret and comprehend the concept were enhanced when they were taught using Multimodal Instructional Approaches. It can be concluded that Multimodal Instructional Approaches improved the knowledge of students in the concept. It helped students to properly interpret and comprehend concepts. Multimodal Instructional Approaches (MIA) also motivated and catered for individual differences among the students during integrated science lessons.

5.4 Implications for Classroom Teaching

Primarily, teachers' instructional approach has direct effects on the learners' understanding and it correlates with students' achievement (Tatto, 2001). The findings of the study indicated that Multimodal Instructional Approaches (MIA) had a direct impact on teaching and students' performance. This approach when adopted is likely to improve the students' knowledge in concepts in science courses. Each of the four modes of instructional approach could be used to cater for students learning styles and aroused and sustained their interest in the classroom. The method of instruction used in the study also motivated and challenged the students to think critically about concepts in the teaching process. The study therefore suggests that students should be taught using MIA in the teaching of concepts.

Furthermore, in the cases of limited resources for science lessons, teachers can use some innovative teaching methods such as Multimodal Instructional Approaches to empower the students to learn science concepts better and also develop positive attitudes towards the subject. The textbooks or literature should highlight the use of Multimodal Instructional Approaches in their writing to provide opportunities for different learning styles. This would make interacting with educational materials more convenient to learners.

In conclusion, integrated science concepts should be taught using MIA to improve students' abilities to interpret and comprehend concepts. This is because it creates conducive and friendly environment for all students with different learning style in the classroom.

5.5 Recommendations

Based on the findings of the study, it is recommended that:

1. The findings would be made available to the management of Winneba Secondary Senior High School for implementation.
2. Teachers of Winneba Senior High School should make it a point to use Multimodal Instructional Approaches (MIA) in the teaching and learning process since could help students have better understanding of topics.
3. Integrated Science teachers in the school should model their instructions to break the monotony in the classroom.
4. Innovative and more effective student-centred strategies such as multimodal instructions should be used in Winneba Senior High School to promote meaningful learning of scientific concepts.
5. Workshops and in-service training sessions should be organised for integrated science teachers in the school on the perceptions of using Multimodal Instructional Approaches in teaching.

5.6 Suggestion for the Further Studies

The research focused on the use of MIA to teach students at Winneba Senior High School WSHS) in the Central Region of Ghana to determine the effect of the method on their performance and their perceptions towards the approach. Based on this study, the following suggestions are made:

1. Further study should be conducted into integrating Multimodal Instructional Approaches to determine its impact on other scientific concepts.

2. The study can be carried out for different levels of education and in different subject areas in science to investigate the effectiveness of Multimodal Instructional Approaches.
3. The sample size of the study can be extended should it be replicated in different schools to provide a generalization of its effect for pedagogy development.
4. Research should be carried out to determine the perceptions and knowledge of science teachers on the use of multimodal teaching techniques.

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APPENDICES

APPENDIX A

Instructional Specific Objectives

By the end of the lesson the student will be able to:

1. Relate molar mass, mass of a substance and amount of substance.
2. Explain the term mole as a unit
3. Define the Avogadro's constant.
4. Perform five calculations using the mole concept
5. Distinguished between amount of substance concentration and mass concentration.
6. Relate amount of substance(n) volume of a solution(V) and concentration of a substance (c)
7. Define assay of a solution.
8. Explain dilution of a solution.
9. Define dilution factor.
10. Explain why 0.1 mole of O_2 would not contain the same number of atoms as 0.1 mole of Na atom.
11. Define standard solution.
12. Mention five apparatus used in the preparation of standard solution.
13. State the function of the five apparatus mention in the preparation of standard solution.
14. Outline how to prepare a standard solution.
15. Prepare 0.5M of 500ml of sodium chloride salt.

APPENDIX B

Pre-Intervention Test Items on Relative Atomic Mass

TIME: 25 MINUTES

Answer all questions. The questions below have four options. On the question paper circle one answer that you think is correct for each question.

Use the diagram below to answer question (1- 4)

Element Name	Atomic Number	Number of Protons	Number of Electrons	Mass Number	Number of Neutrons
A	2	B	C	4	D

1. The element A is likely to be

A. Carbon

B. Hydrogen

C. Helium

D. Lithium

2. B represents

A. 1

B. 2

C. 3

D. 4

3. C is

A. 4

B. 3

C. 2

D. 1

4. The number of neutron, which is represent by D is

A. 2

B. 1

C. 4

D. 3

5. The relative atomic mass, or atomic weight, of an element is the weighted average of the

A. Isotopic masses

B. Atomic numbers

C. Mass numbers

D. Neutron numbers

6. Chlorine consists of 75% chlorine-35 and 25% chlorine-37. Calculate the A_r of chlorine

A. 35.5

B. 37.5

C. 36.5

D. 38.5

Atoms of a certain isotope have 73 neutrons and a mass number of 123.

Use the information above to answer question 7-10

7. What is the atomic number?

A. 123

B. 73

C. 50

D. 196

8. How many electrons are there?

A. 50

B. 196

C. 73

D. 123

9. What is the number of protons?

A. 123

B. 196

C. 50

D. 73

10. The nuclide will be represented as

73123

12350

50123

12373

SECTION B

1. What does it mean when we say that the relative atomic mass of sodium is 23? **(1 mark)**
2. Calculate the relative atomic mass of Na_2CO_3. (Na = 23, C= 12, O= 16) **(1 mark)**
3. What is a nuclide? **(1 mark)**

4. Silicon (Si) consists of 75% of ^{28}Si, 10% of ^{29}Si and 15% of ^{30}Si. Determine the relative atomic mass of silicon. **(2 marks)**

APPENDIX C

Pre-Intervention Test Items on Amount of Substance and Avogadro's constant

TIME: 25 MINUTES

Answer all questions. The questions below have four options. On the question paper circle one answer that you think is correct for each question.

1. Avogadro's number represents the number of atoms in

   A. 12g of $C1_2$

   B. 320g of sulphur

   C. 32g of oxygen

   D. 12.7g of iodine

   (Cl=35.5, S= 32, O=16, I= 127)

2. The number of moles of carbon dioxide which contain 8 g of oxygen is [CO_2 = $44gmol^{-1}$]

   A. 0.5 mol

   B. 0.20 mol

   C. 0.40 mol

   D. 0.25 mol

3. The total moles present in 111 g of $CaCl_2$ is

   A. One mole

   B. Two mole

   C. Three mole

   D. Four moles

4. Which of the following weighs the most?

A. one g-atom of nitrogen

B. One mole of water

C. One mole of sodium

D. One molecule of H_2 $S0_4$

5. 5.0 litres of 0.4 M H_2SO_4 Contains

A. 2.0 mole Of H_2S0_4

B. 0.4 mole H_2SO_4

C. 5.0 mole H_2SO_4

D. 0.08 moles H_2SO_4

6. The number of atoms in 4.25g of NH_3 is approximately

A. 1 x10^{23} atoms

B. 2 x10^{23} atoms

C. 4 x10^{23} atoms

D. 6 x10^{23} atoms

7. Which has maximum number of atoms?

A. 24g of c (12)

B. 56g of Fe (56)

C. 27g of Al (27)

D. 108g of Ag (108)

8. Number of atoms of oxygen present in 10.6g Na_2CO_3 will be

A. 6.02×10^{22} atoms

B. 12.04×10^{22} atoms

C. 1.806×10^{23}atoms

D. 31.80×10^{23} atoms

9. What is the mass of 1 mole of HCl? [H=1, Cl= 35.5]

A. 36.5g

B. 35.1 g

C. 37.7g

D. 34.5g

10. The number of atom of oxygen in 6.02×10^{24} CO molecules is [C = 12, O= 16]

A. 1

B. 0.5

C. 5

D. 10

SECTION B

1. Define the mole.
2. Silver (Ag) is used in jewellery and tableware but no longer in U.S. coins. How many grams of Ag are in 0.0342 mol of Ag? (Ag = 107.9g/mol)
3. Iron (Fe), the main component of steel, is the most important metal in industrial society. How many Fe atoms are in 95.8 g of Fe? (Fe = 55.85 g/mol)
4. How many atoms are there in 0.3 mole of sodium? (L = 6.02×10^{23} mol^{-1}).
5. Calculate the amount of oxygen gas in moles of 1.505×10^{23} molecules of the gas (L = $6.02 \times 10^{23} mol^{-1}$)

APPENDIX D

Pre-Intervention Test Items on Measurement of Concentration

TIME: 25 MINUTES

Answer all questions. The questions below have four options. On the question paper circle one answer that you think is correct for each question.

1. What is the molarity (molar concentration) of a solution made by dissolving 2.355 g of sulphuric acid (H_2SO_4) in water and diluting to a final volume of 50.0 mL? [H_2SO_4] = 98gmol^{-1}

A. 0.48 mol/L

B. 0.58mol/L

C. 0.68mol/L

D. 0.78mol/L

2. Hydrochloric acid is sold commercially as a 12.0 mol/L solution. How many moles of HCl are in 300.0 mL solution?

A. 4.6 mol

B. 3.6 mol

C. 5.6 mol

D. 7.6 mol

3. The concentration of cholesterol in normal blood, ($C_{27}H_{46}O$) is approximately 0.005 mol/L. How many grams of cholesterol are in 750 mL of blood? ($C_{27}H_{46}O$)=368gmol^{-1}

A. 2.24g

B. 1.38g

C. 3.45g

D. 1.45 g

4. How many grams of NaOH would be required to prepare 800 grams of a 40% by mass NaOH solution? [NaOH= 40 $gmol^{-1}$]

A. 320 g

B. 420g

C. 520g

D. 620g

5. What volume of 2.00 M $Pb(NO_3)_2$ contains 600g? (Pb =207.2, N = 14, O= 16)

   A. 0.9 L

   B. 2.45 L

   C. 3.45 L

   D. 4.45 L

6. Determine the molarity of a solution made by dissolving 20.0 g of NaOH in sufficient water to yield a 482 mL solution. [NaOH = 40$gmol^{-1}$].

   A. 1.04mol/L

   B. 2.04 mol/L

   C. 3.04mol/L

   D. 4.04mol/L

7. How many moles of sodium hydroxide are in 25cm^3 of 0.40M of its solution? (Na = 23, O = 16, H = 1)

   A. 0.01 mol

   B. 0.02 mol

   C. 0.10 mol

D. 0.50 mol

8. What is the molarity (molar concentration) of a solution made by dissolving 2.355 g of sulphuric acid (H_2SO_4) in water and diluting to a final volume of 50.0 mL? [H_2SO_4 = 98]

A. 0.78 mol/L

B. 0.58mol/L

C. 0.68mol/L

D. 0.48mol/L

9. A saline solution (contact cleanser) contains 0.90 g of sodium chloride, dissolved to make a 100.0 mL solution. What is the molar concentration (mol/L) of this solution? [NaCl = 58.5 $gmol^{-1}$]

A. 0.25 mol/L

B. 0.35 mol/L

C. 0.15 mol/L

D. 0.45mol/L

10. What is the molarity of a solution of HNO_3 that contains 12.6 g of solute in 5.00 L of solution? [HNO_3= 63 $gmol^{-1}$]

A. 3.93×10^{-2} M

B. $5.00 \text{ x } 10^{-2}$ M

C. 3.93×10^{2} M

D. $4.00 \text{ x } 10^{-2}$ M

SECTION B

1. Define molarity.
2. Glycine (H_2NCH_2COOH) is the simplest amino acid. What is the molarity of an aqueous solution that contains 0.715 mol of glycine in 495 mL? (N= 14, H = 1, C= 12, O = 16)
3. How many moles of sodium hydroxide are in 25cm^3 of 0.40M of its solution? (Na = 23, O = 16, H = 1)
4. The concentration of cholesterol in normal blood is ($C_{27}H_{46}O$) approximately 0.005 mol/L. How many grams of cholesterol are in 750 mL of blood?
5. What volume of 2.00 M Pb $(NO_3)_2$ contains 600 mg of lead? (Pb =207.2, N = 14, O= 16).

APPENDIX E

Pre-Intervention Test Item on Preparation of Standard Solution

TIME: 25 MINUTES

Answer all questions. The questions below have four options. On the question paper circle one answer that you think is correct for each question.

1. How much calcium chloride is required to make one litre of a 0.1M solution? [$CaCl_2$= 111 $gmol^{-1}$]
   A. 1.10g
   B. 110g
   C. 11.0g
   D. 0.110g
2. How many moles of H are contained in 0.400mol H_2S? [H_2S =34 $gmol^{-1}$]
   A. 0.400mol
   B. 0.800mol
   C. 1.600 mol
   D. 0.200mol
3. Calculate the amount of substance in 9g of aluminium. (Al = 27 g/mol
   A. 0.33mol
   B. 3mol
   C. 0.03mol
   D. 0.16mol
4. How many grams of S are contained in 0.400 mol H_2S? [H_2S =34 $gmol^{-1}$]
   A. 11.8g

B. 12.8g

C. 13.8g

D. 14.8g

5. Assuming you want to prepare 1.00 dm^3 of 3.00 M $NiCl_2$ solution, what mass of $NiCl_2$ should you weigh. [Ni = 58.69, Cl = 35.5]

A. 126.59g

B. 12.659g

C. 388.77

D. 38.877g

6. How many molecules of H_2S are contained in 0.400 mol H_2S?

A. 1.41 X 10^{23} molecules

B. 2.41 X 10^{23} molecules

C. 3.14 X 10^{23} molecules

D. 4.14 X 10^{23} molecules

7. Assuming I want prepare 2.50 x 10^2 cm^3 of 0.00200M Cd $(IO_3)_2$ solution, what should be the reading of the mass of Cd $(IO_3)_2$ on the weighing scale [Cd= 112.4, , I = 126.0, O = 16.00]

A. 46.22g

B. 23.11g

C. 0.4622g

D. 0.2311g

8. How many grams of H_2S are contained in 0.400mol H_2S?

A. 13.63g

B. 136.3g

C. 14.00g

D. 63.13g

9. The relative molecular mass of H_2SO_4 is (H = 1, S = 32, = 32)

   A. 96

   B. 98

   C. 104

   D. 66

10. Suppose that 25 mL of the 1.83 M NaCl solution is diluted to 100 mL .What is the final molar concentration of NaCl?

A. 0.25M

B. 0.46M

C. 0.35M

D. 0.56M

SECTION B

1. What is a standard solution?

2. Name two apparatus for preparing a standard solution

3. Why do we use distilled water during when preparing a standard solution.

4. How many grams of H_2S are contained in 0.400mol H_2S? (H =1 , S = 32)

5. Describe how you will prepare 1 dm^3 of 1M of NaOH crystal.

(Na = 23, O = 16, H = 1).

APPENDIX F

Pre-Intervention Test Items on Dilution and Dilution Factors

TIME: 25 MINUTES

Answer all questions. The questions below have four options. On the question paper circle one answer that you think is correct for each question.

1. How would you prepare 500 ml of 3 mol/L HCl using 6 mol/L HCl from the stock room? In other words how much water would you mix to accomplish this dilution?

   A. 450 mL

   B. 350mL

   C. 250 mL

   D. 550ml

2. What is the final concentration if 75.0 mL of a 3.50 mol/L glucose solution is diluted to a volume of 400.0 mL?

   A. 0.33mol/L

   B. B.0.77 mol/L

   C. 0.66 mol/L

   D. 0.88mol/L

   Household chemical cleaners often contain ammonia. Industrial strength ammonia is 14.0 mol/L. If 3.0 L of an ammonia solution are needed to clean the house at a concentration of 0.10 mol/L,

Use this information *to answer question* ***3*** *and* ***4***

3. What would be the volume needed of the original solution that would be diluted?

   A. 0.0114L

B. 0.0214L

C. 0.0314L

D. 0.0414L

4. What volume of water needs to be added to dilute the ammonia?

A. 4.97L of water

B. 1.99L of water

C. 2.99 L of water

D. 5.99L of water

Use the information below to answer *the question* (*5- 7*)

5. You dilute a solution whenever you add solvent to a solution. Adding solvent results in a solution of lower concentration. You can calculate the concentration of a solution diluted by applying this equation. Note: M is molarity, V is volume, and the subscripts i and f refer to the initial and final values.

A. $M_iV_i = M_fV_f$

B. Mi-Vi = Mf-Vf

□□□□= □□□□

D. $M_iVf= M_iV_f$

6. How many millilitres of 5.5 M NaOH are needed to prepare 300 mL of 1.2 M NaOH?

A. 65 mL

B. 35mL

C. 75mL

D. 60mL

7. How many millilitres were added?

   A. 365mL

   B. 235mL

   C. 700mL

   D. 900mL

8. 0.750 L aqueous solution contains 90.0 g of ethanol, C_2H_5OH. Calculate the molar concentration of the solution in $mol{\cdot}L^{-1}$. [C_2H_5OH =46 $gmol^{-1}$]

   A. 3.70M

   B. 2.60M

   C. 4.70M

   D. 5.70M

9. What mass of NaCl are dissolved in 152 mL of a solution if the concentration of the solution is 0.364 M? [NaCl = 58.5$gmol^{-1}$]

   A. 5.05g

   B. 0.45g

   C. 1.45g

   D. 3.24 g

10. A solution of sodium carbonate, Na_2CO_3, contains 53.0 g of solute in 215 mL of solution. What is its molarity? [Na_2CO_3 = 106$gmol^{-1}$]

    A. 4.33M

    B. 1.33M

    C. 3.33M

    D. 2.33 M

SECTION B

1. What is dilution?
2. Explain what dilution factor is.
3. An antiseptic of volume 20ml was diluted with distilled water five times, what was the final volume?
4. From the above information, calculate the amount of distilled water used?
5. How many millilitres of 5.5 M NaOH are needed to prepare 300 mL of 1.2 M NaOH?

APPENDIX G

LESSON ONE

Lesson Plan on Relative Atomic Mass

Date: 7th May, 2015 **Class:** One Home Economics One.

Duration: 80 minutes. **Topic:** Matter

Sub-Topic: Relative atomic mass (A_r) **Teacher:** Joshua Kwabena Owiredu

****

Learning Objectives: By the end of the lesson the students will be able to:

1. Relate atomic number, mass number and number of neutrons
2. Define isotopes and relative atomic mass (A_r)
3. Relate isotopes and relative atomic mass.
4. Calculate the relative atomic mass of five isotopes.

Relevant previous knowledge:

Students have studied the building block of matter.

Introduction (5 minutes)

Teacher – Ask students to explain the building blocks of matter?

Students – The building block of matter is atoms, molecules and ions

Teacher – Guide the students to relate atomic number, mass number and number of neutrons.

Main Lesson (50minutes)

Activities

1. Guide the students to relate atomic number, mass number and number of neutrons
2. Put the students in groups to come out with the relationship atomic number and mass number.
3. Using a video animation, show students how atomic number, mass number and number of neutrons are related.
4. With the help of the smart board assist students to make a connection between isotopes and relative atomic mass (A_r)
5. Before ending the lesson on relative atomic mass, summarizes the lesson and asks students to do the evaluation exercise.

Core Point

Every atom has a positively charged nucleus and one or more electrons that form a charge cloud surrounding the nucleus. The nucleus contains over 99.9% of the total mass of the atom. Every nucleus may be described as being made up of two different kinds of particles, protons and neutrons, collectively called nucleons.

Protons and neutrons have nearly the same mass, but only the proton is charged, so that the total charge of a nucleus is equal to the number of protons times the charge of one proton. The magnitude of the proton charge is equal to that of the electron so that a neutral atom has an equal number of protons and electrons.

The atoms of all isotopes of an element have the same number of protons, the atomic number, Z. The nuclei of different isotopes differ, however, in the number of neutrons and therefore in the total number of nucleons per nucleus. The total number of nucleons is A, the mass number. Atoms of different isotopic forms of an element,

An element is defined by the nuclear charge; the atomic number, Z is equal to the number of protons in the nucleus of an atom.

Mass number, A is the sum of the number of protons and number of neutrons in the nucleus of the atom.

Isotopes of an element have the same Z, but different A's.

Because the mass of an atom is very small, it is convenient to define a special unit that avoids large negative exponents. This unit, called the atomic mass unit and designated by the symbol u (some authors use the abbreviation amu), is defined as exactly 1/12 the mass of a ^{12}C atom.

atomic mass (amu)1/12 mass of 12C (amu) Thus the mass of a ^{12}C atom is exactly 12 u.

Evaluation (25 minutes)

The students answer the test as shown below as the post intervention test in the same manner in which the pre- intervention test was administered. The test is marked and immediately results are provided to the students to see how they performed.

1. Chlorine consists of 75% chlorine-35 and 25% chlorine-37. Calculate the A_r of chlorine

A. 35.5

B. 37.5

C. 36.5

D. 38.5

Atoms of a certain isotope have 94 neutrons and a mass number of 123.

Use the information above to answer question 2-5

2. What is the atomic number?

A. 123

B. 94

C. 29

D. 196

3. How many electrons are there?

A. 29

B. 196

C. 94

D. 123

4. What is the number of protons?

A. 123

B. 196

C. 29

D. 94

5. The nuclide will be represented as

94123

12350

29123

12394

6. Magnesium consists of 78.6% ^{24}Mg, 10.1% ^{25}Mg and 11.3% of ^{26}Mg. Calculate the relative atomic mass, A_r, of magnesium to 3sf/1dp.

   A. 32.6

   B. 40.0

   C. 16.4

   D. 24.3

7. The formula for relative atomic mass is

   A. Average mass of isotopes of the element

   B. Sum of the mass of the elements

   C. The product of the mass of the element

   D. The difference of the mass of the element

8. Rhenium (Re) consists of 37.1% ^{185}Re and 62.9% ^{187}Re. Calculate the relative atomic mass, A_r, of rhenium to 4sf/1dp

   A. 186.3

   B. 200.3

   C. 145.3

   D. 120.3

Copper consists of two isotopes, copper-63 and copper-65. Its relative atomic mass is 63.62.

*Use the information above to answer question **9** and **10***

9. Find the fractional abundance of copper -63 is

   A. 69

   B. 79

   C. 70

   D. 60

10. The fractional abundance of copper -65

   A. 41

   B. 31

   C. 40

   D. 30

SECTION B

1. Rhenium (Re) consists of 37.1% ^{185}Re and 62.9% ^{187}Re. Calculate the relative atomic mass, A_r, of rhenium to 4sf/1dp

2. The relative atomic mass of potassium is 39. Explain this statement.

3. Calculate the relative atomic mass of $Al_2 (CO_3)_3$. (Al = 27, C = 12, O = 16)

4. Silicon (Si) is essential to the computer industry as a major component of semiconductor chips. It has three naturally occurring isotopes: ^{28}Si, 29Si, and 30Si. Determine the numbers of protons, neutrons, and electrons in each silicon isotope.

   1225?

APPENDIX H

LESSON TWO

Lesson Plan on Mole as a unit and Avogadro's Constant

Date 14th May, 2015. **Teacher**: Joshua K. Owiredu

Duration: 80 minutes. **Class:** One Home Economics One

Topic: Matter **Sub-Topic:** Mole as a unit

****

Learning Objectives

By the end of the lesson the student will be able to

1. Explain the term mole as a unit.
2. Define the Avogadro's constant.
3. Relate molar mass, mass of a substance, amount of substance and Avogadro's constant.

Relevant previous knowledge:

Students have studied relative atomic mass (A_r) and relative molecular mass (M_r)

Introduction (5 minutes)

Teacher: Ask students to explain relative atomic mass

atomic mass (amu)1/12 mass of 12C (amu). It has no unit.

Main lesson (50min)

Activities

1. Guide the students explain the term mole as a unit and state its unit?

2. Use symbol manipulation and verbal interaction to illustrate the concept.
3. Assist them to relate molar mass, mass of a substance, amount of substance and Avogadro's constant.
4. Use verbal interaction, symbolic manipulation and computer animation and video to explain the concept.
5. Use process skills such as manipulation skills to let them calculate the number of moles of a substance in the laboratory.

Conclusion

Before ending the lesson on the mole as a unit, summarized the lesson learnt and asks students questions which they did not ask and help them solve questions which they cannot answer.

Core Point

Mole (n)

Mole is the amount of substance that contains so many elementary particles as there are carbon atoms in 12g (0.012kg) of ^{12}C. It has the unit mol.

AVOGADRO'S CONTANTS (L or N_A)

1mol of every substance contains $6.02x10^{23}$ ions, molecules and particles.

It is the number of elementary particles in one mole of a substance. One mole of atoms, molecules and ions contains one Avogadro's number (N_A = 6.0221 × 1023 particles mol^{-1}) of that species.

Molar mass (M)

It is the mass of 1 mole of a substance. Unit= g/mol.

Formulae

n=m/M

Where m = mass of substance in grams and M = molar mass

N =nxL where N= the no. of particles

Evaluation (25 minutes)

1. The concept of the mole says that:

   A. in the atomic weight of an element there is one atom

   B. in a defined mass of an element there is a precise number of atoms

   C. in a defined mass of an element there is a precise number of compounds

   D. none of the choices

2. How many moles are there in 10g of CO_2? [$CO_2 = 44gmol^{-1}$]

   A. 0.23mol

   B. 0.47mol

   C. 0.57mol

   D. 0.37mol

3. The mole is also referred to as:

A. Avogadro's number

B. Bohr's number

C. Pesaro's number

D. Loschmidt's number

4. The mole is also referred to as...entities.

A. 8.02×10^{30}

B. 7×10^{23}

C. 6.02×10^{23}

D. 5.02×10^{23}

5. . Consider, $\frac{1}{2}Na$. it means….

A. $\frac{1}{2}$ an atom of Na

B. $\frac{1}{2}$ a molecule of sodium

C. $\frac{1}{2}$ a mole

D. $\frac{1}{2}$ of Na gas element

6. How many atoms of hydrogen are there in 0.4mol of hydrogen gas? ($L = 6.02 \times 10^{23} mol^{-1}$).

A. 2.408×10^{23} atoms

B. 1.204×10^{23} atoms

C. 3.010×10^{23} atoms

D. 4.816×10^{23} atoms

7. What number of particles does the mole represent?

A. 6.02×10^{23}

B. 3.142×10^{23}

C. 144×10^{23}

D. 12×10^{23}

8. What is the molecular weight of CO_2 giving that (C- 12, O – 16)?

A. 72.00 g

B. 28.00 g

C. 32.00 g

D. 44.00g

9. The number of oxygen atoms in 4.4 g of CO_2 is approximately (C- 12, O – 16, L = 6.03×10^{23})

A. 1.2×10^{23} atom

B. 6×10^{22} atom

C. 6×10^{23} atom

D. 12×10^{23} atom

10. How many moles are there in 12g of CO_2?

E. 0.27 mol

F. 0.47mol

G. 0.57mol

H. 0.37mol

SECTION B

1. Define the Avogadro's constant.
2. Relate molar mass, mass of a substance, amount of substance and Avogadro's constant.
3. How many atoms of hydrogen are there in 0.4mol of hydrogen gas? (H = 1, L = $6.02 \times 10^{23} mol^{-1}$).
4. Explain the term mole as a unit.
5. How many moles of H are contained in 0.400mol H_2S?

APPENDIX I

LESSON THREE

Lesson Plan on Measurements of Concentration

Date: 21st May, 2015 **Teacher:** Joshua K. Owiredu

Duration: 80 minutes. **Class:** One Home Economics One

Topic: mole as a unit. **Sub-Topic:** Calculations using mole concept

****

Learning Objectives: By the end of the lesson the students will be able to;

1. Solve five problems using the mole concept

Relevant previous knowledge:

Students have learnt about the mole as a unit

Introduction (5 minutes)

Teacher – Revise with students the previous lesson on the mole as a unit.

Main lesson (50min)

Guide them to perform calculations on number of moles of a substance using the mole concept.

Activities

1. Use verbal interaction to introduce the topic.
2. Put the students in groups to perform some calculation using the mole concept studied.

3. Use computer animation and video to explain to students the calculations of the concept.
4. Let students practice the concept in the laboratory by weighing the mass of a substance they have calculated for.

Conclusion

Before ending the lesson on the mole as a unit, summarized the lesson learnt and asks students questions which they did not ask and help them solve questions which they cannot answer.

Core Point

In a liquid solution, the dissolved substance is called the ***solute***; the liquid in which the solute is dissolved is the ***solvent***.

For example, in an aqueous solution of NaCl, sodium chloride is the solute, water the solvent. Concentrations can measured in terms of

1. Mass percentage composition
2. Amount of substance concentration (molarity)
3. Part per million
4. Mass by mass percentage (molality)

For example, given that the density of NaCl is 1.071 g/dm3, what is the molarity of the solution?

Solving this problem using the mole concept, we have to calculate the molar mass of sodium chloride (NaCl), = (M of Na g/mol) +1 x M of S g/mol)

= (23 +35.5)

= 58.5 g/mol

□□□□ □□□□□□□□□□□□ □□□□

***1.071*□*/*□□*358.5*□*/*□□□ = 0.018M

Calculating the molarity of a given solution

Problem

What is the concentration of a solution in $moldm^{-3}$ in which 40g of potassium iodide (KI) dissolved and made up to $200cm^3$? (K= 39, I= 127).

Solution

Molar mass of Potassium Iodide (KI)

= 39 +127= 166g/mol

40g166g ⟹ = 0.241 mol

Volume of solution in dm^3 =$200/1000dm^3$ = 0. 2 dm^3

0.241mol0.2 dm3 = $1.21mol/dm^3$

Evaluation (25 minutes)

1. What mass of sodium hydroxide (NaOH) is needed to make up 500 cm^3 (0.500 dm^3) of a 0.500 mol dm^{-3} (0.5M) solution? [A_r: Na = 23, O = 16, H = 1]

   A. 10g

   B. 11g

   C. 12g

   D. 14g

2. How many moles of H_2SO_4 are there in $250cm^3$ of a 0.800 mol dm^{-3} (0.8M) sulphuric acid solution?

A. 0.5 mol

B. 0.1 mol

C. 0.2 mol

D. 0.6 mol

3. From ***question 2,*** what is the mass of the acid used? (H=1, S=32, O= 16)

A. 19.6g

B. 39.6g

C. 10.9g

D. 25.6g

4. 5.95g of potassium bromide was dissolved in $400cm^3$ of water. Calculate its molarity. [A_r's: K = 39, Br = 80]

A. 0.545M

B. 0.125M

C. 0.005M

D. 0.770M

5. What is the concentration of sodium chloride (NaCl) in g/dm^3 and g/cm^3 in a 1.50 molar solution?

A. $100g/dm^3$

B. $87.8g/dm^3$

C. $97.8g/dm^3$

D. $67.8g/dm^3$

A solution of calcium sulphate ($CaSO_4$) contained 0.500g dissolved in 2.00 dm^3 of water.

Use the information above to answer *question* ***6*** *to* ***8***

6. Calculate the concentration in g/dm^3

A. 0.25g/dm^3

B. 0.35g/dm^3

C. 0.45g/dm^3

D. 0.55g/dm^3

7. Calculate the concentration in g/cm^3

A. 0.00025g/cm^3

B. 0.00035g/cm^3

C. 0.00045g/cm^3

D. 0.00055g/cm^3

8. Calculate the concentration in mol/dm^3.

A. 1.44 $x10^{-3}$M

B. 3.42 $x10^{-3}$M

C. 5.50 $x10^{-3}$M

D. 1.72 $x10^{-3}$M

9. What mass (g) of potassium hydroxide (KOH) is needed to make up 1000cm^3 of a solution of concentration 1mol/dm^3? (A_r's: K=39, O=16, H=1)

A. 56g

B. 0.56g

C. 0.0056g

D. 560g

10. What is the molarity of the solution formed by dissolving 80 g of sodium hydroxide (NaOH) in 500 cm^3 of water? (A_r's: Na=23, O=16, H=1)

A. 2M

B. 4M

C. 6M

D. 8M

SECTION B

1. Define mass concentration

2. 5.95g of potassium bromide was dissolved in 400cm^3 of water. Calculate its molarity. [A_r's: K = 39, Br = 80]

A solution of calcium sulphate ($CaSO_4$) contained 0.500g dissolved in 2.00 dm^3 of water. (Ca = 40, S =32, O = 16)

Use the information above to answer question 3 to 5

3. What is the molar mass of $CaSO_4$?

4. What is the concentration in mol/ dm^3

5. What is the concentration in g/ dm^{-3}

APPENDIX J

LESSON FOUR

Lesson Pan on Preparation of Standard Solution

Date: 28th May, 2015 **Teacher:** Joshua K. Owiredu

Subject: Integrated science. **Duration:** 80 minutes.

Topic: Concentrations. **Sub-Topic:** Preparation of a standard solution

****

Learning Objectives: By the end of the lesson students will be able to;

1. State any four measures of concentration.
2. Distinguished between amount of substance concentration and mass concentration.
3. Relate amount of substance(n) volume of a solution(V) and concentration of a substance (c)
4. Calculate for five concentrations involving molarities and purity.

Relevant previous knowledge:

Students have learnt about the mole as a unit and can calculate the number of moles of a substance.

Introduction (5 minutes)

Teacher: Revise with the students some of the sampled problem solved using the mole concept.

Main lesson (50min)

Measures of concentration

Activities

1. Guide students to explain measure of concentrations

2. Use symbol manipulation and verbal interaction to illustrate the concept.
3. Use verbal interaction (group work), symbolic manipulation and computer animation and video
4. Let students demonstrate how to prepare a standard solution in the laboratory using the work sheet provided.

Before ending the lesson on the mole as a unit, the researcher summarized the lesson learnt and asks students questions which they did not ask and help them solve questions which they cannot answer.

Core Point

In a liquid solution, the dissolved substance is called the solute. The liquid in which the solute is dissolved is the solvent. For example, NaCl, sodium chloride is the solute, water the solvent. Concentration is the amount of solute dissolved in a given amount of solution.

A standard solution is one whose concentration is accurately known. A primary standard such as anhydrous sodium carbonate is available in a pure state, is stable and is water-soluble. Anhydrous sodium carbonate (Na_2CO_3) has a molar mass of 106 g mol^{-1}. A 0.1 M solution is made up, using a 250 cm^3 volumetric flask. For 250 cm^3 of 0.1 M sodium carbonate solution, the mass required is: 106 x 0.1 x 250 / 1000 = 2.65 g

Procedure

With the aid of a balance measure accurately 2.65 g of pure anhydrous sodium carbonate in a beaker. Slowly transfer the sodium carbonate with stirring, to about 50 cm^3 of deionised water in a clean 250 cm^3 beaker. To ensure that all the sodium carbonate is transferred, use a wash bottle to rinse the clock glass with deionised water, and add the rinsing to the beaker. Continue stirring the mixture with a stirring rod until the sodium carbonate has fully dissolved. Using a wash bottle, wash off the solution on the stirring rod with deionised water into the beaker. Pour the solution through a clean funnel into the 250 cm^3 volumetric flask. Using a wash bottle, rinse out the beaker several times with deionised water, and add the rinsing to the solution in the flask. Rinse the funnel with deionised water, allowing the water to run into the flask. Fill the flask to within about 1 cm^3 of the calibration mark, and then add the water drop wise, using a dropping pipette, until the bottom of the meniscus just rests on the calibration mark. Stopper the flask and invert it several times to ensure a homogeneous (evenly mixed) solution. Label the flask. Volume = 250/1000 = 0.25 dm^3

Evaluation (25 minutes)

1. The volumetric flasks are usually
   - A. Pear shaped
   - B. U-shaped
   - C. Dumb bell shaped
   - D. Oval shaped
2. How much calcium chloride is required to make one litre of a .10M solution?
   - A. 1.10g
   - B. 110g
   - C. 11.0g
   - D. 0.110g
3. How many moles of H are contained in 0.400mol H_2S?
   - A. 0.400mol
   - B. 0.800mol

C. 1.600 mol

D. 0.200mol

4. How many moles of S are contained in 0.400mol H_2S?

E. 0.400mol

F. 0.800mol

G. 1.600 mol

5. 0.200mol

6. Calculate the amount of substance in 9g of aluminium. (Al = 27 g/mol

A. 0.33mol

B. 3mol

C. 0.03mol

D. 0.16mol

7. How many grams of S are contained in 0.400 mol H_2S?

A. 11.83g

B. 12.83g

C. 13.83g

D. 14.83g

8. Assuming you want to prepare 1.00 dm^3 of 3.00 M $NiCl_2$ solution, what mass of $NiCl_2$ should you weigh. [Ni = 58.69, Cl = 35.45]

A. 126.59g

B. 12.659g

C. 388.77

D. 38.877g

9. How many molecules of H_2S are contained in 0.400 mol H_2S?

   A. 1.41 X 10^{23} molecules

   B. 2.41 X 10^{23} molecules

   C. 3.14 X 10^{23} molecules

   D. 4.14 X 10^{23} molecules

10. Assuming I want prepare 2.50 x 10^{2} cm^{3} of 0.00200M Cd $(IO_3)_2$ solution, what should be the reading of the mass of Cd $(IO_3)_2$ on the weighing scale [Cd= 112.4, I = 126.0, O = 16.00]

    A. 46.22g

    B. 23.11g

    C. 0.4622g

    D. 0.2311g

SECTION B

1. State any four measures of concentration.
2. Distinguished between amount of substance concentration and mass concentration.
3. Relate amount of substance(n) volume of a solution(V) and concentration of a substance (c)
4. Describe how you will prepare 2M of $CuSO_4$ solution in 500 ml volumetric flask.
5. State one precaution needed to be observed during the preparing of the standard solution.

APPENDIX K

LESSON FIVE

Lesson Plan on Dilution and Dilution Factor

Date: 4th June, 2015

Class: One Home Economics One.

Duration: 80 minutes.

Teacher: Joshua K. Owiredu

Topic: concentration.

Sub-Topic: preparation of standard solution

Learning Objectives: By the end of the lesson students will be able to;

1. Define standard solution
2. Name five apparatus that are used to prepared standard solution
3. Define assay of a solution.
4. Explain dilution of a solution.
5. Define dilution factor.

Relevant previous knowledge:

Students have seen a diluted squash before during Christmas.

Introduction (5 minutes)

Teacher – ask students to explain how to demonstrate how squash is diluted during chrismas

Students – about 2.5 litres of the standard squash is poured into a clean bowl and then a clean chilled water is added to the 2.5 litres squash to reduced the sweetness and the colour

Main lesson (50min)

Dilution of solution and Dilution factors

Activities

1. Guide students to explain the term dilution

2. Use symbol manipulation and verbal interaction to illustrate the dilution.
3. Let students demonstrate how to dilute the standard solution they prepared in the laboratory using the work sheet provided.
4. Work in a team to address the questions on the work sheet. Work safely in the laboratory and maintain a proper laboratory notebook throughout the entire session. Complete the necessary calculations that are associated with the questions. Now as a team, prepare and deliver a classroom presentation on your work. Finally, as individual, submit a completed laboratory notebook that includes the results of your work.

Core Point

Solutions are often prepared by diluting a more concentrated solution. For example, if you needed a one molar solution you could start with a six molar solution and dilute it. Consequently, you also need to be familiar with the calculations that are associated with dilutions.

Dilution is therefore the amount of solvent that is added to a standard solution (stock solution).

During dilution, the number of moles in the concentrated solution and the diluted solution does not change. It remains the same. Therefore $n_1 = n_2$, where n_1 and n_2 is the number of moles in the concentrated solution and moles in the diluted solution respectively. Then $C_1V_1 = C_2V_2$

The solvent is not always distilled water. Dilution factor is also the number of times the

□2□1

Evaluation (25 minutes)

1. How much 2.0 M NaCl solution would you need to make 250 mL of 0.15 M NaCl solution?
   A. 19ml
   B. 20ml
   C. 21ml
   D. 22ml
2. What would be the concentration of a solution made by diluting 45.0 mL of 4.2 M KOH to 250 mL?
   A. 2.50M
   B. 3.30M
   C. 0.76M
   D. 0.99M
3. What would be the concentration of a solution made by adding 250 mL of water to 45.0 mL of 4.2 M KOH?
   A. 0.8M
   B. 0.16M
   C. 0.64M
   D. 0.04M
4. 50.0 mL of a 0.357 M KCl solution is diluted to 250.0 mL with water. What is the molar concentration of the final solution?

A. 0.50M

B. 0.40M

C. 0.06M

D. 0.07M

5. How much 0.20 M glucose solution can be made from 50.0 mL of 0.50 M glucose solution?

A. 160ml

B. 150m

C. 140ml

D. 130ml

6. A solution of potassium chloride is prepared by diluting 18.6 g of KCl with water to a final volume of 250.0 mL, what is the molarity of the KCl solution?

A. 0.998M

B. 0.209M

C. 0.108M

D. 1.909M

7. You dilute a solution whenever you add solvent to a solution. Adding solvent results in a solution of lower concentration. You can calculate the concentration of a solution diluted by applying this equation. Note: M is molarity, V is volume, and the subscripts i and f refer to the initial and final values.

A. $M_iV_i = M_fV_f$

B. Mi-Vi = Mf-Vf

□□□□= □□□□

D. $M_iV_if= M_iV_f$

8. A purchased standard solution of sodium hydroxide had a concentration of 1.0 mol/dm^3. How would you prepare 100 cm^3 of a 0.1 mol/dm^3 solution to do a titration of an acid?

   A. 100cm^3

   B. 10cm^3

   C. 1000cm^3

   D. 1cm^3

9. Given a stock solution of sodium chloride of 2.0 mol/dm^3, how would you prepare 250cm^3 of a 0.5 mol/dm^3 solution?

   A. 62.5cm^3

   B. 100cm^3

   C. 87.5cm^3

   D. 178.5cm^3

10. In the analytical laboratory of a pharmaceutical company a laboratory assistant was asked to make 250 cm^3 of a 2.0 x 10^{-2} mol dm^{-3} (0.02M) solution of paracetamol ($C_8H_9NO_2$). What should the mass be?

    A. 0.155g

    B. 0.355g

    C. 0.555g

    D. 0.755g

SECTION B

1. Name five apparatus that are used to prepared standard solution

2. Define assay of a solution.
3. Explain dilution of a solution.
4. Define dilution factor.
5. In the analytical laboratory of a pharmaceutical company a laboratory assistant was asked to make 250 cm^3 of a 2.0 x 10^{-2} mol dm^{-3} (0.02M) solution of 5M paracetamol ($C_8H_9NO_2$) what was the initial volume? (C= 12, H = 1, N = 14, O = 16).

APPENDIX L

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

Students' Perception about the Use of Multimodal Instructional Approaches Questionnaire

This questionnaire seeks information about the effect of Multimodal Instructional Approaches on learning some selected topics on mole concept. All information given is purely for academic and research purposes and therefore remains confidential. Kindly respond to all questions as accurate as possible.

INSTRUCTIONS: Please tick [√] the box for appropriate answers or write the appropriate response.

Section One: Demographic Data

1. Gender : Male[ ] Female[ ]

STATEMENTS	**RESPONSES**				
	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
1. MIA has helped me to improve my performance in the selected topics.					
2. MIA motivated me to learn topics such as preparations of standard solution.					
3. My interest was aroused and sustained when the teacher taught the same					

concept in different modes of instruction.					
4. MIA has helped me to conceptualize mole concept.					
5. I learned better when taught in a single mode approach.					
6. I learnt better when my science teacher teaches with graphic and visual modes such as computer simulations, video, diagrams, tables, charts and smart board presentations					
7. I prefer to be instructed by VARK multimodal instruction approach during lesson presentation in integrated science.					
8. I learnt from my colleagues through the group discussion.					
9. I look forward to (eagerly anticipate) the next lesson because of multimodal instruction.					
10. I developed my process skills such as manipulation, observation, reporting and drawing during multimodal					

instructions.					
11. I cooperated with other students during class presentation.					
12. I worked well with other students in the class.					
13. I developed positive social attitude and communication skills as a result of Multimodal Instructional Approaches.					
14. I was actively engaged during multimodal instructional lessons					
15. I was able to think critically when exposed to multimodal instructional					

Thank you.

APPENDIX M

Student Semi-structured Interview Schedule

1. Do you think engaging with different modes of instruction resulted in improved performance?
2. Which of the Multimodal Instructional Approaches, that is video, aural, read or write and kinesthetic instruction do you engage best with? Give reasons.
3. What is your judgment about the effectiveness of these instructional modes in terms of learning style and interest?
4. In your view, how do Multimodal Instructional Approaches promotes active learning?

Thank you for this conversation

APPENDIX N

Students' Pre- and Post intervention Test Raw Scores

Value Label	Lesson 1 Scores	Lesson 2 Scores	Lesson 3 Scores	Lesson 4 Scores	Lesson 5 Scores
1	1	4	3	3	3
1	2	3	2	3	9
1	3	3	3	2	2
1	7	2	2	3	5
1	3	3	8	2	3
1	1	3	3	8	2
1	3	4	2	2	3
1	1	4	3	2	2
1	2	8	1	1	1
1	3	2	2	1	4
1	1	4	3	2	2
1	3	3	8	3	3
1	2	3	3	4	4
1	1	2	2	2	2
1	3	3	1	3	4
1	2	4	2	4	1
1	3	5	3	2	3
1	2	4	4	1	2
1	4	3	7	3	1
1	2	1	1	3	9
1	3	5	2	4	2
1	1	2	1	9	3
1	3	4	3	3	2
1	4	3	4	2	1
1	2	5	1	3	4
1	2	4	3	1	5
1	3	2	2	3	1
1	4	4	1	2	5
1	1	3	3	3	1
1	3	5	4	4	9
1	4	3	1	3	2
1	4	2	4	3	3
1	2	1	3	2	4
1	3	5	2	1	9
1	2	2	1	8	5
1	4	4	3	2	4
1	1	3	2	3	3
1	5	2	2	4	5
1	2	2	1	2	2
1	2	1	4	1	1
2	5	6	7	9	5
2	7	7	9	7	7
2	9	8	8	8	8
2	7	7	9	6	7
2	3	3	10	8	8
2	6	5	6	10	6
2	3	3	4	8	9
2	8	9	7	9	9
2	10	8	10	7	10
2	8	10	8	10	8
2	1	10	2	8	9
2	6	6	6	6	6
2	2	7	10	10	7

2	1	10	3	8	10
2	9	9	9	9	9
2	4	10	10	7	10
2	10	10	7	8	10
2	8	10	10	10	10
2	9	9	9	9	9

Independent Samples Test

2	7	10	10	10	10
2	9	9	9	9	9
2	10	10	10	10	10
2	9	9	9	9	9
2	10	9	8	8	10
2	9	9	9	9	9
2	7	10	10	10	10
2	10	10	10	9	10
2	10	7	7	7	7
2	9	9	9	9	9
2	9	9	10	10	9
2	9	9	9	9	9
2	10	10	10	10	10
2	9	9	9	9	9
2	10	9	7	4	9
2	8	8	10	8	10
2	10	10	9	10	10
2	10	10	10	10	10
2	10	8	8	8	8

Coding for the Value: **1**-Pre-intervention test scores **2**- Post intervention test scores

APPENDIX O

	t-test for Equality of Means						
	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Lesson 1	-11.014	78	.000	-5.15000	.46760	-6.08093	-4.21907
	-11.014	55.985	.000	-5.15000	.46760	-6.08673	-4.21327
Lesson 2	-14.536	78	.000	-5.25000	.36118	-5.96905	-4.53095
	-14.536	72.418	.000	-5.25000	.36118	-5.96992	-4.53008
Lesson 3	-13.597	78	.000	-5.60000	.41184	-6.41992	-4.78008
	-13.597	76.762	.000	-5.60000	.41184	-6.42013	-4.77987
Lesson 4	-15.835	78	.000	-5.67500	.35839	-6.38851	-4.96149
	-15.835	72.868	.000	-5.67500	.35839	-6.38930	-4.96070
Lesson 5	-12.954	78	.000	-5.37500	.41493	-6.20105	-4.54895
	-12.954	62.337	.000	-5.37500	.41493	-6.20434	-4.54566

Independent Samples t-Test between the Pre- and Post-intervention Tests Scores

APPENDIX P

Reliability Co-efficient of the Research Instrument

Case Processing Summary

		N	%
Cases	Valid	40	100.0
	Excluded[a]	0	.0
	Total	40	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics of Students' Questionnaire

Cronbach's Alpha	N of Items
.079	15

Reliability Statistics of Students' Pre-intervention Test

Cronbach's Alpha	N of Items
.078	5

Reliability Statistics of Students' Post intervention Test

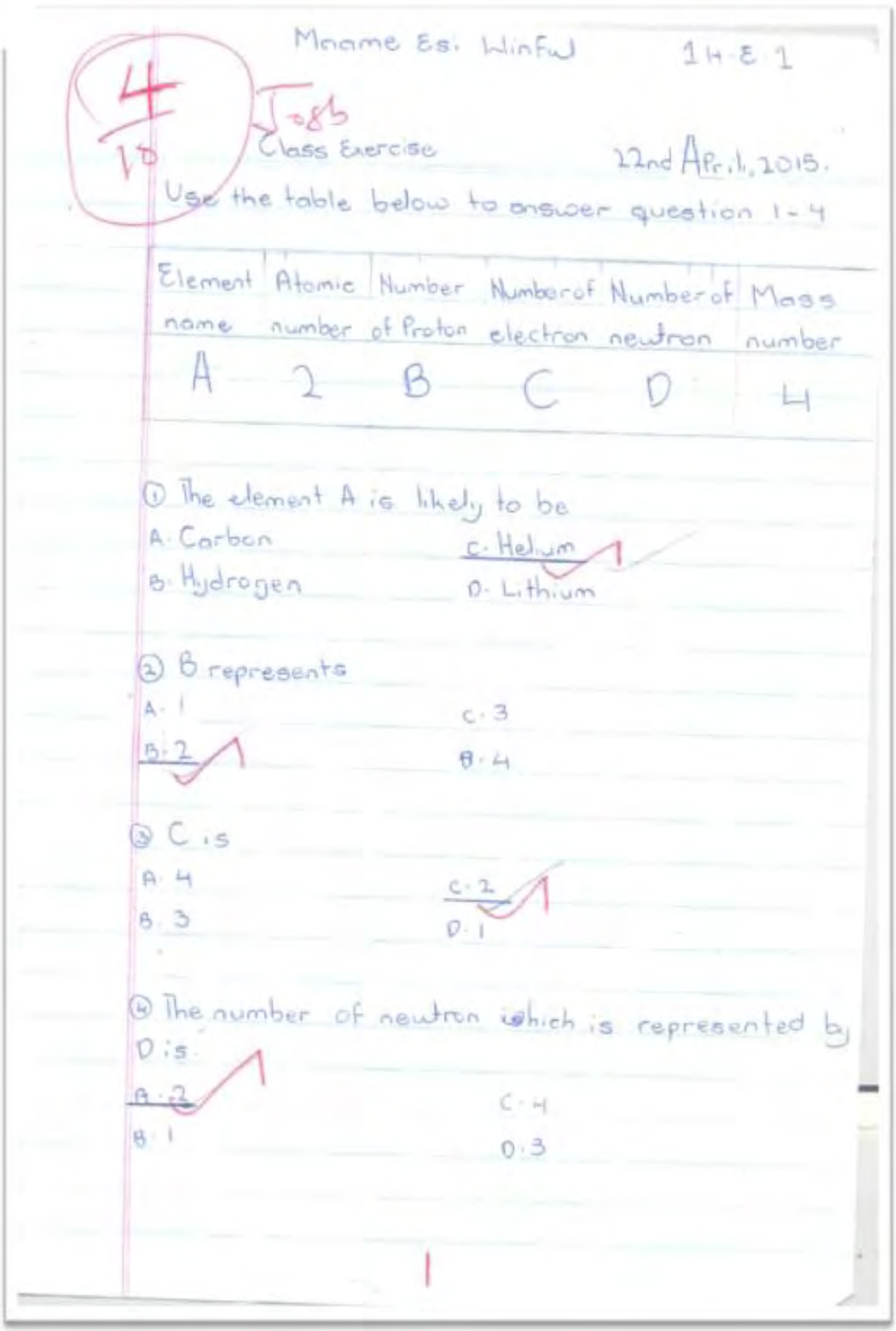
Cronbach's Alpha	N of Items
0.843	5

APP

ENDI

X Q

Sample of a Student's Pre-intervention Test Script



Maame Esi Winful 1H E 1

4/10

Class Exercise 22nd April, 2015.

Use the table below to answer question 1-4

Element name	Atomic number	Number of Proton	Number of electron	Number of neutron	Mass number
A	2	B	C	D	4

① The element A is likely to be

A. Carbon C. Helium

B. Hydrogen D. Lithium

② B represents

A. 1 C. 3

B. 2 D. 4

③ C is

A. 4 C. 2

B. 3 D. 1

④ The number of neutron which is represented by D is

A. 2 C. 4

B. 1 D. 3

A. 123
B. 196
C. 50
D. 73

(10) The nuclide will be represented by

A. $^{123}_{50}X$
B. $^{73}_{123}X$
C. $^{73}_{50}X$
D. $^{50}_{73}X$

SECTION B

(1) What does it means, when we say that the relative atomic mass of sodium is 23?

It means that sodium's atomic number / has an atomic number of 23.

Given alternative explanation to tha concept.

(2) Calculate the relative atomic mass of Na_2CO_3 ($Na = 23$, $C = 12$, $O = 16$)

=> 23(×2) + 12 + 16(3)

=> 106

3

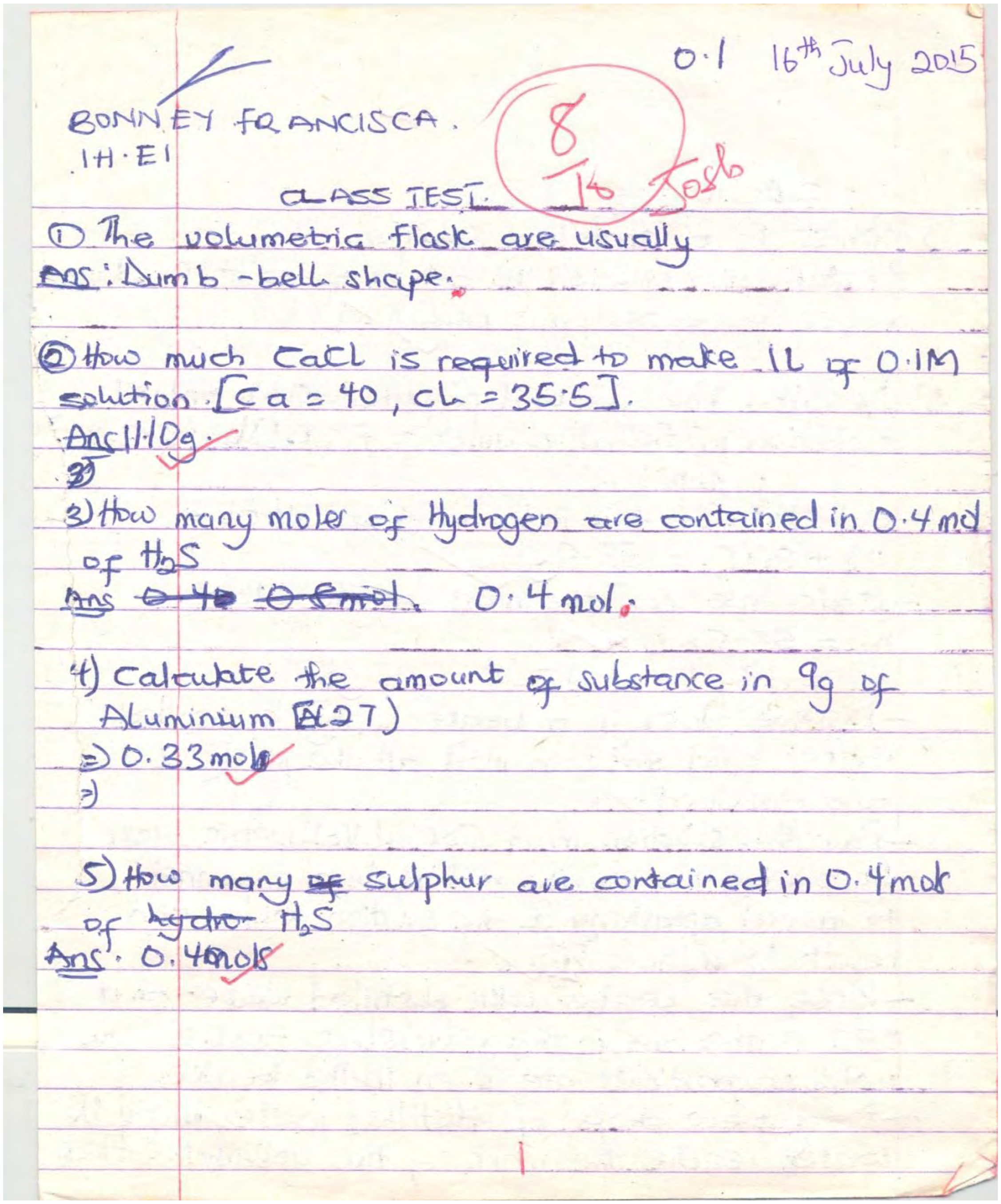
(3) What is a nuclide?

(4) Silicon consist of 75% silicon 28, 10% of silicon 29 and 15% of silicon 30. Calowlate the Ar of silicon

4

APPENDIX R

A Sample of a student Post-intervention Test Script


0.1 16th July 2015

BONNEY FRANCISCA.
1H·E1

8/16

CLASS TEST

① The volumetric flask are usually
Ans: Dumb-bell shape.

② How much CaCl is required to make 1L of 0.1M solution. [Ca = 40, Cl = 35.5].
Ans 11.10g.

3) How many moles of Hydrogen are contained in 0.4 mol of H_2S
Ans ~~0.40~~ ~~0.8mol.~~ 0.4 mol.

4) Calculate the amount of substance in 9g of Aluminium (Al 27)
⇒ 0.33mol

5) How many ~~of~~ sulphur are contained in 0.4mols of ~~hydro~~ H_2S
Ans. 0.4mols

2

SECTION B

1) What is a standard solution.
A standard solution is a type of solution whose exact concentration is known.

2) Describe how you will prepare 2M NaCl solution in 500ml volumetric flask. [Na=23, Cl=35.5]

solu

- Calculate for the molar mass of NaCl = 23 + 35.5 = 58.5 g/mol
- Calculate for the mass of the NaCl
  m = 58.5 × 2
  = 117g/dm³ × 0.5dm³ = 58.5g
- Dissolve NaCl in a beaker using a distilled water and ~~stir~~ stir until all the particles are dissolved.
- Pour the solution in a 500ml Volumetric flask by placing the stirring rod inside the funnel to avoid splashing of the solution which can result in a inaccuracy.
- Rinse the beaker with distilled water and add to the one in the volumetric flask. Do this until no particles are seen in the beaker
- Add few drops of distilled water until the water reaches the mark of the volumetric flask

1

- Cork the flask with a stopper/cork ~~to~~ and turn the flask up and down to enable equal distribution of Particles.

(3) State one precaution you will observe during the preparation of the standard solution.

⇒ The stirring rod must be placed inside the funnel whiles pouring the solution into the volumetric flask to avoid splashing.

8/10 Josh

3

APPENDIX S

INTRODUCTORY LETTER

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION
[redacted]

April 23, 2015.

Dear Sir,

TO WHOM IT MAY CONCERN
INTRODUCTORY LETTER

The bearer of this letter, Joshua K. Owiredu with Index Number 8130130012 is a Master of Philosophy in Science Education student in the Department of Science Education in the above University.

He is conducting a research on "Effect of Multimodal Instructional Approach on Students' Performance in Some Selected Topics in Integrated Science".

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

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

Thank you.

DR. K. D. TAALE
Head of Department