UNIVERSITY OF EDUCATION, WINNEBA

INTEGRATING EXEMPLARY MATERIALS AND FLIPPED CLASSROOM INSTRUCTION TO ENHANCE STUDENTS' PERFORMANCE AND MOTIVATION IN CHEMICAL BONDING AND NOMENCLATURE

EMMANUEL ISSAH AZUUGA

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EMMANUEL ISSAH AZUUGA

(9180130002)

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DECLARATION

CANDIDATE'S DECLARATION

I, Emmanuel Issah Azuuga, hereby declare that this thesis, with the exception of quotations and references contained in published works which have all been duly identified and acknowledged is entirely the results of my own original work, and that it has not been submitted in part or whole for another it has been presented for another degree in this university or elsewhere.

SIGNATURE...

DATE..

SUPERVISOR'S DECLARATION

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

NAME: PROF. JOHN K.EMINAH (PRINCIPAL SUPERVISOR)

SIGNATURE...

DATE..

NAME: PROF. VICTUS SAMLAFO (CO - SUPERVISOR)

SIGNATURE...

DATE..

DEDICATION

This work is dedicated to my beloved wife, Vida Azuuri Afuugu and my special twins namely Lawrence Awintuumah Azuuga and Lawrencia Awinipuud Azuuga.

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GLOSSARY/ABBREVIATIONS

CHEMBONOT	–	Chemical bonding and nomenclature Test
CHEMBONOPET	–	Chemical bonding and nomenclature Performance Test.
CoE	–	College(s) of Education
CRDD	–	Curriculum Research Development and Division
DBE	–	Diploma in Basic Education
GASTs	–	Ghana Association of Science Teachers
GES	–	Ghana Education Service
MOE	–	Ministry of Education
JHS	–	Junior High School
PCK	–	Pedagogical Content Knowledge
PRE	–	INTQUE- Pre-intervention questionnaire
POST	–	INTQUE- Post-intervention questionnaire
SHS	–	Senior High School
SSS	–	Senior Secondary School
TPACK	–	Technological Pedagogical Content Knowledge
WAM	–	Wooden Atomic Model

ABSTRACT

The study focused on integrating exemplary materials and flipped classroom instruction to enhance students' performance and motivation in chemistry. The study involved three stages, namely pre-intervention, intervention and post- intervention. The action research design was employed in this study at Gbewaa College of Education, Pusiga in the Upper East Region of Ghana. Purposive sampling technique was used to select a sample size of 40 students for the study. Test and questionnaire items were the research instruments used to collect data for the study. A test- retest method was used to calculate the reliability of the test items. Reliability indices of 0.833, 0.794, and 0.824 were obtained for the test items. Cronbach Alpha coefficient was used to determine the internal consistency of 30 questionnaire items. Qualitative data based on students' preconceptions were analysed and classified into levels of understanding and causes of conceptual errors among the respondents and through the use of descriptive statistics. Quantitative data on the other hand were analysed using student t-test at 0.05 level of significance to determine significant differences between pre-intervention test and post- intervention test scores.The questionnaire items were analysed using Regression analysis.The results showed that the use of Wooden Atomic Models and hence, the integrating exemplary materials and flipped classroom instruction enhanced the teacher trainees'understanding and levels of motivation in chemical formulae and the nomenclature of inorganic compounds, helped both males and females to improve their levels of understanding and majority of the students exhibited three levels of understanding spiraling from no understanding, understanding with specific misconception to partial understanding. These levels of understanding were characterised by four types of errors which overlapped each other. Among other recommendations, it was suggested that, Wooden Atomic Models and integration of exemplary materials and flipped classroom instruction be respectively used as teaching and learning materials and instructional strategy to enhance students' performance in chemical formulae and nomenclature of inorganic compounds.

CHAPTER ONE

INTRODUCTION

1. 0. Overview

This section describes the background to the study, statement of the problem, purpose of the study, significance of the study and research questions. It also includes null hypothesis, delimitations, limitations and operational definition of terms and organisation of the study.

1.1. Background to the Study

One of the many definitions of science states that, it is the generation of knowledge from the natural world through observation, identification, description, experimentation, investigation, and theoretical explanations (Logerwell & Sterling, 2017). Science is simply described as a body of knowledge obtained through observation. For science teaching to make the desired impact, science teachers must be adequately exposed to science education curriculum materials. The calibre of science teachers produced is the function of the quality of training given to them by the teacher training institutions in the country. According to Entsua-Mensah (2014), without strong and efficient teacher education institutions, the foundation of our entire educational system would be weak and would continue the downward slide into mediocrity.

Several studies have been designed to investigate the causes of decline in the numbers of qualified science teachers world-wide (UNESCO, 2015; 2016; Bloom, Lan, & Adil; 2016; Mouton, 2008). In many developed countries, science teachers' performance and participation in science related activities is yet to see significant improvement (Hay, Kinchin, & Lygo-Baker, 2008, Broggy & McClelland, 2010).

However, the case is worst in the African -sub region due to poor resources and inadequate funding in spite of the fact that some efforts have been made in research and development under vision 2030 plan in the African-sub region. These poor resources for instruction in most West African countries have remained unchanged without any proper attention (Ajaja, 2011 & Iruka, Chinedum, Denis, Abdoulaye & Omolaja, 2017).

Resources for instruction are often grouped under facilities, equipment and consumables
(Iruka, Chinedum, Denis, Abdoulaye & Omolaja, 2017). The process of teaching and learning the curricular content of science education largely depends on the availability and quality of these resources. Teachers need a wide range of stimulating and exciting resources to teach curricular content to ensure that students are actively involved in the learning. Instructional resources should reflect what is familiar to the student as well as introducing new learning approaches to engage learners in a variety of science activities. It is established that one of the important considerations in the development and promotion of comprehensive science programme in schools is the availability of facilities, equipment and consumables (Ajaja, 2011). Although facilities, equipment and consumables are different in meaning, all are physical things which are needed to make the teaching of science education programme meaningful.

Firstly, facilities are resources that cannot be carried from place to place for the teaching and learning. These items are more fixed and permanent (Hay, Kinchin, & Lygo-Baker, 2008, Broggy & McClelland, 2010). Facilities are large, immovable properties meant for specific purposes. Good examples of facilities are laboratories and plant gardens. A well equipped science education facility contributes to the potential of the curricular programme of the school. Yet, many of learners do not have the benefit of instruction within a well equipped facility. It is reported that, nearly 80 percent of elementary science education is taught in the classroom (Broggy & McClelland, 2010). Broggy and McClelland (2010) states that, facilities for science obviously affect what can be taught (choice of activities) and how it can be taught (teaching method). This assertion by Broggy and McClelland (2010) does not suggest that high quality science education cannot occur in schools without real science facility. The issue here is that providing appropriate facilities can help learner to achieve the full range of benefits within a subject matter. It is important to note that: A facility does not have to be of standard size in order to be used for teaching science. As much as possible, facilities should be designed for multiple purposes. Any space available can be used for practical science activities provided it is safe (Hay, Kinchin, & Lygo-Baker, 2008).

It is important to note that, school facilities can have negative impact on the implementation of the curriculum if they are not available or if they are in deplorable state. Conversely, if school facilities are in good state and in correct supply, all the planned experiences to be offered to the learners can be adequately implemented and learning would take place effectively.

Secondly, equipment are resources that can be carried from place to place for teaching and learning. These items or resources are movable, relatively permanent and can last for a few years even with repeated use (Ajaja, 2011). Teachers organize a variety of science activities to create practice opportunities for learners while also allowing them to develop the process skills being taught. Equipment is necessary to allow active participation and practice for every learner. A variety of equipment enhances confidence and skill development of the learners in different types of science activities. Examples of these equipment are models, computers, projectors, cylinders, flasks, beakers, videotape recorders, stop watches, measuring tapes, audio/audiovisual equipment, tape recorder, magnifying glass, desiccators, calorimeters and thermometers among others. To have a good science activity experience begins with buying equipment that is of good quality. The equipment learners use while participating in science activity is key to the development of process skills. Teachers must ensure that equipment is kept up to date and routinely inspected for safety and shelf live.

Finally, consumables in science education, are supplies or materials that become exhausted after one or a number of uses. Such materials include chemicals, distilled water, indicators, cardboards, papers and writing materials among others. When possible, good quality consumables levels should be maintained throughout the academic year (Ajaja, 2011 & Iruka, Chinedum, Denis, Abdoulaye & Omolaja, 2017). Consumables influence and promote learning and provide important opportunities for students to explore ideas and develop knowledge and process skills about a variety of science activities. The successful implementation of science education curriculum requires the use of a variety of consumables to enable the teacher to teach effectively and for the student to learn through a rich and varied selection of instructional consumables.

Furthermore, among the major problems that chemistry students complained about within the West African sub-region is the instructional delivery of concepts, theories, and facts to students in a didactic pattern described as the lecture method (Ajaja, 2011; Mouton, 2008; Broggy & McClelland, 2010). The end result of a poor method of instruction is to make teaching and learning non-stimulating which leads to students' inability to perform better (Hay, Kinchin, & Lygo-Baker, 2008). In spite of students' poor performance and participation rate in chemistry education, the unique role of chemistry in society has made many countries including Ghana to consider it a subject one must pass in order to pursue many science disciplines at the tertiary level in Ghana (Mouton, 2008; Broggy & McClelland, 2010) hence the need for a solution.

To improve the quality of teacher training in Ghana, the new Educational Reforms in 1987 led to the conversion of Certificate "A" Post Middle Teacher Training Colleges into Certificate "A" Post Secondary Teacher Training Colleges and finally, to Diploma in Basic Education Colleges. Presently, the Diploma in Basic Education Colleges have been converted into degree awarding institutions with effect from October 2018. The upgrading of the colleges led to the introduction of integrated science with redefined course content as a core course among others because there is no educational system that can succeed without science. Integrated science as an integral part of the national school curriculum and is compulsory for all students in teacher training institutions.

The compulsory nature of the subject implies that all topics in the integrated science course outline are equally important and should be treated as such. At present, chemical bonding and nomenclature of inorganic compounds form a significant part of the Colleges of Education integrated Science course content for the first year, first semester course. Students' performance in this particular integrated science course has been very poor. Research conducted in science education by Logerwell and Sterling (2017) found that, the conceptualization of the chemistry aspect of integrated science was indeed difficult for students. This was confirmed by Anamuah-Mensah and Apafo (1989), Johnstone (1993) and Khoo and Koh (2018) that, the acquisition of scientific concepts especially chemistry concepts posed a serious challenge to most students. Chemical bonding and nomenclature of inorganic compounds within which chemical bonding is taught is one of such difficult scientific chemical concepts. The difficulty associated with the acquisition of chemical concepts is the result of the use of traditional approaches or methods in teaching the concept of bonding (Dun,2015; Taber,2017). According to Teichert and Stacy (2012), many studies conducted worldwide revealed that, the traditional approach of teaching the concept of bonding is problematic because it leads to rote learning. To Henderleiter (2012), it appeared that students rely on rote memorization to determine which elements could be involved in chemical bonding because of the traditional approach used to teach the concept. Although rote memorization of some facts is critical, in many cases, it seems that students memorize a list or a pattern but are not able to fully reason through it (Henderleiter, 2012).

Chemical bonding as a concept has inherent challenges associated with its content, thus making it difficult for both teachers and students to grasp. As a result of this, teachers easily mislead students because of lack of both content and pedagogical knowledge (Teichert & Stacy, 2012). During the last two decades, researchers have found that students lack deep conceptual understanding of the key concepts regarding the concept of bonding and fail to integrate their mental models into a coherent conceptual framework (Taber 2014). Bonding is considered by teachers and chemists to be a very complicated concept (Robinson, 2013 & Taber, 2014). According to Taber (2012), most alternative conceptions in chemistry are not derived from the learner's informal experiences of the world but from prior science teaching. Students' alternative conceptions which are considered to largely stem from the way earlier instruction was dispensed have been labeled as pedagogical learning impediments (Taber, 2001). It is not surprising that teacher trainees found it difficult to understand because, apart from listening, they are not always engaged in any hands - on activities. The trainees are also not encouraged to utilize the enquiry processes of science to solve problems during practical activities simply because no practical activities are organized in the schools.

Additionally, the trainees are not placed at the centre of the teaching and learning process. The tutors do not always utilize their professional capabilities to make complex and inaccessible ideas simple and accessible to their students through the use of improvised materials (Taber, 2001). These observations were consistent with comments made in the 2016 Chief Examiner's Report on FDC 114 within which chemical bonding and nomenclature of inorganic compounds was taught. The report also noted that, the candidates' performance on the whole was poor (Institute of Education, 2015). Some of the candidates were unable to answer questions based on chemical bonding and nomenclature. Others who attempted to answer such questions provided incomplete answers. It appeared that the candidates were either not used to answering questions based on chemical bonding and nomenclature of inorganic compounds or were not taught how to go about answering such questions. The Institute of Education, Science Chief Examiner (2016) asked for the intensification of science lessons through the use of innovative approaches, hands-on activities and the use of improvised materials that can help boost the motivations of the trainees in answering such questions. Additionally, the researchers' experience as an Assistant Examiner for Institute of Education Integrated Science 1 paper exposed him to the conceptual difficulties teacher trainees encountered in their end of first year first semester science paper.

Strict adherence to the octet rule by teachers is part of the problem as it can result into pedagogical learning impediments (Dun, 2015; Hurst, 2012; Taber, 2001). To address this, Taber and Coll (2012) suggested that students should not learn bonding by relying solely on the "octet rule framework," which might lead to learning impediments. The existence of bonding which does not lead to atoms having full electron shells is consequently something of a mystery to many students. Moreover, students may have difficulty accepting anything that is not clearly explicable in "octet" terms, such as a hydrogen bond as being a chemical bond. Other researchers such as Hurst (2018), Taber (2014) and Coll and Taylor (2013) also referred to the "octet rule" as an over simplification of the electronic structure of molecules. Students' difficulty in bonding as inferred from the above can be traced back to the initial and inappropriate instruction in lessons on chemical bonding and nomenclature of inorganic compounds. As encouraging as these research efforts were, the overall performance of pre-service teachers in chemical bonding and nomenclature of inorganic compounds has not shown any significant improvement, perhaps due to the fact that the real challenges facing the teaching and learning of the concept has not been addressed. The unanswered question is whether the real problem confronting the trainees as far as the concept is concerned in both internationally and locally has been properly conceptualized for effective redress. If a concept is properly conceptualised, a reservoir of perceptual and visual options would synergistically enrich the minds of the students.

One instructional instrument which is entirely new, both internationally and locally in any educational system world wide, developed by the researcher and hence untested is the use of Wooden Atomic Models (WAM) to teach chemical bonding and nomenclature of inorganic compounds. WAM is specially designed teaching and learning material made with wooden cuboids and capable of being used to teach different concepts in chemistry including chemical bonding and nomenclature. These models do not use one atomic property in the formation of compounds as it happens in the architecture of conceptual models already known. When one atomic property is used, it makes pre-service teachers handicap in reasoning how inorganic compounds are formed and named. This means that WAM contains a number of atomic properties used in illustrating how inorganic compounds are formed and named.

Students' performance on chemical bonding and nomenclature of inorganic compounds, motivation and attitude towards chemistry in general may depend on the way chemical bonding and nomenclature concepts were introduced to them at the early stages of learning science. Early stages may be influential in determining students' performance in chemical bonding and nomenclature of inorganic compounds and chemistry later on in life. Hence there is need for a clear understanding of students' prior conceptions on elements and symbols as a prelude to effective teaching of chemical bonding and nomenclature of inorganic compounds.

Having realized that students enter Colleges of Education with different backgrounds and capabilities in handling chemical elements and symbols, steps need to be taken as early as possible to develop motivations towards the learning of chemical bonding and nomenclature. One of the most effective ways of doing this is to design the activities that are student-centred and interest students most as well as the strategies students could easily use to learn chemical bonding and nomenclature of inorganic compounds. When this is done, teaching approaches could be designed to suit or meet each student's academic level in order to further demystify the concept of bonding.

Ausubel (1968) argued that the most important single factor influencing meaningful learning is indeed what the learners already knew, and that this should be ascertained to teach them accordingly. Determining student's prior knowledge and alternative conceptions about a fundamental concept is a very important strategy in teaching science. This will enable science teachers to plan lessons to incorporate new information with this poorly imbibed concepts and also preventing it from interfering with subsequent concepts or learning. Additionally, scientific realities in textbooks the students would be studying could be very complex or inaccessible to students. For this reason, integration of exemplary materials and flipped classroom instruction is easy to manipulate and manage in the classroom and present valuable strategies for differentiating learner's ideas and has the potency of influencing teachers' practices with little or without the need for extensive further training.

In another development, integration of exemplary materials and flipped classroom instruction is effective for initiating interactions and eliciting responses from students, helping students to co-construct knowledge, argue with confidence, conceptualise and contextualise complex and inaccessible concepts with ease. When teachers make all the decisions through the use of traditional lecture method, the motivation to learn diminishes and so learners have no option than to become cognitive dependants of their teachers. For this reason, leaner-centered instructional approaches should be employed because of its far-encompassing effects ranging from increased motivation for learning, greater satisfaction with learning environment, increased commitment and motivation to succeed all of which finally lead to higher academic output.

However, it is disheartening to note that in spite of the importance attached to chemical bonding and nomenclature of inorganic compounds as a fundamental concept, limited discernible efforts have been made both internationally and locally to produce improvised materials to help students easily conceptualise how inorganic compounds are formed and named apart from the verbal instructions that make your lesson practical, use activity oriented approaches or use teaching and learning materials among others. The mind boggling question is "What materials should be used to make the teaching and learning of this important fundamental concept practical"? However, a search through available literature showed that some researchers such as Taber (2017); Levy-Nahum, Hofstein, Mamlok-Naaman and Bar-Dov (2014) and Dun (2015) designed different types of conceptual models that were deficient in one way or the other in helping learners to improve their performance and motivation in chemical bonding and nomenclature of inorganic compounds. It is against this background that the researcher developed integration of exemplary materials and used flipped classroom instruction. This is an improvement over the deficient conceptual models used earlier. Deficiencies associated with the use of the conceptual models are duly rectified in the improvisation process. This helped provide empirical evidence on the effects of integration of exemplary materials and flipped classroom instruction on learners on the concept and hence established the relationship between the use of the latter on one hand and motivation enhancing factors (self-efficacy, anxiety and enjoyment levels) of pre-service teachers on the other hand after learning chemical bonding and nomenclature of inorganic compounds.

It is a recognizable fact that, for Ghana to make any significant progress in educational development, substantial resources need to be directed at improving educational delivery through the use of Information and Communication Technology [ICT] (Koehler & Mishra 2009; Novak, 2013; Koc, 2012). The role of ICT in widening access to education to a wider section of the population and facilitating educational delivery and training at all levels are recognized as a key priority under the 2007 Educational Reforms. Information technology means all equipment, processes, procedures and systems use to provide and support information systems (both computerized and manual) within an organization and those reaching out to distance education learners (Apeanti, 2016; Vosniadou, 2013). The term information and communication technology was coined to reflect the seamless convergence of digital processing and telecommunications. ICT therefore includes hardware, processes and systems that are used for storing, managing, communicating and sharing information. Planning for effective use of these technologies is crucial if information is to have positive educational impact (Oguz-Unver & Arabacioglu, 2014; Novak, 2013; Koc, 2012). International experience from both developed and developing countries have shown that these technologies have an enormous potential for knowledge dissemination, knowledge acquisition, effective teaching and the development of more efficient instructional strategy such as integration of exemplary materials and flipped classroom instruction (Oguz-Unver & Arabacioglu, 2014). Educational animation is one technological process that can be incorporated into improvised wooden atomic models to form integrated exemplary materials and flipped classroom instruction which could be effectively used to teach chemical bonding and nomenclature of inorganic compounds. Educational animations are effects produced by inanimate things for the purpose of promoting learning. Computer Generated Imagery (CGI) has allowed animations to help learners understand and remember information to be produced by animation than in previous years (Novak, 2013; Koc, 2012).

Research evidence about the educational effectiveness of animations is mixed. Various investigations have compared the educational effectiveness of static and animated displays. While there have been some findings that show positive effects of animations on learning, other studies have found no effects or even negative effects (Oguz-Unver & Arabacioglu, 2014). People are always looking for new ways to educate their children. If they are having fun, they learn better. Computer animation can be very exciting into which education and training can easily be incorporated. It is much more interesting to learn chemical bonding and nomenclature of inorganic compounds for example when concrete materials such as wooden items are used to represent atoms which exist only at the microscopic level, with the letters nicely written, colourful and flying around the computer screen instead of solving problems on plain paper or white marker board .This is so because the tutors have control of all aspects of the programme and can use computer animation to demonstrate things visually exactly how they want them. In this case for example, computer animation might be used to show how to manipulate integrated exemplary materials and flipped classroom instruction to form chemical bond of inorganic compounds and name them accordingly.

Animation is integrated into exemplary materials and flipped classroom instruction because a lot of concepts in chemistry and physics are either abstract, too small to see, handle, experiment on, or even trying to imagine, for example atoms and molecules (Oguz-Unver & Arabacioglu, 2014; Vosniadou, 2013). Computer animation is a perfect tool for these concepts because instructors can create realistic models of those things like atoms and molecules from the data they have and look at the way these integrated exemplary materials and flipped classroom instruction would interact with each other to form inorganic compounds. Tutors can choose to make an animation experiment exactly like the real one in the laboratory depending on their competence level in ICT.

Well-designed animations help students learn faster and easier. Animations are also excellent aids to teachers when it comes to explaining difficult concepts associated with chemical bonding and nomenclature of inorganic compounds. The difficulty in comprehension of these concepts is due to the fact that, the concepts lie at the microscopic level (abstract), thus appearing inaccessible. With the aid of computer animations, teaching and learning becomes easier, faster and amusing. Since animation is an inspired and interactive way for flexible education and training, learners are more motivated to learn more and more without realizing the need to go for break. Learners acquired more skills, which was the main reason for motivating them. Educational animations are effects produced by inanimate things for the purpose of promoting learning.

Again, having knowledge of students' prior conceptions and procedures for solving problems in relation to chemical bonding and nomenclature of inorganic compounds at the beginning of a professional teacher training programme provided a useful starting point for determining the appropriate intervention. This prescribed intervention enabled the students to live up to both their academic and professional expectations that lay ahead of them. It was in the light of the above that this study was designed to explore students' prior conceptions and investigate how these conceptions could be better organised, strategised, and administer appropriate intervention to assist the students accordingly.

1. 2. Statement of the Problem

Logerwell and Sterling (2017) found that conceptualization of the chemistry aspect of science is indeed difficult for learners of science. The finding is consistent with Khoo and Koh (2018) citing Anamuah-Mensah and Apafo (1989) and Johnstone (1993), that the acquisition of scientific concepts especially the chemistry concepts poses a serious challenge to most students. Chemical bonding and nomenclature of inorganic compounds within which chemical bonding is taught is one of such difficult scientific chemistry concepts. This was again confirmed by the Chief Examiner's Report of WAEC (2016) that Science and for that matter chemistry as a branch of Science in Ghana continues to produce poor results year after year because of the chemical-concepts oriented nature of the subject. The study of chemical bonding and nomenclature forms part of the elective chemistry and Integrated Science course outlines for decades in Ghanaian Teacher Training Colleges, Colleges of Education (CoE) and now University Colleges of Education.

This topic includes various abstract concepts which seem to give students some troubles due to its abstract nature (Dun, 2015). According to Levy-Nahum, Hofstein, Mamlok-Naaman and Bar-Dov (2014) students possess a variety of misconceptions regarding the concept of Chemical bonding and nomenclature of inorganic compounds. Although there have been serious efforts to overcome this problem, the same crucial misunderstanding regarding the concept had been with students for the last two decades. Several methods and resources were used to explore and alleviate the problem but to no avail. Based on the findings, it was suggested that, students demonstrate a superficial understanding of chemical bonding because the concept has intrinsic complexities and external misleading factors concerning the traditional approach used for teaching the concept. Chemical bonding and nomenclature of inorganic compounds is a fundamental topic in school chemistry, yet it continues to be a concept that students struggle to understand (Logerwell & Sterling, 2017). However, even if students understand atomic structure and ion formation, it could be difficult for students to visualize how ions fit together to form compounds (Logerwell & Sterling, 2017).

International experience from both developed and developing countries have shown that technology has enormous potential for knowledge dissemination, acquisition, effective teaching and the development of more efficient educational services (Oguz-Unver & Arabacioglu, 2014). Educational animation is one such tool that can be incorporated into improvised Wooden Atomic Models to form integrated models that could be effectively used to teach chemical bonding and nomenclature of inorganic compounds. Optimum educational output is derived when taught through flipped classroom approach.

Personal experience as a teacher right from Junior Secondary School to Senior Secondary School and to Colleges of Education indicated that students at all levels of education perform poorly on test items drawn from chemical bonding and nomenclature of inorganic compounds. Institute of Education, Chief Examiner's Report on Integrated Science 1 (2015- 2017) indicated that, the performance of students in Integrated Science was poor because the candidates scored very low marks in the chemistry aspect. In 2015, 20% of the pre-service teachers who sat for Integrated Science 1 examination at the end of first year obtained grades A to C with 80% obtaining grades D to E. In 2016, 22% obtained grades A to C with the remaining 78% obtaining grades D to E. Again, in 2017, 21% obtained grades A to C while the remaining 79% obtaining grades D to E. The foregoing data suggests that the pre-service teachers' performance had been very much appalling over the period under review. The report attributed the poor performance of the students to their failure to grasp the required fundamental concepts in writing chemical bonding and nomenclature of inorganic compounds. The required fundamental concepts include correct writing of chemical symbols, ions, electronic configurations and knowledge of oxidation states. The report stated that, majority of the candidates had challenges in writing chemical symbols and oxidation numbers. Mastering chemical bonding and nomenclature of inorganic compounds in the chemistry aspect is a central concept in teaching chemistry. This topic is a central concept because it forms the basis for understanding almost every other topic in chemistry such as carbon compounds, proteins, polymers, acids and bases, chemical energy, and thermodynamics (Hurst, 2018).

Over the years, science teachers have used traditional methods of teaching with little or no activities and this further mystifies their efforts as it resulted in the development of alternative conceptions. According to Taber (2017), most alternative conceptions in chemistry are not derived from the learner's informal experiences of the world but from prior science teaching. Since chemical bonding and nomenclature of inorganic compounds is the most important concept which forms the basis for understanding chemistry at any educational level, it was incumbent on students to have a good grasp of it. This therefore called for a better way of teaching and learning of this concept in an easier and much more meaningful way to the students at the CoE level, hence the use of integration of exemplary materials and flipped classroom instruction.

1.3. Purpose of the Study

The purpose of the study was to enhance the academic performance and motivation of pre-service teachers in chemical bonding and nomenclature through the integration of exemplary materials and flipped classroom instruction. Again, it was to produce physical teaching and learning materials for teaching selected inorganic compounds just as 'ball and stick models' which are used to teach organic chemistry.

1.4. Objectives

The objectives of the study were to:

1. determine the preconceptions of level 100 pre-service teachers in writing chemical bonding and nomenclature of inorganic compounds.

2. determine the possible causes of conceptual errors amongst students with respect to chemical bonding and nomenclature of inorganic compounds.

3. examine the effect of integrating exemplary materials and flipped classroom instruction on students' performance in chemical bonding and nomenclature of inorganic compounds.

4. determine the relative improvements of male and female students when taught chemical bonding and nomenclature of inorganic compounds using integration of exemplary materials and flipped classroom instruction.

5. examine the effect of integration of exemplary materials and flipped classroom instruction on students' motivation to study chemical bonding and nomenclature of inorganic compounds.

1.5. Research Questions

The following research questions were addressed in the study.

1. What preconceptions do level 100 students hold about chemical bonding and nomenclature of inorganic compounds?
2. What are the possible causes of the conceptual errors amongst students in learning chemical bonding and nomenclature of inorganic compounds?

3. What is the effect of integrating exemplary materials and flipped classroom instruction on the students' performance on chemical bonding and nomenclature of inorganic compounds?
4. What are the relative improvements of male and female students when taught chemical bonding and nomenclature of inorganic compounds using the integration of exemplary materials and flipped classroom instruction?
5. What is the effect of the integration of exemplary materials and flipped classroom instruction on the students' motivation to study chemical bonding and nomenclature of inorganic compounds?

1.6. Null Hypotheses

Research question three and five were formulated into null hypotheses and tested in the study:

Ho 1. There is no statistically significant difference in effect of integrating exemplary materials and flipped classroom instruction on students' performance in chemical bonding and nomenclature of inorganic compounds.

Ho 2. There is no statistically significant difference in the motivation of students before and after using integration of exemplary materials and flipped classroom instruction to study chemical bonding and nomenclature of inorganic compounds.

1.7. Significance of the Study

It would help students to develop a much more positive attitude towards learning of Integrated Science more especially the chemistry aspect of the course.

For this reason, this research was to produce a document that would report the relationship between the use of models and performance of students in Chemical bonding and nomenclature. The self-explanatory nature of the model makes it a useful study material for students who study the chemistry aspect of integrated science on their own. The material would be made available to teachers, curriculum designers and other stake holders in science education in their decision making concerning methods of teaching science especially at CoE level.

By emphasizing the use of models, it was hoped that the outcome of this research work would enable science educators particularly chemistry teachers to realise the importance of models. Realizing the importance of models would motivate the teachers to incorporate it into the teaching and learning process. The incorporation would lead to the improvement of science teaching and learning at the CoE.

The study would additionally serve as baseline for GES and GASTs to organize in-service training for science teachers to help improve teachers' conceptual and pedagogical understanding of chemical bonding and nomenclature of inorganic compounds at all levels of education. The outcome of this work would serve as basis for Ministry of Education (MOE), Curriculum Research Development and Division (CRDD) and other agencies associated with science education to make certain structural changes in the curriculum of science education in CoE, SHS and JHS to encourage the use of models in teaching and learning of science.

1. 8. Delimitations of the Study

The study was delimited to Gambaga and Gbewaa Colleges of Education both of which are in northern part of Ghana. This is because these colleges had signed a Memorandum of Understanding (MoU) to work in partnership with each other. Under this partnership the colleges would assist each other in terms of teaching and learning resources as well as human resources. By default, this was to undoubtedly dissolve any administrative barriers, if any, for easy data collection. Furthermore, students from these colleges had similar entry standards and for that matter, academic challenges because of the common science curriculum they used at both the JHS and SH S levels. Some of these academic challenges included poor science foundation, inadequate teaching and learning materials, lack of science teachers, and high rate of unqualified science teachers. The study was additionally delimited to an aspect of chemistry focusing principally on chemical bonding and nomenclature of selected inorganic compounds within the course outline of the Integrated Science course, FDC 114 for Colleges of Education.

1.9. Limitation of the Study

According to Best & Kahn (2003), limitations are conditions beyond the control of the researcher that would place restriction on the conclusion of the study and its application. Firstly, the researcher encountered the problem of reactivity. Reactivity is the unintended effects of the outcomes of the study (Ary *et al.*, 2017). The nature of reactivity encountered was respondents holding a perception that the researcher was assessing them to find out whether their admission into the college of Education was justified or not.

Another limitation was the commitment and motivation levels of the students to learn with the integration of exemplary materials and flipped classroom instruction. A positive attitude was likely to produce good results. Additionally, since the instruments were mainly test and questionnaire, any form of examination irregularities like cheating or communication during the administration of the research instruments might not make the research results authentic. The results might not be generalised since only one College of Education was used. Finally, absenteeism on the part of the respondents during the period of the study could affect the results because these respondents were likely not to understand the concepts of integration of exemplary materials and flipped classroom instruction well.

1. 10. Definition of Terms

Flipped classroom instruction: It is a type of blended learning that reverses the conventional classroom learning environment by delivering instructional content, often online, outside of the classroom.

Northern part of Ghana: Refers to Colleges of Education that are located in the Savanna, Northern, North East, Upper East and West regions of Ghana

Wooden Atomic Model (WAM)- is a specially designed teaching and learning material made with wooden materials and capable of being used to teach different concepts in chemistry including chemical bonding and nomenclature.

1. 11. Organisation of the Study Report

This report has been organised into five chapters. Each chapter starts with a brief overview followed by the main content of the chapter. Chapter one, being the introduction begins with the background to the study followed by the statement of the problem and the purpose and objectives of the study. The chapter also includes research questions for the study, null hypotheses, significance and delimitation of the study. The chapter ends with operational definition of terms followed by organisation of the study.

Chapter two dealt with conceptual framework of the study, review of related literature and Summary of related literature justifying and establishing the premises for this research work. Chapter three focuses on the methodology used in the study. Under this are the research design, population and sample selection, research instruments, pilot testing, pretest, intervention and posttest, and finally, the data analysis plan. Chapter four deals with results/ findings and discussion, while chapter five focuses on summary of findings, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2. 0. Overview

This chapter examines the relevant literature to the concept of models and flipped classroom approach integration which this study argues could be used for effective teaching of chemical bonding and nomenclature of selected inorganic compounds. The chapter therefore reviews literature on the theoretical framework, conceptual framework, the concept of flipped classroom approach and benefits of flipped classroom approach. Additionally, the chapter includes limitations of flipped classroom approach, effective use of flipped classroom approach, exemplary materials, WAM and learners' motivation and the role of WAM in learners' Preconceptions and Misconceptions. The rest include the concept of models in teaching of science, significance of models in science teaching, problems associated with the use of science models, learners' misconceptions in chemical bonding and nomenclature, effects of inadequate models on science education, the role of improvisation in providing science teaching and learning and empirical framework of the study.

2. 1. Theoretical Framework

The theoretical base of this research is embedded in the constructivists' theory of learning. Constructivists' theory of learning is an approach to teaching and learning based on the idea that, learning is the result of mental construction. Students learn by fitting new information together with their past experience. Constructivists believe that learning is affected by the context in which an idea is presented as well as by the students' personal beliefs and attitudes. Constructivists' theory sees learning as a process of constructing meaning; it is how people make sense of their experience

(Davis & Sumara, 2012; Henson, 2013; Merriam, Caffarella, & Baumgartner, 2017; Piaget, 1984; Proulx, 2016; Wilson & Lowry, 2017).

Constructivism theory sees knowledge acquisition basically as learning rather than teaching. The emphasis is therefore laid on the learning environment and it is learner centered rather than teacher centred (Proulx, 2016). The teacher's role is to ask "what should be taught" and "how can this be learnt" (Proulx, 2016). Henson (2013) cites some of the benefits of learner-centred education put forward by Dewey as including students' increased intellectual curiosity, creativity, drive, and leadership skills.

Educators who are committed to learner-centered education do challenge learners within their abilities while providing reinforcement and appropriate rewards for learners‟ success. In developing learning experiences that would have utmost benefit to learners, the teacher addresses the needs of individual learners. In preparing for lesson delivery, viewing the lesson from the learners‟ perception and from its relevance to the learner promotes learning experiences that would have maximum impact on learners (Garmston, 1996; Henson, 2013; Spigner-Littles & Anderson, 1999).

To ensure maximum conditions for construction of meaning, educators need to provide a safe learning environment where learners are free from fear and open to constructive learning. In addition, learners must feel welcomed, comfortable, and respected (Henson, 2003; Spigner-Littles & Anderson, 1999). Constructivist theory has several implications for educators. According to Proulx (2016), a constructivist encourages educators to be aware of the fact that learners bring with them prior knowledge, most of this prior knowledge may be faulty. Learning from mistakes is a key element of constructivist learning activities, as they provide opportunities for further learning and are a natural part of the learning process. Learners' mistakes are not seen as failures (Proulx, 2016). It excites and sustains the interest of learners, ensures practical work, enables learners to acquire skills and promotes acquisition of first hand information.

A multiple approach involving the use of the many senses: seeing, touching and smelling makes learners focus on the lesson for knowledge construction. The physical manipulation of the Wooden Atomic Models and the use of WAM-ICT integration ensures and creates safe and sound environment for learning to occur. Learners with different skills and backgrounds collaborate in performing tasks and discussions in order to arrive at a shared understanding of the truth in a specific field (Duffy & Jonassen, 1992).

2. 2. Conceptual Framework

From the history underpinning conceptual understanding, theories of learning and definition of conceptual understanding amongst others, is a cord of interrelationship among the student, environment, teaching and learning processes. Conceptual understanding is entrenched in the peculiar manner the individual student perceives, processes, stores, interprets, interacts with and responds to related concepts in the learning environment. The conceptual framework is conceptualised as an interaction of several student factors and the environment (Figure 1). It indicates that student factors, prerequisite conceptions and environmental factors could possibly influence student's conceptual understanding. Conceptual understanding implies that students have the ability to use knowledge, apply it to related problems, and to make connections between related ideas (Bransford, Brown & Cocking, 2018).

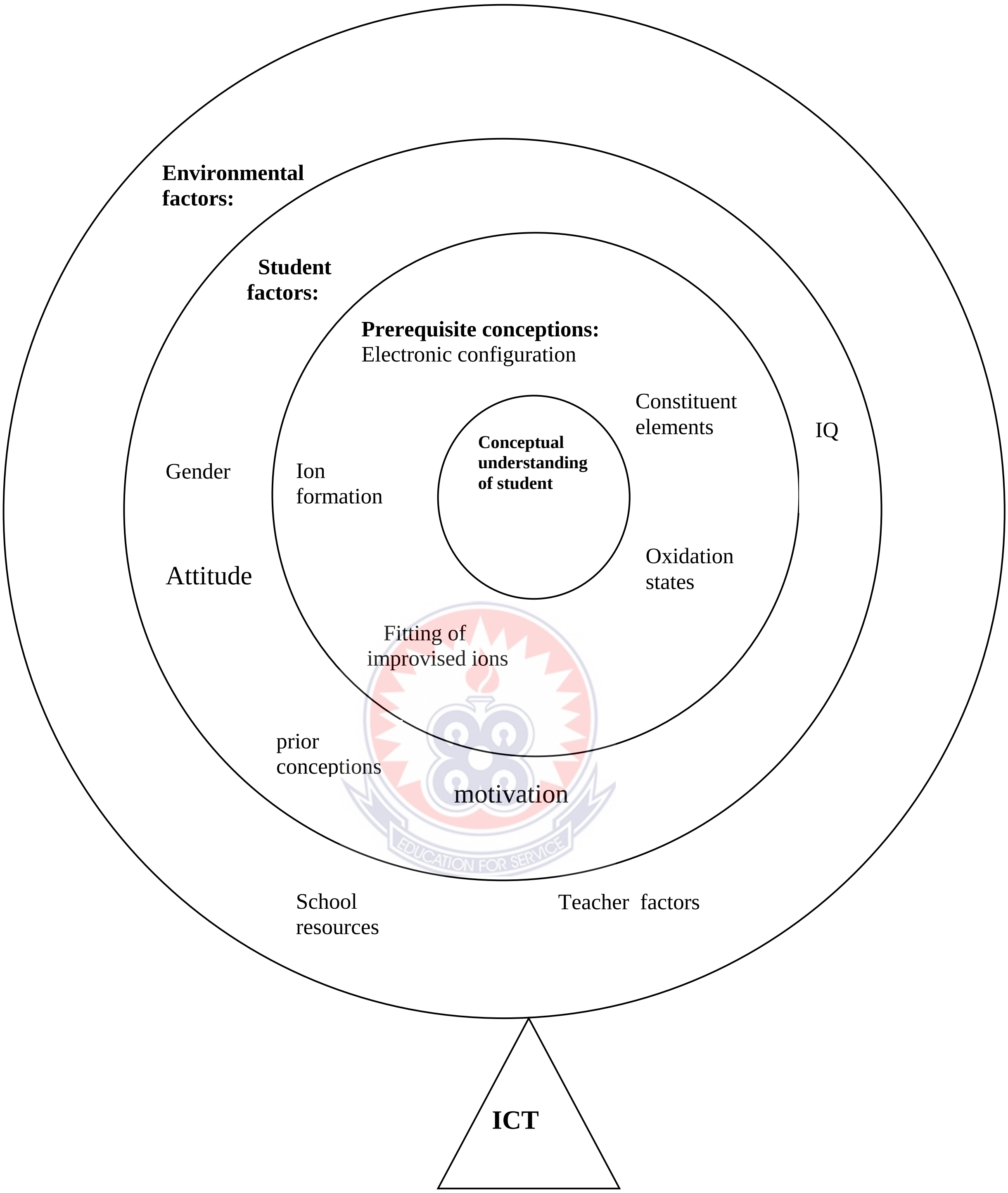


Figure 1: **Conceptual framework on factors influencing students' conceptual understanding**

Ideally, the sense-making involved in developing conceptual understanding involves taking newly introduced information and linking it to existing knowledge as the student builds an organised and integrated structure of knowledge (Ausubel, 1968; Linn, Eylon, & Davis, 2014; Okonkwo, 2018; Taber, 2017). The conceptual framework of the study consists of four (4) concentric circles representing different factors influencing student's conceptual understanding. Additionally, the concentric circles are seated on a triangular fulcrum representing the influence of ICT on students' conceptual understanding. The innermost circle depicts conceptual understanding of students. This is influenced by factors in the second smallest circle which consists of factors such as a gender, intelligence quotient (IQ), attitude, prior conceptions and motivation enhancing factors (self-efficacy, anxiety and enjoyment levels) of the student (Taber, 2017). The third concentric circle influencing the second and consequently the first, represents possible prerequisite conceptions such as oxidation states, ion formation, identification of constituent elements forming a given inorganic compound and electronic configuration (Trimpe, 2017). The fourth and outermost circle represents environmental factors such as teacher factors and school resources (Taber, 2017). These factors have the potential of influencing the prerequisite conceptions, student factors and conceptual understanding. The framework implies that any one of the factors or a combination of the prerequisite conceptions (oxidation states, ion formation, identification of constituent elements and electronic configuration) could have synergic influence on student's conceptual understanding. Individual characteristics selected for the study include gender, level of motivation, prior conceptions and the effect of the use of WAM –ICT integration through a flipped classroom approach.

Finally, the dream of achieving conceptual understanding would not be totally realized without ICT integration through a flipped classroom approach. The integration was done by using the ICT at appropriate points to explain the concepts being learnt. This explains why the concentric circle as a whole is seated on a triangular fulcrum and being controlled same. The pre-service teachers need competency skills in the form of Technological Pedagogical Content Knowledge [TPACK] (Koehler & Mishra, 2009) in order to use the WAM-ICT integration effectively.

The Wooden Atomic Models are used to effect conceptual change because the acquisition of the concepts is supported by meaningful conceptual learning (Ausubel et al, 1978; Bruner, 1983; Vosniadou, 2013). Cognitive learning theory explains that one's existing cognitive structure is capable of learning any new concepts when presented in an organized and related pattern that fits into existing domain of the learner (Koc, 2012). According to pragmatism and social constructivism theory, learning becomes motivating and meaningful when learners are actively generating, predicting and relating new relevant knowledge to prior-concepts (Novak, 2013; Koc, 2012). Although, the use of Wooden Atomic Models is recognized as giving an insight into the invisible hence its conception, construction and innovative use constitutes webs of knowledge (Novak, 2013; Koc, 2012). Wooden Atomic Models' perceptibility and visualisation illustrate interconnections among concepts when conceptual reasoning is used to find relationship among visualised concepts of interest. ICT aspect of the flipped classroom approach simplifies the inclusion and conversion of colours, hyperlinks and provides audio for better conceptual understanding (Koc, 2012). This helps to change attitudes, thus making the students more anxious, joyous, self- efficacious and above all, self-motivating towards learning Chemical bonding and nomenclature of inorganic compounds better than using paper and pencil to learn.

2.3.1. *The Concept of Flipped Classroom Instruction*

Flipped classroom instruction otherwise known as the “inverted classroom” is a relatively new instructional strategy and a type of blended learning that reverses the conventional classroom learning environment by delivering instructional content, often online, outside the classroom. It moves activities, including those that may have conventionally been considered homework, into the classroom (Marco-Ronchetti, 2019; Bergmann & Sams, 2012; Sparks, 2011). In a flipped classroom, students watch online lectures, participate in online discussions, or carry out research at home while engaging in concepts in the classroom under the supervision of a mentor. The idea is to use precious limited class time for a teacher to introduce concepts in a lecture. The introduction may include the creation of a video lecture or screen cast that teaches students the concept (Makice, 2012; Ryback & Sanders,1980; Strauss & Valerie, 2018; Abeysekera, Lakmal, Dawson & Phillip;2015).

Furthermore, the flipped classroom intentionally shifts instruction to a learner-centred model in which time in the classroom is used to explore topics in greater depth and create meaningful learning opportunities while students are initially introduced to new topics outside of the classroom. In a flipped classroom 'content delivery ' may take a variety of forms. Often video lessons prepared by the teacher or third parties are used to deliver content. However, online collaborative discussions, digital research, and text readings could be used. It is claimed that the ideal length for the video lesson is eight to twelve minutes (Abeysekera, Lakmal; Dawson & Phillip, 2015; Marco-Ronchetti, 2019; Topp, 2011).

Flipped classroom also redefines in-class activities. In-class lessons accompanying flipped classroom may include activity learning or more traditional home work problems, among other practices to engage students in the content. Class activities vary but may include using manipulative models and in-depth laboratory experiments, original document analysis, debate or speech presentation, current event discussions, peer reviewing, project based learning, and skill development or concept practice (Topp, 2011). This is because these types of active learning allow for highly differentiated instruction (Makice, 2012). More time can be spent in class on higher-order thinking skills such as problem-finding, collaboration, design and problem solving as students tackle difficult problems, work in groups, research, and construct knowledge with the help of their teacher and peers. This saves the precious class time for more collaborative and engaging activities typically facilitated by the teacher. It is important to note that the strategy involves more than just the "take home" video lecture (screen cast or podcast). It equally incorporates formative and summative assessment as well as meaningful face-to-face learning activities. Although many teachers at all educational levels and from various settings have been incorporating this strategy for years, Bergmann and Sams (2012) were pioneers in creating screen casts and podcasts for their students in 2006 (Makice, 2012).

The flipped classroom strategy advocates numerous benefits. Most seem to be plausible advantages (e.g., increases time for more engaging instruction), especially for those teaching in hybrid or blended settings consisting of some combination of face to face and online instruction. According to Makice (2012), the strategy also has its limitations. First, the quality of the video lecture may be very poor; even though a teacher might be outstanding in face to face settings, he or she may not produce a quality video instructionally and/or technically. Second, taking for granted that all students are able to view the video lecture on their own computers, the conditions under which they might view the video may not be the best for learning any concepts (e.g., a student might view a video while also watching a game and listening to music).

Furthermore, there are many distractions in face to face classrooms, but at least the teacher can monitor comprehension with several formative assessments (Ryback & Sanders, 1980; Strauss &Valerie, 2018; Abeysekera, Lakmal, Dawson & Phillip, 2015). Third, students may not watch or comprehend the video and therefore be unprepared or insufficiently prepared for the more engaging activities that will occur face to face. Fourth, students may need a lot of scaffolding to ensure they understand the material presented in the video. Although good teachers will likely build-in effective scaffolding activities while students watch the video such as “stop, think, and answer” questions (and also rewind if needed), they may still fall short in providing enough scaffolding activities for all types of learners. Fifth, students are not able to ask the teacher or their peers questions if they watch the video alone (Ryback & Sanders, 1980; Abeysekera, Lakmal, Dawson &, Phillip, 2015).

Therefore, important just-in-time questions to help them comprehend the material cannot occur unless the instructor is available during the viewing—which is difficult. Finally, the flipped classroom strategy may not be the best approach for second language learners or those with learning challenges—which represents learners not only at the Senior High School level, but all educational levels and settings.

2.3.2. *Benefits of Flipped Classroom Instructions*

According to Ryback and Sanders (1980), Strauss and Valerie (2018) and Abeysekera, Lakmal, Dawson and Phillip (2015), the following benefits are imminent when flipped Classroom's approach is adopted in teaching:

- Flipped Classroom's approach meets the learning style of individual learners because it utilizes all forms of learning (i.e. oral, visual, listening, hands-on, problem solving, etc.)
- Rather than learning in a traditional classroom setting, Flipped Classroom uses a more application-based approach for students (i.e. hands- on and problem solving activities).
- The accessibility of Flipped Classroom is extremely convenient, especially for students who would face difficulties in traveling to the physical classroom. Such students would still have the foundational information of the course at hand via online.
- Communication is greatly emphasized in a Flipped Classroom setting, essentially referring to: student-student and student-teacher interactions.
- Flipped Classroom utilizes a student-centered teaching modeled in order to ensure that the course is primarily aimed at contributing to the student's overall success in obtaining a proper, effective education.
- Avoids the over arching idea of "cramming" for examination and forgetting the information after examination, as it encourages students to understand the underlying rationale behind the information being provided to them.
- Students must account for the responsibilities given to them in regards to learning the

foundational information provided, as their personal work and contribution would be reflected in the grade received at the end of the course. This would, in turn, make the students better prepared for future courses.

2.3.3. *Challenges Associated with Flipped Classroom Instructions*

Critics argued that, the flipped classroom model has some consequences for both students and teachers. For students, there exists a 'digital divide'. Not all families are from the same socio-economic background, and thus access to computers or video viewing technology outside the school environment is not possible for all students. This model of instruction may put undue pressure on some families as they attempt to gain access to videos outside school hours (Ryback & Sanders,1980; Abeysekera, Lakmal, Dawson & Phillip, 2015; Marco-Ronchetti, 2019; Bergmann & Sams, 2012; Sparks, 2011). Additionally, some students may struggle due to their personal responsibility. In a self-directed home learning environment for instance, students who are not at the developmental stage required to keep on-task with independent learning might not cope up with their peers Ryback & Sanders, 1980).

Other educationists argued that the flipped classroom leads to increased computer time in an era where adolescents already spend too much time in front of computer screens. Inverted models that rely on computerized videos do contribute to this challenge, particularly if videos are long (Marco-Ronchetti, 2019; Bergmann & Sams, 2012; Sparks, 2011). Again, flipped classrooms that rely on videos to deliver instruction suffer some of the same challenges as traditional classrooms. Students may not learn best by listening to a lecture, and watching instructional videos at home is still representative of a more traditional form of teaching. Critics argue a constructivist approach would be more beneficial (Ryback & Sanders, 1980; Strauss & Valerie, 2018; Topp, 2011; Abeysekera, Lakmal, Dawson & Phillip, 2015)

Teachers may find challenges with this model as well. Increased preparation time is initially likely needed, as creating high quality videos requires teachers to contribute significant time and effort outside of regular teaching periods. Additional funding may also be required to procure training for teachers to navigate computer technologies involved in the successful implementation of the inverted model (Ryback & Sanders, 1980; Strauss & Valerie, 2018)

The potential performance increase from flipped classrooms varies greatly on classroom by classroom basis. The potential benefits may be affected by the method of conducting the

Classroom lessons and the level of intensity of the course. Currently, the amount of research available is not enough to create rigorous practical guidelines for all teachers to use. Therefore, some teachers may conduct the flipped classroom more effectively than others. In addition, the level of intensity of the course may also play a crucial role in the efficacy of the flipped model (Bergmann & Sams, 2012; Sparks, 2011).

2.3.4. *Effective use of Flipped Classroom Instruction*

Although there are many limitations associated with the use of flipped classroom strategy, no empirical research exists for substantiation, anecdotal reports by many instructors maintain that it can be used as a valuable teaching strategy at any educational level. Nonetheless, it depends on o learners, resources, and time. Moreover, it is more appropriate for teaching how to generate the four general types of knowledge, more particularly procedural and conceptual knowledge described in the revised Bloom's Taxonomy (Anderson, Krathwohl, Airasian, Cruikshank, Mayer, Pintrich & Wittrock, 2001). The general types of knowledge include procedural, factual, conceptual and meta-cognitive knowledge. Procedural knowledge is knowledge about how to do something. Therefore, a flipped classroom video lecture about how to write chemical formulae for inorganic compounds in which a tutor describes and models how to solve this type of problem would be a good use of the strategy. Complex procedural knowledge can also be taught utilizing the flipped classroom strategy although scaffolding and chunking of content would be very important not only to ensure that videos are short, but to ensuring that all the prescribed steps of the procedure are introduced adequately so as to enable the students understand it thoroughly. Although procedural knowledge is arguably one of the best types of knowledge that could be generated using the flipped classroom strategy, the other three types could equally be generated. Factual knowledge describes the basic and essential elements of a phenomenon under consideration. Conceptual knowledge shows one's ability to establish relationship between classifications and categories. Finally, meta-cognitive knowledge which is knowledge about one's own cognition can also be generated using this strategy. However, it is important to note that much more time and thought are needed to go into employing the flipped classroom strategy. Many resources exist regarding the flipped classroom strategy.

2. 4. Exemplary Materials

Exemplary materials are locally available resources for instruction (Iruka, Chinedum, Denis, Abdoulaye & Omolaja, 2017). The process of teaching and learning the curricular content of science education principally depends on the accessibility and quality of these exemplary materials. Teachers need a variety of stimulating and exciting exemplary materials to teach curricular content to in order to ensure that students are actively involved in the learning. Exemplary materials must reflect what is already well-known to the learner as well as introducing originality and novelty in learning approaches to engage learners in a variety of science activities. It is established that one of the important considerations in the development and promotion of comprehensive science programme in schools is the accessibility and quality of exemplary materials (Ajaja, 2011).

The accessibility and quality of these exemplary materials rely heavily on the ability of the teacher to improvise depending on the type of raw materials available in the locality. Examples of these include conceptual models of all kinds, measuring cylinders, flasks, beakers, magnifying glass, desiccators, chemicals, distilled water, indicators, calorimeters and thermometers among others. To have a good science activity experience begins with conceptualizing and improvising exemplary materials that are of good quality. The exemplary materials learners use while participating in science activity is key to the development of both process skills and desirable scientific attitudes among learners. Exemplary materials influence and promote learning and provide important opportunities for students to explore ideas and develop knowledge and process skills about a variety of science activities (Ajaja, 2011; Iruka, Chinedum, Denis, Abdoulaye & Omolaja, 2017).

The successful implementation of science education curriculum requires the use of a variety of exemplary materials to enable the teacher to teach effectively and for the student to learn through a rich and varied selection of exemplary materials. For this reason, when possible, good quality exemplary materials should be available in the laboratory throughout the academic year. Finally, teachers must ensure that these are kept up to date and routinely inspected for both safety and quality.

2.5. Integration of Exemplary Materials in Flipped Classroom Instruction and Learners' Motivation

Motivation is an impetus to pursue or work to accomplish a goal and could either be intrinsic or extrinsic. Intrinsic motivation refers to the internal psychological drive an individual has to pursue and accomplish a given goal because it is enjoyable, exciting, fulfilling, or meaningful to the person. Whereas, extrinsic motivation on the other hand refers to the impetus that comes from outside an individual in the form of giving or withholding tangible rewards or meting out punishments (Shumow & Schmidt, 2013).

Motivation to learn is important in science education because of the bond between motivation, cognitive engagement and conceptual change (Pintrich, Marx, & Boyle, 1993). Learners typically have an affinity for nature and for that matter science. Connecting the science to be learnt to the reality of learners' lives, the relevance of their age-appropriate experiences, and the rigor of the science concepts can make science come alive in unique and meaningful ways for these learners. (Sparks, 2011).

To Shumow and Schmidt (2013), motivation is situational and as such depends on the goal and characteristics of the environment. Motivation is a state, not a trait. In reality, both extrinsic and intrinsic motivations play a complementary role in sparking learning but most schools rely heavily on extrinsic motivation. As a result, teachers have been exposed to and have access to many techniques that attempt to promote learning through the use of external means such as reinforcements. Nonetheless, most teachers have far less exposure to knowledge and strategies for promoting intrinsic motivation. Practising science teachers must include strategies that encourage learners to learn the science that will help them in class and in life (Sparks, 2011).

WAM- integrated models through flipped classroom approach is one strategy that teachers can use to encourage and motivate students to learn science since they provide a stimulus to intrigue, think and provoke discussion to generate scientific thinking (Long & Marson, 2003). Research findings showed that teachers who are effective at supporting learners regarding the affective domain also enable environment in students' learning and academic achievement in science (Shumow & Schmidt, 2013). Making the science real, relevant and rigorous for young children can help them to be more successful. A study on motivation to learn indicates that children are attracted to ideas that address both their cognitive and affective needs. Young children inherently have interest in nature, the environment and how things work. This serves as a springboard for science teachers to take advantage of the students' interests as a source for engaging and motivating students to high levels of achievement (Shumow & Schmidt, 2013; Sparks, 2011). WAM- integrated models have been found to be extremely motivating for learners at the colleges of education level including those students who have emotional and behavioral difficulties. Learners tend to stay longer on task with sustained levels of **in**terest and to interact confidently with their peers. According to Keogh and Naylor (1999), motivation serves as voices that speak to less confident student and gives them the confidence to discuss their ideas. Frequent use of the concept models approach does not appear to decrease the level of engagement of learners (Keogh & Naylor, 1999; Birisci, Metin & Karakas, 2010). WAM- integrated models activate two levels of inquiry among students. In the first place, they work in groups to engage in reading and experimenting and the other where they work individually to develop their understanding beyond class discussions. Group work can give students the confidence they need to move on to exploring science on their own. Finally, scientific rigor is also one critical aspect of science notebooks, where students can document their scientific experiences in ways they think are important to them. In addition, the consistency in recording information in the science notebooks adds more rigor for students as they consider how the recorded information before accenting their thoughts (Butler & Nesbit, 2008).

The use of WAM- integrated models makes science learning fun, causing concepts to be learnt in more pleasurable ways. The WAM- integrated models with alternative viewpoints help pupils to perceive concepts from different perspectives and encouraging active pupil participation in the lesson. In a typical lesson with WAM-integrated models, the students have the opportunity to discuss the topic either online or during face to face with each other. By giving them that kind of discussion opportunity, students play active role in the lesson. The colourful visual features of WAM- integrated models attract students' attention, causing them to focus principally on the lesson from beginning to end. Teaching via WAM- integrated models is more effective than the traditional methods because students are more interested and engaged. This makes students to retain the taught material longer than they do through traditional approach to teaching. Research proved that the earlier defective WAM-integrated models could create discussion environment in the classroom, encourage students to be more attentive and actively involved with the lesson, reveal students' misconceptions and help them develop alternative viewpoints and this generally make lessons more interesting and exciting (Keogh & Naylor, 1999; Balim, Inel & Evrekli, 2008).

A study by Birisci, Metin and Karakas (2010) indicated that using WAM- integrated models in instruction salvages students from traditional approach to teaching and helps science teachers improve their instructional pedagogical approaches to the teaching of science. WAM- integrated models make the lesson more real, interesting, captivating and students become more actively involved in the lesson. It creates a discussion environment in the classroom where students can improve their critical thinking skills, influence in positive way students' attitudes towards lesson and may have an important role in improving students' academic performance.

2.6. The Role of Integration of Exemplary Materials in Flipped Classroom Instruction

Learners do not always come to school as empty vessels to be filled by the teacher. Children are active cognitive agents who come to school after years of cognitive development (Committee on Science Learning, Kindergarten through Eighth Grade, 2007). They come to the classroom with a repertoire of knowledge based on intuitions, every day experiences, or what was taught in other contexts. This pre-instructional knowledge is referred to as prior conceptions or preconceptions. The students bring more to the interpretation of the situation than we realize. Whatever is learnt is conditioned by what they already know or what they know. What they know is equally as damaging as what they do not know. It is important for teachers to be aware of the preconceptions of their students because learning depends on and is related to students' prior knowledge (Bransford, Brown, & Cocking, 2000; Lucariello & Naff, 2016; Piaget & Inhelder, 1969; Resnick, 1983). Students interpret incoming information in terms of their current knowledge and cognitive organization. Learners try to link new information to what they already know (Resnick, 1983). This type of learning is known as assimilation (Piaget & Inhelder, 1969). When new information is incompatible with what learners already know, the new information cannot be assimilated, instead, the learners' knowledge would rather have to change or alter because of this new information and experience. This type of learning is known as accommodation (of knowledge / mental structure).

To maximize what exists in our students, teacher must take time to discover what learners actually bring to the class. According to Lucariello and Naff (2016), when presenting new information to learners, it is essential to first find out their preconceptions. This enables the teacher to get more potential misconceptions and offers students an opportunity to see how far they come in their understanding of newly learned concepts. One method used by teacher is simply asking at the start of a programme for information from the students. This information is based on their level of preparation, the kind of courses the learners have already taken in the field, and why they are taking the course. It could be in the form of classroom assessment called a 'background knowledge probe', or explained, a series of specific questions center about the content of the course. As Angelo and Cross (1993) explained, the questions focus on specific information or concept the student would need to know in order to succeed in subsequent assignments rather than on personal histories or general knowledge. The advantage of getting such information at the beginning is that it can offer valuable data not only about students' knowledge of the course but about their skills in communicating what they know and that by building on specific background knowledge the instructor can give students a familiar starting point, a 'hook to hang new information on'.

After assessing students' preconceptions about the content to be taught, it is imperative to consider the component in which their already acquired knowledge could be beneficial in building more robust understanding of new concepts. When students come into a class with initial impression of the curriculum, even if it is inaccurate, it could be evidence of previous content coverage or a tool for priming student thinking. Though it may seem that misconceptions are only barrier to learning, when used properly could serve a productive purpose in the classroom (Larkin, 2012).

Most importantly, it is always a good idea to check for misconceptions regularly so that it is not allowed to continue to detract the learning process. Until students are asked what they understand about what is being taught, teachers would never really know what is being learnt. Learning should be structured so as to bring those misconceptions to the attention of the students. The confusion is not often realised until it is too late. WAM- integrated models can be useful in this regard, eliciting and developing learners' ideas. Usually, learners readily engage in discussion when WAM- integrated models are used and as they attempt to justify their ideas, this expose their views to possibility of challenge by their peers. In looking for evidence and constructing suitable arguments to justify their ideas, learners often come to recognize for themselves that, there are more productive ways of understanding the materials (Naylor & Keogh. 2013).

Students' preconceptions when consistent with concepts in the assigned curriculum, are called anchoring conceptions. Learning, in such cases, is much easier. It becomes a matter of conceptual growth, enrichment, or adding to student knowledge. More often, teachers find themselves teaching concepts that are difficult for their students to learn because students' preconceptions are inconsistent with the concepts being taught. In this case, the preconceptions are termed alternative conceptions or misconceptions. (Lucariello, &Naff, 2016).

According to Lucariello and Naff (2016), alternate conceptions (misconception) can really impede learning for several reasons. Firstly, although misconception can be much enriched in students' thinking, students are generally unaware that the knowledge they have is wrong. In addition, students interpret new experience through these erroneous understanding, thereby complicating their inability to grasp new information accurately. Furthermore, alternate conceptions (misconceptions) tend to be very resistant to instruction because learning entails replacing or radically reorganizing student knowledge. Hence, conceptual change has to occur for learning to happen. This put teachers in the very challenging position of needing to bring about significant conceptual change in the students' knowledge. For all these reasons, misconception can be hard nuts for teachers to crack. However, several instructional strategies have to be effective in achieving conceptual change.

According to Dabell (2004), utilizing concept models in the classroom can reveal misconceptions and uncertainties on different kinds of subjects by helping students question their ideas, improve their thinking ability, look at events from dissimilar perspectives and hence connect and widen different concept activities. Using the models at the beginning of a lesson or midway through a lesson to teach chemical bonding and nomenclature of inorganic compounds can reveal and examine students' prior knowledge and thoughts, which can later be corrected as learning progresses. Learners also have the opportunity to listen to their peers' explanation about the correct science concept and build on their initial conceptual framework. This experiences give students opportunity to investigate and reinterpret the ideas being presented using the models (Kabapinar, 2005). During face to face discussions, low achievers' misconception emerged when they agreed with the characters with misconceptions also expressed their ideas and this led to exchange of ideas among pupils. Then, the pupils with correct conceptions took the role of challenging their peer's ideas and remedying their peer's misconception during this discussion. These enabled students to correct their misconceptions and construct the correct science concepts actively in an interactive environment through flipped classroom approach-models. Concept models are more effective when discussed in a mixed-ability group, this results in a greater degree of exchange and allows different ideas to surface which can then be debated (Dabell, 2008).

2.7. The Concept of Models in Teaching of Science

A model is a system of objects or signs of objects which reproduce some essential properties of the original system. It is simply a mind constructed picture of reality. Models are used as instructional tools because they aid understanding of phenomena. Creation of simplified models is an effective way of verifying the connection and fullness of theoretical concepts. Taber (2017) opined that it is the professional capability of every teacher to find ways to make complex ideas accessible to students. Based on this, it was not out of place on the part of the researcher to use integration of exemplary materials and flipped classroom instruction to make complex ideas associated with chemical bonding and nomenclature of inorganic compounds accessible to students.

This 21st century has witnessed a huge research effort into learners understanding of scientific concepts. Much of this research has been concerned with perceptions of learners' inabilities to understand scientific concepts or to develop conceptual understanding about mental models that are in accord with scientific or teaching models (Pfundit & Duit, 2017). The practice of chemistry and science is dominated by the use of mental models. This is argued by many authors that, since scientists seek to understand macroscopic properties, they inevitably need to consider what is happening at the microscopic level (Oversby, 2000). However, because we cannot see what happens at the microscopic level we need to develop mental images or mental models of matter and what its changes might be like at this level. This macroscopic-microscopic link in chemistry can be traced to the development of the atomic theory.

Atomic theory, although tremendously successful, is nonetheless a theory, a mental model of how scientists view the make up of the material world that surrounds us. Scientists' current theory of the nature of matter is intrinsically linked to Dalton's notion of the atom and the atomic nature of matter, which explains the formation of chemical bonding and nomenclature of inorganic compounds.

Many other theories and mental models in science and chemistry built upon atomic theory have important implications for the teaching of abstract mental models. Examination of chemistry content at different educational levels, shows that mental models are deeply embedded in chemistry content, and consequently in chemistry teaching and learning (Coll, 2005; Coll, Francis & Taylor, 2005; Eduran & Duschl 2004; Justi & Gilbert, 2005). Harrison and Treagust (2002b) proposed a typology of mental models which includes chemical formulae, mathematical models, analogy, physical artifacts, and diagrams such as maps.

A chemistry learner would of course need to learn things other than specific chemistry models to 'understand' chemistry to the satisfaction of teachers or chemistry professors (for example, chemical processes and reactions, conventions for naming compounds, etc.), but every feature of chemistry content and learning includes the use of at least one mental model (Harrison & Treagust's, 2001 typology). As a consequence, the learning of chemistry requires learners to learn about a variety of mental models, and learning about mental models dominates the learning process for this discipline (Harrison & Treagust, 2002a). This might stem from the fact that the bulk of the subject matter is at the microscopic level and without the use of the models, comprehension will be seemingly impossible. It is in line with this that WAM via flipped classroom approach was designed to facilitate the comprehension of selected chemical bonding and nomenclature of inorganic compounds

Gilbert, Boulter and Rutherford (2000) pointed out that, what researchers encounter or uncover during inquiry are in fact participants' expressed mental models; in other words, how they describe their mental models to education researchers. In some instances this results in methodological complications (Johnson & Gott, 2003). Individuals may hold a particular mental model, but finds it difficult to express or articulate this model in manner that is clear and meaningful to a teacher (Norman, 2002). Furthermore, an individual's mental model may not be 'neat' or consistent artifact that appears in textbooks or that researchers construct during inquiry. Glynn and Duit (2002) commented that, individual mental models are 'sloppy' and 'inconsistent', irrespective of any difficulties associated with it. Hence, comparison of individuals' mental models is commonly associated with inquiry that works from a deficit model in which learners' mental models are compared with scientific or 'correct' teaching mental models that appear in textbooks or lecture notes.

One of the key findings from the science education literature is that, scientists and expert modellers see and use mental models in very different ways to novices or learners - and indeed many teachers (Coll, 2005). Teachers tend to use models to aid understanding, for example, draw upon analogy to guide learners towards a 'better' understanding of the 'correct' model (Dagher 2001a, 2001b; Gilbert & Boulter, 2001; Justi & Gilbert, 2005; Weller, 2001). Scientists understand that a model by definition has limitations (Maksic, 1990). That is, models share only some attributes with the target (what is to be modelled). As a consequence, Taber (2002) pointed out that, if a model did not possess limitations (that is, differ from the target in some way) it would in fact become the target or artifact (or process) that is being modelled. This does not mean that scientists discard models that possess limitations, indeed they continue to use models. A simple example connected to this inquiry is the so called ligand field theory (Coll, 2005). In this model the bonding between atoms or groups of atoms surrounding a metal centre is proposed to arise from pure electrostatic interaction between an electron deficient centre (the metal) and attached electron rich groups (usually called ligands).

This electrostatic interaction results in the formation of a ‘field’ that attracts the ligands to the metal; an examination of this model shows clearly how simplistic and crude a model is. The model also possesses many well-established limitations (e.g., it fails miserably to explain the spectrochemical series), but the crystal field theory is still in common use even in research chemistry (Smith, 2001). Scientists still use crystal field theory (model) in their research even though there are severe limitations, simply because it works well in certain well-defined circumstances; and is helpful in understanding certain aspects of chemistry (Taber, 2017). Aufbau principle of electron configuration is similarly best explained by using models (Coll, 2005). Scientists thus see models in a functional, utilitarian capacity, and recognise that, a model is intended to serve the user (Borges & Gilbert, 2001). Scientists are able to visualise mental images of abstract things rather than physical entities. So, whilst learners and novices are able to mentally picture physical objects or artifacts, scientists are able to conduct experiments and use mental models to conduct mental ‘experiments’ for the purpose of prediction. Another key difference between scientists and novices use of mental models is the tendency for scientists to use physical models (Coll, 2005; Coll et al., 2005, Eduran & Duschl, 2004). The scientist is commonly capable of constructing a mental model based on another mental model.

To illustrate scientists' mental models, chemical bonding itself is based on another abstract mental model as well as chemical bonding and nomenclature of inorganic compounds, the atomic theory which posits that, matter is made up of small, microscopic particles of a specific nature and form. Scientists thus use mental models for a variety of purposes. They use them to understand macroscopic phenomena as described above, but they also use mental models to generate new hypotheses (Justi & Gilbert, 2005). They may go on to modify or use their mental models to evaluate and expose the limitations of their own scientific inquiry.

2. 8. Challenges Associated with the Use of Science Models

The use of models in the classroom is personal and commonly involves the use of analogy. Dagher (2001[a], 2001[b]), for example, reported that, teachers draw upon analogy when they feel their explanations have not been understood by learners. Analogy use has been reported to aid learner's understanding of variety of models like kinetic theory to explain dissolution (Stavy, 2001, 2005; Taylor & Coll, 2007; Lawson, Baker, DiDonato, Verdi & Johnson, 2003). As pointed out, learners seldom see models as mental constructions. This seems to come about because learners frequently confuse mental models with physical models, seeing models as copies of reality. This results in a number of alternative conceptions in chemical bonding and nomenclature of inorganic compounds

Harrison and Treagust (2002[a]) found that, secondary school learners thought of atoms as small spheres or balls. Stavy (2001) reported confusion between ball-and-stick models and mental models. Common themes about learners' alternative conceptions for chemical bonding and nomenclature of inorganic compounds emerge from the literature and include confusion of intermolecular and intramolecular bonding (Coll &

Taylor, 2001), confusion over polar covalent bonding and ionic bonding (Coll & Treagust, 2002, 2003; Coll & Treagust, 2004) and that the formation of ionic bonds occurs as a result of electron transfer (Oversby, 2000 Taber & Coll, 2002). The literature points to significant difficulties in learning and teaching of conceptual models in both science and chemistry. The study of learners' conceptual models is dominated by a few conceptual themes, namely, atomic theory (Harrison & Treagust, 2001) and kinetic theory (Taylor & Lucas, 2007), with few studies on chemical bonding (Nicholl, 2001; Taber & Coll, 2002). This is a remarkable observation given that an understanding of chemical bonding and nomenclature is crucial to the understanding of carbon compounds, structure of proteins and thermal energy among others.

2.9. Students' Misconceptions in Chemical Bonding and Nomenclature

According to Anamuah-Mensah and Apafo (1989), the conceptualisation of the chemistry aspect of science is indeed difficult for learners of science. This was confirmed by Johnstone (1993) and Khoo & Koh (2018) that, the acquisition of scientific concepts especially the chemistry aspects poses a serious challenge to most students. The difficulty associated with the acquisition of concepts in chemical bonding and nomenclature of inorganic compounds is as a result of the use of traditional approaches or methods in teaching concepts in chemical bonding and nomenclature of inorganic compounds. According to Teichert and Stacy (2002), many studies conducted worldwide revealed that the traditional approach of teaching the concept of chemical bonding and nomenclature of inorganic compounds is problematic to both low and high achievers because it leads to rote learning. According to Henderleiter (2001), students regardless of both gender and academic ability rely on rote memorisation to determine which elements are involved in forming a chemical formula because of the traditional approach used for teaching the chemical bonding and nomenclature of inorganic compounds. In many cases, it seems that students often memorise a list or a pattern but are not able to fully reason through it.

Chemical bonding and nomenclature of inorganic compounds as a concept has its own challenges. According to Taber (2001), many chemistry teachers lack both content and pedagogical knowledge to teach chemical bonding and nomenclature of inorganic compounds. As a result of this, such teachers easily mislead students because they lack both content and pedagogical knowledge. During the last two decades, researchers have found that students lack a deep conceptual understanding of the key concepts regarding chemical bonding and nomenclature of inorganic compounds and fail to integrate their mental models into a coherent conceptual framework (Taber, 2002). Chemical bonding and nomenclature of inorganic compounds are considered by chemistry teachers and chemists to be a very complicated concept (Robinson, 2003; Taber, 2001). This is attributed to the fact that learners easily form erroneous concepts during lessons due to misunderstanding or lack of understanding passed from teacher through inaccurate teaching. According to Taber (2002), most alternative conceptions in chemistry are not derived from the learner's informal experiences of the world but from prior science teaching. If so, we need to ask ourselves how often can teaching strategies and pedagogy mislead students. This calls for a comprehensive preparation of chemistry teachers both in content and pedagogy to reverse the problem.

Also, students' alternative conceptions, which are considered to largely stem from the way they have been taught, have been labeled as pedagogical learning impediments

(Taber, 2001). Strict adherence to the octet rule by teachers is part of the problem as it can lead to learning impediments. Octet rule is the idea that atoms attain stability if the valence (outer most) shell of the atom contains eight electrons. Taber and Coll (2002) suggested students should not learn by using the "octet framework," because it could lead to learning impediments. This is so because the existence of chemical formula which does not lead to atoms having full electron shells would be a mystery to many students. Moreover, students may have difficulty accepting anything that is not clearly explicable in "octet" terms. Hurst (2002) also referred to the "octet rule" as an over simplification of the electronic structure of molecules. A study carried out by Dun (2005) revealed that, students from all levels of education have difficulties in learning certain chemical bonding and nomenclature of inorganic compounds concepts and this affects their ability to do well in chemistry at the tertiary level. This is confirmed by various reports of the Chief Examiner of WAEC (2004) that, candidates who take part in Chemistry Examination would continue to produce poor results over the years because of poor pedagogical approaches to the teaching of the subject.

According to Levy-Nahum, Hofstein, Mamlok-Naaman and Bar-Dov (2014), students irrespective of cognitive ability groups possess a variety of misconceptions regarding Chemical bonding and nomenclature. Although several methods were put in place to explore and provide lasting solution to the problem, the same crucial misunderstanding regarding the chemical bonding and nomenclature of inorganic compounds has arisen each year for the last two decades (Trimpe, 2003). Some of the methods used included " A new teaching approach for the chemical bonding concept aligned with current scientific and pedagogical knowledge" (Levy-Nahum et al, 2014) and "Fun with ionic compounds- ionic bonding games actively engage students in processing key concepts" (Logerwell & Sterling, 2017). Available literature indicates that "even if they understand atomic structure and ion formation, it is still difficult for students to visualise how ions are fitted together to form a compound" (Logerwell & Sterling, 2017).

2. 10. Effects of Inadequate Models on the Teaching of Science

One of the activities in science is experimentation. It provides a forum for practicalising the theoretical knowledge gained in the classroom and for demonstrating the psychomotor skills of teachers and learners. It further aids the understanding of difficult concepts in the curriculum; creates opportunity for the testing of facts and theories in science. It is believed that learners can achieve more if given the opportunity to practicalise what they have been taught in the classroom. Experimentation thus gives room for better attainment of lesson objectives. Experimentation in science is however dependent on the availability of science teaching and learning materials for proper understanding, development and application (Ugwu, 2008).

One of the goals of science education in Africa is the acquisition of appropriate skills, the development of mental, physical and social abilities and competencies as equipment for individual to live and contribute to the development of the society (Asiruiwa, 2005). The realisation of this goal can be impeded by non-availability of science models that can ensure effective teaching and learning. Many authors have, however, reported the issue of inadequacy of science models in educational institutions in Africa (Ogunleye, 2007; Ugwu, 2008; Ogunmade, Okedeyi &Bajulaiye 2006; Nwagbo, 2008; Osobonye, 2002). It has also been reported that the non-availability of science models in educational institutions serve as barrier to effective science teaching (Adeyemi, 2007), which confirms the persistent poor performance of students in science in educational institutions in Africa over the years. The situation is attributed to various factors. One of the major issues is inadequate science models in African educational institutions. The issue of inadequate funding of the education sector is also a contributing factor to the inadequacy of science teaching and learning materials in educational institutions. Over the years, financial allocation to the colleges of education in Ghana has been inadequate for the needs of the sector thus making it impossible to procure adequate models for teaching and learning.

Asiruiwa (2005) regarded education in science and technology as centrally and necessarily concerned with teaching or training of individual in order to acquire systematic skills, knowledge and attitude and application of these to the society. Inspite of the benefits of education to man and the society, the educational system has continually turned out products (graduates) with skills and attitudes that are neither needed in the modes of production nor saleable in the limited industrial-commercial establishments. This, according to Nwagbo (2008) has continuously led to mass unemployment of school leavers with the attendant problem of increased economic, social and moral vices. Aggarawar (2001) declared that all knowledge a learner gains will be of no use if he or she cannot make ends meet in his life after school.

2. 11. The Role of Improvisation in Providing Science Teaching and Learning Materials

Various authors have defined the concept 'improvisation' in different ways. Ogunbiyi, Okebukola and Fafunwa (2000) defined it as the act of substituting for the real thing that is not available. Bajah (2002) conceived it as the use of substitute teaching and learning materials where the real one is not available. Kamoru and Umeano (2006) further define it as the act of using materials obtainable from the local environment or designed by the teacher or with the help of local personnel to enhance instruction. According to Ihiegbulem (2006), it is the act of substituting for the standard instructional materials not available, with locally made instructional materials from readily available natural resources. From these varied perspectives, improvisation entails the production of instructional materials using available local and cheaper resources and the use of such instructional materials for effective teaching.

Improvisation serves the following purposes in the education system:

- Reduces the money spent on the purchase of instructional materials in educational institutions;
- Ensures the realisation of lesson objectives;
- Helps in solving the problem of lack of instructional materials in educational institutions;
- Gives room for a teacher to demonstrate his creative skills;
- Gives room for the use of cheap local materials as alternatives to the expensive foreign ones;
- Encourages students towards the development of creative abilities;
- Enables teacher to think of cheaper, better and faster methods of making teaching learning process easier for students;
- Affords students the opportunity of becoming familiar with resources in their environment.

There is no need saying that science and technology plays crucial role in the development of a nation. According to Okeke (2007), science and technology serves as the key to modernising or developing a society. The developed nations in the world today have achieved greatness due to the special attention paid to science and technology. One of the strategies for enhancing the growth of science and technology in a nation is by paying attention to the training of children at the foundational stage. This implies that there should be more focus on science and technology at the primary, secondary levels and more especially at the CoE level. Over the years, the issue of inadequate instructional materials for the teaching of students in educational institutions in Africa has been predominant. It is therefore imperative that the issue of improvisation of instructional materials be given serious attention by attaching improvisation to science education programmes.

Many factors make the call for improvisation of instructional materials in educational institutions in Africa expedient. One of these is the persistent poor funding of the education sector. Over the years, financial allocation to colleges of education has been inadequate for the realisation of educational objectives. There are therefore inadequate science instructional materials in colleges of education in Ghana. For instance, many authors such as (Gilbert, Boulter & Rutherford, 2000) have observed that, ineffective teaching of science in educational institutions in Africa is due to non-use of science instructional materials for teaching, among other factors. Consequently, there is poor performance of students in science in both internal and external examinations (Eduran & Duschl, 2004; Justi & Gilbert, 2005).

2.12. The Use of Susman (l983) Model in Relation to Diagnoses of the Problem

Initially, the problem was identified as level 100 students' inability to answer test items based on chemical bonding and nomenclature of inorganic compounds correctly. Data were collected from both class assignments and quizzes for a more detailed diagnosis. The diagnosis revealed quite a number of weaknesses. The weaknesses included inability to identify chemical symbols, inability to write electronic configuration for quite a number of given elements and how to understand ion formation as well as oxidation states.

This was followed by a collection of several possible solutions from which integration of exemplary materials and flipped classroom instruction emerged as a plausible plan of action and implemented. Data on the results of the intervention were collected, analysed and the findings interpreted in the light of how successful the integration of exemplary materials and flipped classroom instruction has been. This was done by adopting action research model used by Susman (l983) shown in Figure 2. At this juncture, the problem was not re-assessed and the process never repeated another cycle due to remarkable success achieved.

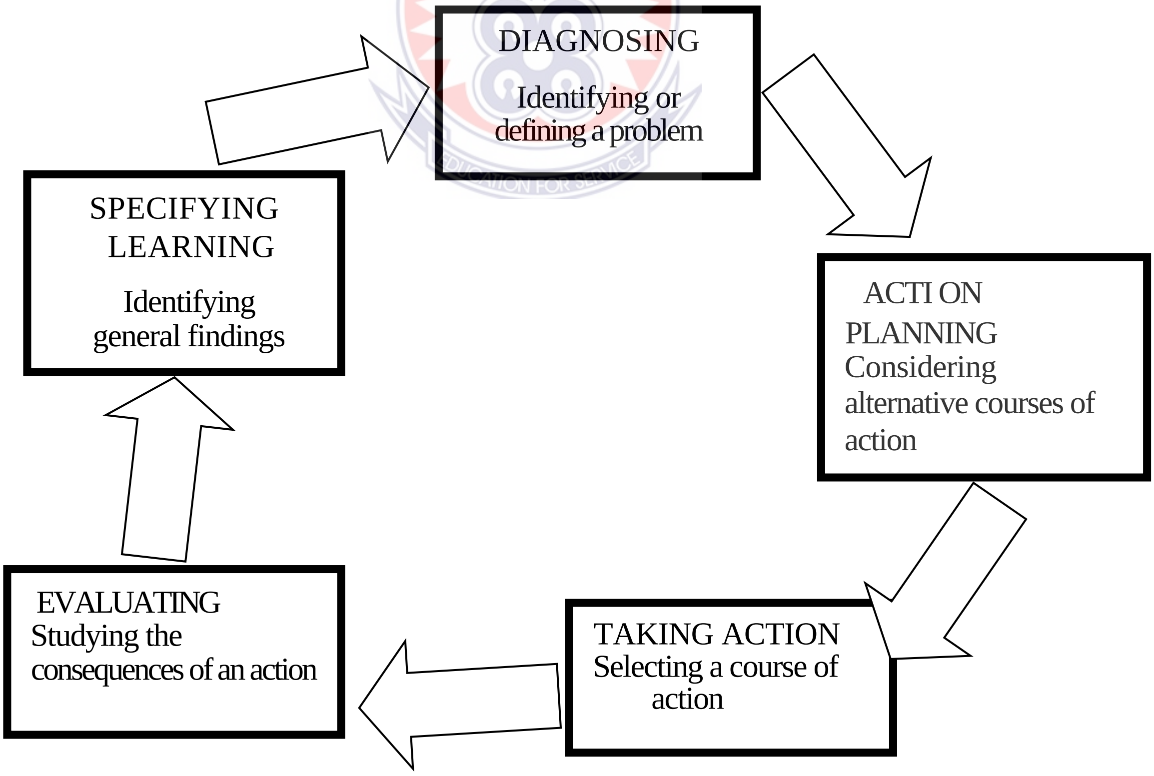


Figure 2: An action research model (Adopted from Susman, l983)

2. 12. Empirical Framework

Conceptual model is a product of recent advances in cognitive science and the new philosophy of science. Contemporary perspectives of cognitive psychologists and the new philosophers of science on cognition view learning as an active internal process of construction where the learner's prior knowledge plays a significant role in further conceptual learning (Ausubel, 1968; Ausubel, Novak & Hanesian, 1978; Novak, 2013). These educators consider learners to be the architects of' their knowledge because they construct their own idiosyncratic meanings of concepts and natural phenomena.

The new philosophers of science reject the traditional cumulative view of scientific knowledge and replace it with a conceptual-change view as reflected in the works of Kuhn (1970), and Lakatos (1970), among others. In general, it is these newer ideas of cognitive psychologists with constructivist epistemological views and the new philosophers of science that form the cornerstone of Wooden Atomic Models. However, Ausubel (1963, 1968) and Ausubel, Novak and Hanesian (1978) cognitive assimilation (subsumption) theory, formed the theoretical foundation of Wooden Atomic Models. The use of Wooden Atomic Models which is an exemplary material constitutes an effective pedagogical approach for teaching bonding and nomenclature of inorganic compounds.

The innovative Wooden Atomic Models being an improvement over conceptual models that had promoted logical reasoning and thinking among students in their learning. It has been established that many educational benefits that expand from a wide variation of meaningful conceptual understanding has the potential of enhancing students' achievement (Vodovozov & Raud, 2015; Schaal, 2010). Most of the findings indicated that by presenting alternative ideas in a visually manipulative and interactive manner could lead to further development and refinement of same. Since then, research and feedback from teachers and students have led to a variety of improvements in the architecture, format and presentation of conceptual models. For several years, Hurst (2018) ground-breaking research provided the evidence for how conceptual models can be implemented in the classroom and its impact on learners. More recently, a wide range of researchers have added to that research base by reporting that, teaching through the use of conceptual models promotes conceptual change by eliciting misconceptions and challenging same cognitively (Dun, 2015; Hurst, 2012; Taber, 2001). The models help to support progression in students' understanding of scientific ideas and increases enquiry learning skill and perceptibility. Conceptual models are also valuable for their ability to concretise scientific ideas by having alternative ways of looking at the conditions under which bonds are formed. In this way, conceptual model help students to question and critique their own thoughts, consider perspectives which might contradict their views before solving the problem at stake (Lim, 2011; Koc, 2012).

Broggy and McClelland (2010) considered what made conceptual models more effective using research to inform practice. The study was conducted to investigate how conceptual models impacted students learning and to propose several ways of making them a more useful education tools. Broggy and McClelland (2010) used both case study and pre-and post-experimental research designs. The study revealed that conceptual models were equally effective as worksheets in remedying students' misconceptions and helped them to understand scientific ideas. Furthermore, appropriately used models do not cause change in students' response patterns but rather minimizes class management problems during whole class activity.

Ajaja (2011), Mouton (2008) and Broggy and McClelland (2010) revealed that conceptual models can function as effective threshold tools to get children to engage in their own manipulations of inorganic chemical compounds with little experience in manipulation and hands-on learning. This process also leads to reasoning with concepts and evidence. It was also concluded that conceptual models are effective stimulus to trigger argumentation and scientific investigations because of their manipulative nature. However, it continued by asking teachers and researchers to rehearse properly and adequately before teaching students how to manipulate the models. Thus, the role of the teacher is very important to achieve results.

In 2010, pre-service elementary teachers' views on conceptual models were studied using mixed research method, such as questionnaires and interviews. The subjects taken comprised 40 fresh university students enrolled in an elementary teaching department in Northeastern Turkey in the spring 2009 semester. Data were gathered and analysed after six- ten weeks. The results suggested that using conceptual models in instruction saved students from boring traditional lecturing and as such helped teachers to improve their instruction and aligned it with the constructivist learning theory, made lectures more interesting and entertaining, and increased students' involvement in the lecture. The results further indicated that conceptual models create discussion environments where students can improve their communication and critical thinking skills and positively influence students' attitudes towards the lessons particularly and school in generally. In sum, conceptual models may have a potential role in improving students' academic achievement.

Iruka, Chinedum, Denis, Abdoulaye and Omolaja (2017) explored the use of conceptual models accompanied by specially designed assignment sheets in supporting Grade 11(eleven) learners to plan scientific investigation involved in naming inorganic compounds. This design-based study followed a continuous cycle of design, enactment, analysis and redesign which is typical of design-based research. The findings suggested that conceptual models and the related specially designed assignment sheets enabled the students to take first steps in naming inorganic compounds that would had been done at a higher grade later.

Hay, Kinchin and Lygo-Baker (2008) probed the use of conceptual models in naming organic compounds using constructive science and technology education. This constructive approach discusses the effect of the use of conceptual models and the use of conceptual models in science education. The study demonstrated that conceptual models are visual tools which enable students to participate actively in naming the compounds and the learning environment in general and as such is used as a stimulus for argumentation in class. The use of conceptual models in science education was known to help students to construct their knowledge. Mouton (2008) studied the effects of conceptual model worksheets on students' conceptual understanding of isomerism. The study also investigated the effects of conceptual model worksheets on both male and female and their interactions on pre-service science teachers' conceptual understanding of isomerism. They were 90 students from three intact classes and were of Caribbean origin. A quasi-experimental design was used as the research approach. The experimental group studied isomers using conceptual model assignment worksheets prepared in consideration with a constructivist view of learning, while the control group studied the lesson unit with traditional instruction. Students' conceptual understanding of isomerism was measured by a three-tier misconception test. The main effects of intervention, gender and their interactions on post-test scores were examined via ANCOVA test. The data analysis indicated that, the concept models and the assignment worksheets synergistically produced a statistically significant intervention effect. Nonetheless, gender and gender intervention interaction effect on student' post-test performances were not significant.

While Mouton (2008) considered the effect of conceptual models on students' understanding of an aspect of organic chemistry, McClelland (2015) study on the effects of conceptual models on general chemistry self-efficacy of 7th Grade Students explored the effect of conceptual models on students' overall perception of their level of Self-efficacy towards general chemistry. The research was designed as the pre-test post-test with quasi experimental control group. The respondents were composed of 120 students schooling on the European side of Istanbul during the 2013/2014 academy year. "The impact of chemistry on our daily lives" was taught for six weeks using conceptual models during lesson presentations. Homogenous groups, consisting of five students sharing the same opinions were utilized in order to enable them discuss the concepts more comprehensibly and to question their own thinking patterns by creating a social learning environment. Data were collected using "Chemistry Self Efficacy and Motivations scale" and through the written opinions of the students about the implementation process. The quantitative data were analysed using t-test for dependent and independent samples, while the qualitative one was analysed using descriptive statistics. The results of the research indicated that conceptual models have appositive effect on the students' perception level of General Chemistry Self-efficacy and Motivation enhancing Factors (anxiety and enjoyment levels). This means that, the student greatly enjoyed conceptual models and their interest in the lesson increased, and they gained motivation that they would love to choose chemistry as a career. Khoo and Koh (2018) on developing instructional material using conceptual models to enhance pre-service teachers' motivation enhancing factors such as self-efficacy, anxiety and enjoyment level, reechoed the importance of instructional models. However, they urged further research should be undertaken in order to investigate its effectiveness in a comparative manner after revising the architecture of the conceptual models and rectifying the deficiencies associated with same.

Logerwell and Sterling (2017) explored the use of the conceptual models for probing students' understanding of science, focusing on student teachers in the UK. The study examined the impact of the strategy on their attitudes to assessment as to whether it helped them to begin to restructure their understanding, and whether it might provide a possible strategy for them to use in their own teaching. The results suggested that, the strategy was potentially valuable as a means of assessing students. Dun (2015) probed the effects of computer-aided conceptual models and outdoor science activities on first year university students' awareness of water pollution. In addition to creating awareness of water pollution via computer aided conceptual models applications, the study also sought to help the students identify the chemical composition of water pollutants and to determine the appropriate practices to curb water pollution. The study was conducted in the Mugla province of Aegean Region in Turkey using a single group pre-test post-test model. The data for the study were collected through open ended questions and semi-structured interview questionnaire about water pollution. Semi-structured interviews were carried out with students. The data collected from the open-ended questions were coded. After the implementations, it was found that, there was an increase in the correct answers of students on water pollution. Also, all students interviewed gave positive opinions regarding the implementations. The implementations suitably enabled the students to identify the chemical composition of water pollutants and determined the appropriate practices to curb water pollution.

Taber (2017) researched on the effects of conceptual model on academic achievement in instruction on ionic bonding. The purpose of this study was to compare the effect of conceptual model on academic achievements and activity-based action on ionic bonding. The matching-only design, which is quasi experimental was used in this study. Two different groups participated in the study. One of the groups constituted the control group, used activity-based teaching. The experimental group on the other hand used conceptual models approach as instruction. The SPSS 16.0 packet programme was used in the analysis of the data in this study and revealed that the experimental group, taught using conceptual model approach performed significantly better than those taught with activity-based instruction. The finding also shows that, the conceptual models method is an effective method of teaching ionic bonding.

However, the account of how the model has been successfully used to enhance teaching and learning would be incomplete without making references to such experiences from medical, physics and chemistry classrooms. Medical Classroom: In multiple classrooms, short videos about the current medical topic, Rheumatology, that was being taught in the class were created and uploaded to youtube or emailed to students for a medical class. The students were to watch the videos before attending lecture. The lecture class was then used to focus on application of the material learnt in the videos through case studies and activities in order to give students a more interactive type of learning in the classroom (Ryback & Sanders,1980; Bergmann & Sams, 2012; Sparks, 2011). In order to re-inforce the use of videos for prelecture, students were asked to take a quiz or complete a home work assignment and submit it before class (Sparks, 2011).

In one instance, the flipped classroom technique was implemented in a physics classroom. The pre-Lecture videos were not made specifically by the teacher, but instead they were down loaded from other data bases like Ted, You tube, and Khan Academy. Before class, students were supposed to watch the video lecture, take a quiz, and write down any questions they had. During class, the information in the videos was applied to questions through group discussion activities and hands-on simulations. Students were also encouraged to attend other public lectures about soil physics to gain more information.

(Bergmann & Sams, 2012; Sparks, 2011).

In a chemistry class, pre-lecture materials were distributed through Moodle and Youtube. In class, students independently completed problems while the Professor acted as a guide in case anyone needed assistance. Along with practice problems, laboratories were also completed during regular class time, and workshops about choosing the appropriate approach, order and technique were implemented. Study materials for tests were administered through the videos in order to prepare students for assessments. In the chemistry setting, only certain topics including chemical bonding were conveniently flipped. For example, the flipped classroom technique was implemented for chromatography and IUPAC nomenclature of inorganic compounds, but the traditional classroom teaching method was used to teach spectroscopy. The lecture videos went over the theory, instrumentation and explanation of the flipped topics. Administered examination for the flipped topics were then based more on what was done in class than the lecture videos (Abeysekera, Lakmal; Dawson & Phillip, 2015; Marco-Ronchetti; 2019; Topp, 2011).

The researches outlined above were conducted to improve the teaching and learning of inorganic chemical compounds but none of them employed the use of the untested integration of exemplary materials into flipped classroom instruction. Again, no study has been conducted using this untested method to teach in any Ghanaian schools. This therefore necessitated the need for the study.

CHAPTER THREE

METHODOLOGY

3. 0. Overview

This chapter looks at the research design, population, sample and sampling technique, research instruments, pilot- testing, validity and reliability. It also includes data collection procedure, data analyses, and intervention administration.

3. 1. Research Design

A research design is a plan or an outline that specifies how data relating to a given problem should be collected and analysed (Merriam, Caffarella, & Baumgartner, 2017). Also, the quality of a research is determined by how the data gathered is used to solve the stated problem of the study (Duffy & Jonassen, 1992; Merriam, Caffarella, & Baumgartner, 2017). According to Cohen, Manion and Morrison (2002), a research design is the organizational plan for a research. The purpose of the study dictates its methodology and research design. This refers to what specific research questions are and which design offers the best way to use data in order to answer them (Silvennan, 2006). In searching for appropriate design, the researcher came across Experimental, Quasi-experimental, Descriptive survey, Case study and Developmental research design among others.

The action research design was adopted for this study. This approach made it possible for the intervention strategy to be studied during its enactment process. Features that emerged during the enactment process always informed changes to the strategy and allowed understanding of underlying learning issues (Sandoval & Bell, 2004). Action research contributes to the development of effective learning environment and using such environment as natural laboratories to study teaching and learning (as cited in Letsoalo, 2011). Furthermore, action research is responsive and evolving.

Again, this design makes it possible to respond to the emerging needs of the situation in a way that some research designs cannot. The process also takes place gradually. The cyclical nature of it helps in making it responsive and aids precision. According to Duffy and Jonassen (1992) and Merriam, Caffarella and Baumgartner (2017), action research is a simple set of thoughts and methods that can introduce one to the power of systematic reflection on one's own practice. It involves taking action to improve teaching and learning with orderly study of the action and its consequences. Carr and Kernmis (1983) defined action research as a form of self-reflective inquiry that can be utilized by teachers in order to improve the rationality and justify their own practice, their understanding of these practices and the situations in which these practices are carried out. Bums (2000) described it as a professional developmental tool since it tries to enhance the capacity of teachers as producers of professional knowledge in contrast to enhancing their capacity to apply their knowledge.

Ary *et al.* (2002) distinguished between two types of this developmental tools. These include Type 1 and Type 2. Type 1 is the study of specific product or programme design, development or evaluation of a project. Lessons are learnt from developing specific products and analysing the conditions that facilitate their use. Type 2 is the study of a general design, development, evaluation processes, tools, or models. New design, development, evaluation procedures, models, and conditions that facilitate their use are generated (Ary *et al.*, 2002). The researcher adopted the Type 1 developmental tool which aimed at developing teaching and learning materials (WAM) to improve the teaching of chemical bonding and nomenclature of selected inorganic compounds that can be used by both teachers and students of science and in particular Chemistry in Ghanaian schools.

The researcher's choice of developmental tool type 1 action research design is summarised as follows:

- Flexibility in developing an intervention step by step within the context of the problem.
- Developmental tool type 1 type of action research design is seen as a means of influencing educational practices by experimenting with promising interventions and seeing whether they work in real classroom setting (Pimpro, 2005).
- It is methodologically eclectic, that is, it employs a variety of research methodologies, applying any tool that meets their requirements.
- Developmental tool type 1 action research design may include a number of component parts. Sub-studies may be conducted to analyse and define the instructional problem, to specify the content, or to determine instrument reliability and validity.
- Sub-studies may be conducted to provide a formative and summative evaluation, or a follow-up of post instruction performance. Recent study following this line of investigation in similar context in Africa was in Tanzania by Pimpro (2011). Again, there are a number of action research models. This study adopted Susman (1983) model which distinguishes five phases of action research to be conducted.

3.2. Population

The target population was all students from the ten Colleges of Education in the five Northern regions of Ghana. However, the accessible population consisted of all level

100 students in the 3 partnership Colleges of Education (Gbewaa, Gambaga and Tumu) in northern part of Ghana.

3.3. Sample and Sampling Procedure

In selecting the sample, the purpose of the research, the representativeness of the sample, the availability of the participants, the accessibility of the site and participants, sample size and cost involved must all be considered (Cresswell, 2007; Altricheter, Feldman. Posch & Somekh, 2008; Alhassan, 2006). Convenience and purposive sampling techniques were used to draw the desired sample size. These techniques ensured equal gender representation and easy access to students by the researcher since the students were in their assigned classes.

Precisely, in the first stage of the sampling process, convenience sampling technique was employed to sample Gbewaa out of the three partnership Colleges of Education. Gbewaa was chosen as against the rest because, apart from the fact that the students could be most easily contacted and were readily available to take part in a study, proximity of the researcher to Gbewaa and willingness of the Gbewaa's administration to co-operate with the researcher were equally taken into consideration. The following fundamental assumptions were also made about the Northern Colleges of Education: students from these colleges used a common science curriculum at both the JHS and SHS levels, all of the students do the Science course, FDC 114, within which the topic of interest, chemical bonding and nomenclature of inorganic compounds is taught, the students were admitted based on the same entry behavior spelt out in the admission policy and samples drawn from level 100 students of any one of these Colleges of Education could therefore be considered as having similar characteristics of the entire Northern Colleges of Education.

Secondly, Purposive sampling was used at this stage to select one intact class of 40 students consisting of equal number of females and males (20 males and 20 females) from Gbewaa College of Education. Having a sample size of 40 is consistent with Aryl et al. (2017) that, there is no rule for determining sample size action research. Aryl et al (2017) further stated that the sample size depends on what the researcher wants to know, what is at stake and the purpose of the research.

3.4. Research Instruments

Two (2) main types of instruments were used for data collection. These included achievement test and questionnaire. The test consisted of Chemical bonding and nomenclature Test (CHEMBONOT) and Chemical bonding and nomenclature Performance Test (CHEMBONOPET). The CHEMFONOT which was linked to conceptual understanding of chemical bonding and nomenclature was adapted from an original called Ionic Bonding Achievement Test (IBAT) developed by Trimpe (2007). Researchers including Robinson (2013), Taber (2014), Teichert and Stacy (2002) and Trimpe (2017) used modified versions of Ionic Bonding Achievement Test /Ionic Bonding Test (IBAT/IBT) to assess students and teachers' achievements on chemical bonding and nomenclature.

The IBAT has test items similar to what was used by Trimpe (2017) for diagnostic purposes regarding chemical bonding and nomenclature. The CHEMFONOPET used by the researcher was similar to IBT except that it contained additional test items on oxidation states meant to elicit prior conceptions of students on the topic which was in line with the prescribed course outline. The instrument consisted of three (3) sections namely A, B and C. Section A provided general information about the purpose of the test. B was on biodata such as sex, age and levels among others. However, it was not compulsory for the participants to write their names and levels. The section C was made up of two parts, namely part 1 and part 2. The part 1 consisted of (ten) 10 test items meant to elicit prior conceptions of students on oxidation states. Part 2 contained 30 test items in Chemical bonding and nomenclature of inorganic compounds. This was meant to assess student's knowledge and difficulties before determining the appropriate intervention to assist the students.

The original form of the instrument was slightly modified. The modification was to replace some of the elements present in the IBAT/IBT with elements that were found in the prescribed course outline for Colleges of Education programme. The items increased in complexity from the beginning to the end in order to reflect the thinking levels of students as much as possible. For the pre-test (see Appendix A). The same form was used for post test to assess the effects of the intervention (Appendix B). Time allotted for students to respond to either the pre-test or post-test was 40 minutes. Each correct response in any of the test instrument attracted one mark.

However, part 1 was scored separately out of 10 marks from part 2 which was scored out of 30 marks before summing the two up to give a total of 40 marks in all using validated scheme (Appendix C). The justification for this separation was to enable the researcher to determine differences between the preconceptions and post conceptions after the implementation of the intervention. For this reason, the post-test was scored using a validated scheme shown in Appendix D.

On the other hand, the questionnaire used for data collection consisted of pre-intervention and post-intervention questionnaire. Both questionnaires did not have the same number of statements and were responded to before and after the intervention. The land mark difference between the two was the exclusion of statements based on one of the three aspects (the self-efficacy aspect) from the pre-intervention questionnaire. That aspect was based on the intervention (that was the use of WAM via flipped classroom approach for which the respondents were yet to be introduced to). This exclusion prevented a situation where the respondents might have responded to statements without understanding. Furthermore, the Pre-Intervention questionnaire (Pre-Intque) was structured to comprise two sections with a total of 20 statements (see Appendix E) whereas the Post-Intervention questionnaire (Post-Intque) comprised three sections with a total of 30 statements (see Appendix F). Both questionnaires helped in eliciting the required responses to determine the effect of the intervention on motivation. The sections included pre-service teachers' anxiety level, enjoyment level and self-efficacy level in chemical bonding and nomenclature of inorganic compounds.

For each of the sections, the respondents were required to respond to each of the ten statements by choosing from options based on a 5-point Likert scale ranging from Strongly Agree (SA=5). Agree (A=4), Not Sure (NS=3), Disagree (D=2) to Strongly Disagree (DA=1).

The respondents used 20 minutes to complete the questionnaire since all the statements of the questionnaire were closed - ended types and were meant to be precise and specific for easy elicitation of responses. The use of questionnaire for this study was very appropriate because all respondents were characterized by high level of literacy and could read, understand and provide responses to the items. It additionally ensured consistency of presentation of statements to the respondents, a greater anonymity for the respondents and less time-consuming. However, the scoring of the statements depended on whether it was negative or positive. Positive statements were scored from highest to lowest (descending order) while negative were scored from lowest to highest (ascending order).

3.5. Validity of the Main Instrument

Validity of a research instrument is how well it measures what it is intended to measure (Ary et al, 2017; Cresswell, 2007). To Kuranchie (2014), it is the extent to which the content of a measuring instrument sufficiently represents all items under study. In assertion, Ogah (2013) identified two forms of validity; internal validity and external validity. For internal validity observations and representations of a phenomenon are accurately shown (Ogah, 2013). External validity has to do with the intention to say what is observed from a small group which is applicable to the large group (population) from which the sample is taken (Ogah, 2013).

Furthermore, face, content and construct validity of the instruments were addressed. For face validity, the instrument was assessed by the researcher's supervisors in the Department of Science Education. The validators determined the appropriateness of the content material, clarity of the test items and instructions.

The content validity of the achievement test instrument was ensured by developing a table of specification (Appendix G). The CHEMFONOPET and the table of specification were scrutinised by the supervisors who identified and corrected any mismatches between the test items, table of specification and the course content that was used in the intervention. The comments of the validators were used to revise the content and instructions.

Construct validity refers to the theoretical foundations underlying a particular scale or measurement. With respect to this, modified versions of Chemical Bonding and

Nomenclature Test (CHEMFONOT) which have been validated by previous researchers including Robinson (2001), Taber (2001), Teichert and Stacy (2002) and Trimpe (2007) to assess students and teachers' knowledge on chemical formulae nomenclature was used.

Additionally, anonymity was assured of the respondents which presumably made them respond to the items with honesty. The recommendations of the validators were used to revise the content material and the instructional package. This was followed by a trial testing of the instructional package through a pilot study.

Validity of the self-structured questionnaire was given the required attention before using it for the actual studies. In this study, the researcher ensured that the data collection instrument had adequate items to cover the research questions which enhanced the content validity of the self-structured questionnaire. The internal validity of the instruments used to collect data for the study was properly constructed, pre-tested in a way that achieved acceptable validity.

For the purpose of dealing with validity issues, the self-structured instrument for data gathering was subjected to scrutiny by three university instructors who were experienced in educational and social research. These researchers inspected, analysed and ascertained the capability of the instrument of collecting accurate and valid data for the study. Precisely, three university senior lecturers, all of whom were professors in science education validated the data collection instrument. Their judgments and suggestions were used to construct the final instrument for the actual study. Additionally, the construction of questionnaire was supervised and vetted by the supervisors for this study. This additional validation of the data collection instruments further enhanced the accuracy and suitability of the instrument in collecting valid data. Comments and suggestions made by these experienced researchers were used to improve the general quality of the instruments for data gathering in the actual study.

3.6. Reliability of the Main Instrument

Reliability concerns the degree to which an experiment, test, or any measuring procedure yields the same results on repeated trials (Patton, 2002). According to Trimpe (2007), reliability is the degree to which a test consistently measures whatever it was designed to measure. This meant that the scores of study participants should provide consistent information about their performance. But Gay et al (2009) indicated that, for test items, scores would likely be quite different any time the test is administered. Furthermore, reliability is expressed numerically, usually as reliability coefficient which is obtained by using a correlation. A perfectly reliable test would have a reliability coefficient of 1.00, meaning that students' scores perfectly reflected their true status with respect to the variable being measured even though no test is perfectly reliable. High reliability (i.e., a coefficient close to 1.00) indicates minimum error. That is the effect of errors of measurement is small.

Precisely, Cronbach's alpha was used to determine the reliability of items of the data collection instrument. The Cronbach's alpha according to literature is generally used as a measure of the reliability of a set of test items or statements in test and survey questionnaire respectively. It was reported that "A level of alpha that indicates an acceptable level of reliability has traditionally been 0.70 or higher. However, interpretation of alpha in specific contexts is generally more complicated than what has been presented here (Gay *et al.*, 2009). In this regard, the Cronbach's alpha values for both the test and the survey questionnaire were respectively [0.833; 0.794; 0.824] and [0.814; 0.874] (see Appendix H). With respect to the test, the magnitude of the

Cronbach's alpha value depends on the number of test items used. One fundamental principle influencing this value states that the more questionnaire items there are in a scale designed to measure a particular concept, the more reliable the measurement would be (Ary et al, 2017). In the light of this, as many as 40 t items were drawn from the topic of interest so as to maximize the value of Cronbach alpha. A high degree of stability indicates a high degree of reliability, which makes results repeatable.

The reliability coefficient of all the items of various sections indicated that, the self-structured questionnaire was reliable. The results of reliability analyses conducted at 0.05 significance level (95% CI) using Cronbach's alpha statistics yielded reliability coefficient values [0.814 ;0.874] mean=103.800 and SD±=22.869. This value was above the recommended test item reliability score of 0.80 and therefore met the minimum acceptable standards. This suggests that the internal consistency of the test items was excellent. George and Mallery (2013) provided the following rules of thumb for interpreting the alpha value: [_ > .9 – Excellent, ≥ .8 – Good, ≥ .7 – Acceptable, ≥ .6 – Questionable, ≥ .5 – Poor, and ≤ .5 – Unacceptable]. Hence the alpha value obtained in this study for all the 30 items responded to on a 5-point Likert scale type questionnaire ranging from 1 = strongly disagree to 5 = strongly agree was excellent. The calculated values [0.814 ;0.874] also indicated that items on the instruments had sufficient internal consistency as outlined in Pallant (2015) and Cronbach and Richard (2004). In view of the assertion above, the questionnaire items as mentioned earlier were made close-ended. The close-ended items were used to solicit specific responses on a five point likert type scale. This is easier for cross checking the trustworthiness of the data collected using the close-ended questions as indicated by Trimpe (2007).

3.7. Pilot Study

Both the achievement test and the questionnaire instruments were piloted on a small sample of twenty (20) pre-service teachers of Gambaga College of Education. The reason for using this College of Education was based on convenience; in terms of time, proximity and resources. This set of students was not used for the main study. The main objective of this pilot study was to find out how the respondents would react to the items of both the achievement test and the questionnaire, modified some items that were difficult to understand, reduced ambiguities among the items, it also incorporated into the instruments new categories of responses that were identified as relevant to the study, detected weakness in the research design and determined appropriate corrective measures and improved the research instruments and the intervention fidelity of the study ((Patton, 2002; Gay *et al.*,2009). Again, it was also meant to investigate whether there was the need to construct more items in some sections of the items. Items that were found unanswered or yielded low reliability coefficient were restructured, replaced or deleted, depending on the prevailing situation. Pilot testing the instruments enhanced the content constructs and implored the quality of the questions since those with ambiguities were corrected before the actual administration of the final instrument. The comments passed based on the administration of the items enabled the researcher to do away with ambiguous questions and restructure some of them to ensure clarity, suitability, validity and reliability of the instrument. Kuranchie (2014) reported that, pilot study helps researchers to obtain feedback on the research instruments, administration procedures, analyses among others that could be used to improve the main study.

3.8. Ethical Considerations

Permission letter for research study was taken from the University of Education, Winneba after obtaining ethical clearance. The principals of Colleges of Education as well as heads of Science Department in the colleges concerned were given this permission letters asking for their assistance. In addition, respondents were guided to sign a consent form assuring them of confidentiality and voluntary contribution towards the research study.

3. 9. Design and Development of Exemplary Materials (Wooden Atomic Models, WAM)

The innovative Wooden Atomic Models is an improvement over conceptual models that promoted logical reasoning and thinking among students in their learning. It has been established that many educational benefits that expand from a wide variation of meaningful conceptual understanding has the potential of enhancing students' achievement (Vodovozov & Raud, 2015; Schaal, 2017). The report was centred on its effects on the motivations and gender with the use of its verisimilitude of the exemplary materials and not of that of Wooden Atomic Models (Schaal, 2010). It was helpful in identifying misconceptions, alternative concepts and provided a link with prior and new knowledge (Koc, 2012) as confirmed by Vodovozov and Raud (2015). It helps students to develop positive learning attitudes (Koc, 2012) and self-efficacy (Anne, 2008) in handling chemical bonding and nomenclature of inorganic compounds and answering challenging concepts in chemical bonding and nomenclature of inorganic compounds more easily and efficiently (Schaal, 2017). In teachers' preparation and the use of technological tool for instruction, findings made by Lim (2011) and Schaal (2017) on Korean teachers' professional development confirms the findings addressed by Koc (2012) and Erdogan (2019) on pre-service teachers as effective for building pedagogical motivational skills among teachers.

On the other hand, Miller et al (2009) and Schaal (2010) on pre-service teachers' in Germany reviewed an enhancement of teachers' conceptual understanding in chemical bonding and nomenclature of inorganic compounds (Koc, 2012) with the use of conceptual models in tutorials. The Wooden Atomic Models were of different design because the model representation of non-metal ions (anions) is different from those representing the metal ions (cations). Non-metal ions are those ions formed by gaining one or more electrons. Examples include Cl^-, N^{3-}, O^{2-}, Br^-, H^- etc as well as the oxoanions such as NO^-_3, CO_3^{2-} , PO_4^{3-}, SO_4^{2-} etc. On the other hand, metal ions are those ions formed by losing one or more electrons. These include Na^+, K^+, Mg^{2+}, Al^{3+} etc as well as the transition metals such as Cu^+, Cu^{2+}, Fe^{2+}, Fe^{3+}, Zn^{2+} etc. It also includes H^+ and NH_4^+ which are non-metal cations. There were also models for special cases involving both peroxides and super peroxides. For those models representing non-metal elements have holes on one face meant to allow the stick-projections from the metal elements to be fitted into them in order to form a chemical bond. Whereas their metal counterparts have stick-projections on one face that could easily be fitted into the holes of the non-metals to form a chemical bond or compound. The stick-projection represents electron(s) being donated into the receiving holes to signify the acceptance of electrons to form a chemical bond.

The number of holes or sticky-projections on the WAM depends on its oxidation state. In the design, each group one, two and three elements have one, two and three stick-projection respectively while each group seven, six and five elements have one, two and three holes respectively. The size of each WAM is the same regardless of whether it is a metal or non-metal element. For example, WAMs with either one socket or stick-projection are of the same size and those with two holes or stick-projections are of the same size. Also, the length of a given WAM is proportional to the number of holes or stick-projections it has. If given elements with equal but opposite charges are to form an acceptable chemical bond, they must have equal length and fit into each other without leaving any gap.

Improvisation and usage of WAM constituted intervention for teaching chemical bonding and nomenclature. The models were specially designed wooden blocks portraying atoms. A number of these models could be manipulated to form a chemical formula. The WAMs have three types of design. These include designs metal atoms/ ions, non-metal atoms/ ions and oxoanions illustrated in Table 1, Table 2 and Table 3 respectively.

Table 1: **Interventional design for metals atoms/ ions**

Group	Number of stick projections	Charge	Ionic form	Valence electrons
1	1	+1	X^{+}	1
11	2	+2	X^{2+}	2
111	3	+3	X^{3+}	3

Table 2: Interventional design for non-metal ions

Group	Number of holes	Charge	Ionic form	Valence electrons
V	3	-3	X^{3-}	5
VI	2	-2	X^{2-}	6
VII	1	-1	X^{-}	7

Table 3: **Interventional design for oxoanions**

Oxoanion	Number of holes	Oxidation state	Ionic form	Valence electrons
MnO_4^-	1	-1	MnO_4^-	-
CO_3^{2-}	2	-2	CO_3^{2-}	-
SO_3^{2-}	2	-2	SO_3^{2-}	-
SO_4^{2-}	2	-2	SO_4^{2-}	-
PO_4^{3-}	3	-3	PO_4^{3}	-

The non-metal and metal atoms/ions designs have certain number of holes and stick projections respectively portraying their periodic groups, oxidation states, valence electrons and ionic forms of its atom on each side of wooden block/cuboids. Samples of these improvised WAM are shown in Figure 3. However, the use of WAM is only limited to ionic compounds.

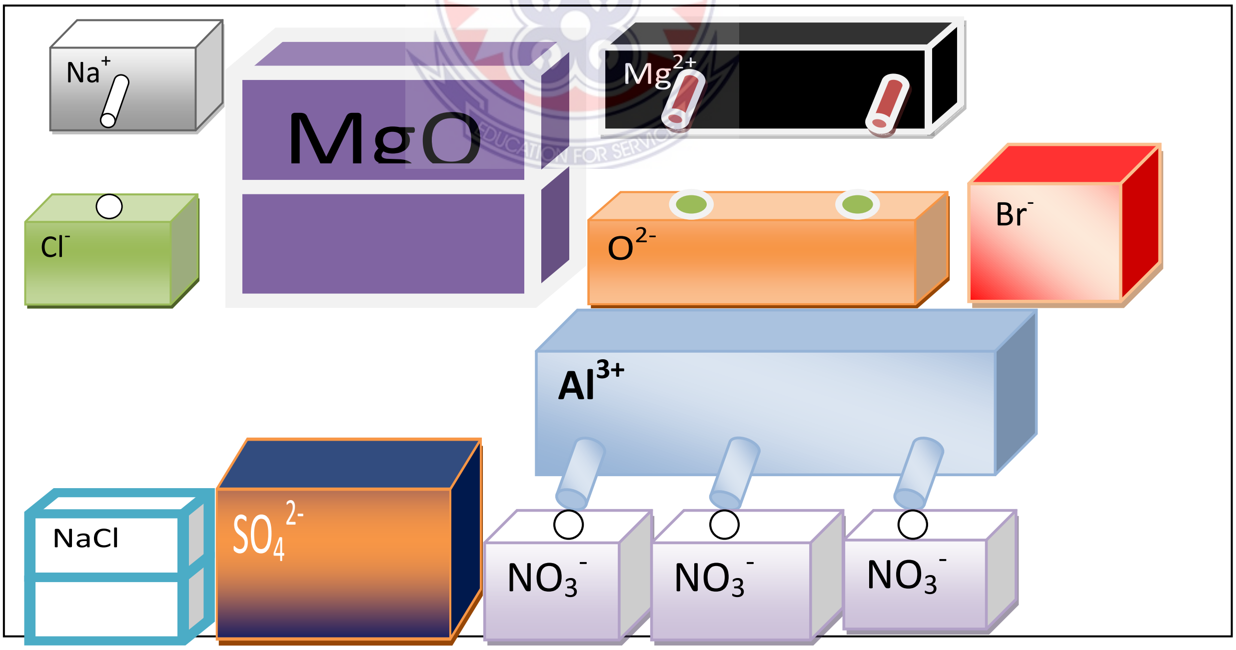


Figure 3: A sample of WAM used for the study

The final WAM was implemented and evaluated on a large scale. In developing the four (4) prototypes (prototype I to IV) the prime focus was to meet the intended purpose for which the prototypes were being developed. The design guidelines for the WAM are described below.

The following preliminary guidelines were used to guide the design of the prototypes:

- Active learning through WAM activities**:** - focusing on students-centred pedagogies was designed to actively engage students in the learning process through both hands-on and minds-on activities. The activities designed were simple to carry out in classrooms with more emphasis on manipulation of the materials rather than manipulation of ideas.
- Rational and learning goals of Science Education at the CoE level**:** - to help teachers with the implementation, WAM was designed with clear learning objective of enhancing learning outcome.
- Content support**:** - reflects on the challenges Ghanaian science teachers face in teaching abstract concepts.

3.11 .0. ***Progressive Integration of Flipped Classroom into Action Research***

The implementation of the intervention went through a number of stages such as the concept of WAM, a simplified periodic table for some elements, designs of WAM, some of the rules involved in using IUPAC nomenclature and steps involved in naming and writing a chemical formulae using WAM. Meanwhile the last stage focused on how metals bond with non- metals and oxoanions to form inorganic compounds using WAM. This last topic was subdivided and developed into four lessons reflecting specific examples of compounds formed as a result of bonding between any metal group and a non-metal. In all, nine weeks were used to complete the implementation since there were nine topics in all.

However, the first five topics were developed as lessons and taught during face to face sessions of the teacher-centred instructional period. This was marked by activities such as on-line collaboration among learners, individualized learning and presentations of simple hands-on-activities assigned to the students involving how to manipulate WAM to form compounds. This was done in order to enable the students have personal interaction and a feel of WAM which was completely new to them. The students equally learnt how to critique the WAMs being used for hands-on- activities. Nonetheless, the remaining five lessons were taught using learner –centred approach which was mainly an independent study at home. Student' engagement during this period included watching video clips, doing independent reading, drilling and practising terms involving the use of mono-, di-, tri-, and tetra- among others. Finally, the period was again used to ensure in-depth study of the key concepts and their applicability on students' daily lives. This was done by developing short videos, vodcast and podcast about the topics being taught in the class and uploaded on to a Google classroom which was created for the students in the class to download. This was summarised and represented diagrammatically in Figure 4. The interaction between the teacher-centred instructional period and learner –centred approach which was mainly an independent study at home remarkably led to conceptual understanding of chemical bonding and nomenclature of inorganic compounds among the students.

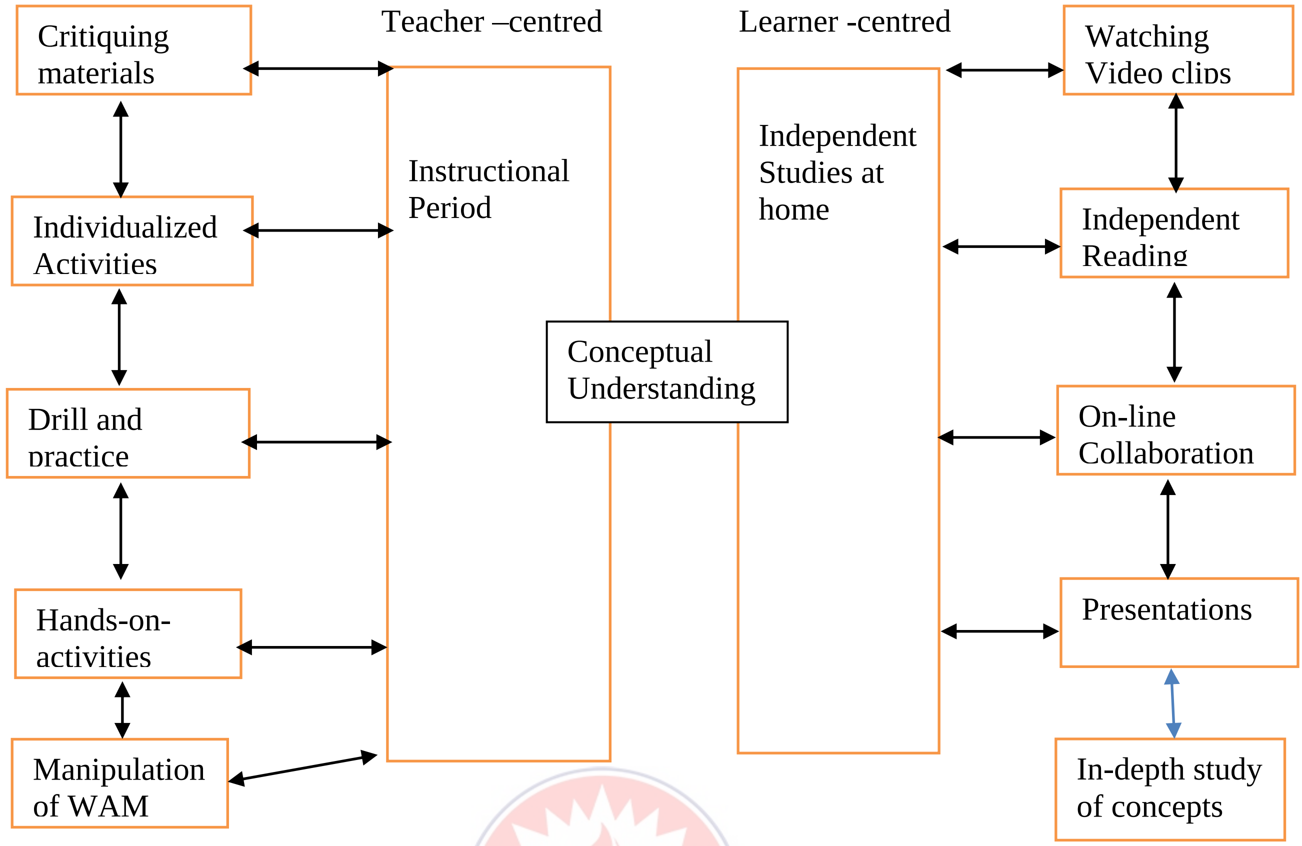


Figure 4: A diagrammatic representation of components of the flipped classroom utilized in the study

The students watched the videos and practised how to write chemical formulae and nomenclature of inorganic compounds using WAM. The face to face sessions were then used to focus on application of the material learnt in the videos using specific examples from each group in the simplified periodic table in order to give students a more interactive type of learning in the classroom (Ryback & Sanders,1980; Bergmann & Sams, 2012; Sparks, 2011). In order to re-enforce the use of videos for prelecture, students were asked to take a quiz or complete a home work and returned it before face to face class. The duration for each lesson involving the use of videos, vodcast and podcast never exceeded 20 minutes as recommended by Bergmann and Sams (2012) and Sparks (2011).

3.11.1. *Step 1 : The Concept of Wooden Atomic Models*

The first interventional activity after the development of WAM was to guide the pre-service teachers on how to use it. This was done during the first face –to- face interaction. WAMs were physically brought into the classroom for the students to see, touch, feel and learn how to manipulate them to form overlapped blocks to represent compounds.

3.11.2 *Step 2: A Simplified Periodic Table for some Elements*

Most students are inherently handicapped in chemistry concepts (Johnstone, 1993; Khoo & Koh, 2018). Having recognized the situation of most students in chemistry concepts, a simplified periodic table which was considered very critical towards the accomplishment of the aim of the research was developed. The developed simplified periodic table was used as a guide to help the pre-service teachers gain insight into how the arrangement of elements in the periodic table related to the properties of the elements (Appendix I). Evaluation exercises were provided to help re-enforce the lesson. Copies of the evaluation exercises and corresponding validated schemes are found in Appendix J.

3.11.3. *Step3: Designs of WAM*

The pre-service teachers after having gained insight into the arrangement of elements in the periodic table and their properties, were again taken through different types of designs in relation to the improvised wooden atomic models (see Tables 1, 2 and 3). These included interventional design for electropositive elements (metals), electronegative elements (non-metals) and design for oxoanions respectively. This was done using the improvised wooden atomic models while making reference to the simplified periodic table in order to consolidate the preceding lesson. The rationale here was to enable the pre-service teachers determine the oxidation states of the elements concerned without any problem.

3.11.4. *Step 4: Some of the Rules Involved in Using IUPAC Nomenclature*

This stage was centred on how to name chemical substances using internationally accepted nomenclature. To achieve this, the International Union of Pure and Applied Chemistry (IUPAC) nomenclature was adopted and utilised. This enabled the pre-service teachers to gain insight into how chemical substances were named. It involved the use of rules shown in both Table 4 and 5 below. Again, it included elements in their uncombined, atomic or molecular form as well as polyatomic ions. After each table followed its corresponding evaluation exercises and validated responses meant to ascertain the level of mastery before progressing to the next level (see Appendix K). The facilitation was delivered online through flipped classroom approach using Google Classroom.

Table 4: Rules involved in using IUPAC nomenclature

Rule 1	*Formula*	*Oxidation number*	*Notes*
(a)	H_2, H, Pb, Cl, Cl_2	0	
	O^{2-}, S^{2-}	-2	
	Cl^-, F^-, I^-	-1	
(b)	Ca^{2+}, Mg^{2+}	2	
	K^+, Na^+, Li^+	+1	
(c)	H_2O, Na_2O	O = -2	
	H_2O_2, K_2O_2	O = -1	
(d)	NaH, MgH_2	H = -1	

From Table 4, the oxidation number of an atom is the charge the atom carries in its pure state or in its compound. The following are the rules for determining the oxidation states of substances:

The oxidation number of:

- an element in its uncombined, atomic or molecular form is zero (0)
- an ion of a single atom is equal to the charge on the ion.
- an oxygen atom is -2 except in peroxides e.g. H_2O_2 and K_2O_2 and superoxides e.g. KO_2 where it is -1 and -1/2 respectively.
- hydrogen is -1 in metal hydrides.

The total oxidation state of all atoms in an ion consisting of two or more atoms is equal to the charge it carries.

Table 5: Polyatomic ions

Polyatomic Ion	Oxidation Number	IUPAC Name
SO_3^{2-}	-2	Trioxosulphate(IV) ion
NO_3^{2-}	-2	Trioxonitrate(V) ion
OH	-1	Hydroxide ion
SO_4^{2}	-2	Tetraoxosulphate(VI) ion
PO_4^{3-}	-3	Tetraoxophosphate(V) ion
NH_4^{+}	+1	Ammonium ion

3.11.5 ***Step 5 : Steps Involved in Naming and Writing a Chemical Formula Using WAM***

The pre-service teachers were taken through two main types of steps involved in naming or writing a chemical formula using WAM through face –to face interaction.

These include steps involved in naming and steps involved in writing a chemical formula using WAM.

Steps Involved in Writing a Chemical Formula Using WAM

i. Identifying the constituents of a chemical compound.
ii. Recognizing WAMs representing the constituting ions of the compound.
iii. Fitting of the WAMs into each other side by side.
iv. Writing ratio of the number of metal ion WAMs to that of non-metal.
v. Reducing the ratio to its lowest term and rewriting them as subscripts. When the ratio is 1:1, subscripts are not written for them.

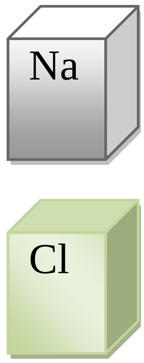
Steps Involved in Naming a Chemical Formula Using WAM

i. Displacing the fitted WAMs forming the compound from their positions.
ii. Identifying the WAMs representing cations and anions of the compound.
iii. Writing the names of the cation and anion using their ionic names.
iv. Finding out whether the cation has variable or fixed oxidation state. If variable, write the name of the cation, then its oxidation state in capital Roman numerals and place in a parenthesis. This is followed by the name of the anion. Where the oxidation state is fixed, write the name of the cation straight forward, followed by the name of the anion.
v. Reducing the ratio to its lowest term and rewriting them as subscripts, and when the ratio is 1:1, subscripts are not written for them.

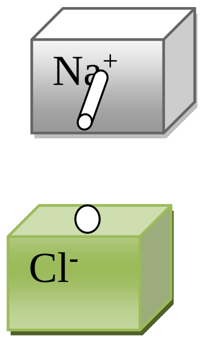
After having taken the subjects through the necessary steps, they were again guided to use the WAMs to write chemical formulae for compounds using the following general examples before making reference to specific groups in the periodic table through flipped classroom approach.

General example1: How to use WAMs to write chemical formula for Sodium Chloride.

1. Identifying the Constituents of Sodium Chloride as Sodium and Chloride atoms.



2. Identifying WAMs Constituting Sodium Chloride as Na^+ and Cl^-.



3. Fitting of the WAMs into each other side by side to form a fully overlapped block.

4. Writing the ratio of the metals model to that of the non-metals one as

Na: Cl =1:1

5. Since the ratio is 1:1, no subscripts are written for them, hence the formula is NaCl.

3.11.6 *Step 6: How Metals Bond with Non- Metals and Oxoanions to Form Inorganic Compounds Using WAM*

This was the most laborious and detailed stage of the interventional process. This stage was subdivided into five lessons. The rationale was to have illustrative lessons depicting how each group of metals from the periodic table bond with non-metals to form compounds using WAM. That is to say that group 1,2,3 and the transition elements as well as ammonium ion and Hydrogen bond with elements from group 7,6,5 or oxoanions to form different inorganic compounds. Copies of these have been sequentially arranged a week after week as lesson one to five through flipped classroom approach for the pre-service teachers to access in a Google Classroom dubbed 'the intervention class' (Appendix L_1 to L_5).

3.12. Data Collection Procedure

Data was collected both at the pre-interventional and post- interventional stages of the intervention. For effective data collection, two (2) familiarization visits were made to Gambaga College of Education where pilot testing was done. Formal introductory letters from the Head of Chemistry Education Department, University of Education, Winneba was given to the Principal of the college (see Appendix M). This enabled the researcher to seek permission from the college authority. The benefits of the research work were discussed with the science tutors of the college. Time table for the integrated course was copied from the master time table to enable the researcher to plan his intervention and the number of periods allotted to the course per week. During this visit, the researcher was introduced to the students as a new member of staff. This identity concealment was meant to minimize the change in behaviour of the subjects in accordance with (Ary et al, 2002) that the behaviour of the subjects changes when they become aware that they are being observed for a purpose.

The second visit was made to the pilot college to administer the research instruments. These included both test items and questionnaire statements to twenty (20) level 100 students of the college. The time allotted for responding to these instruments was 40 minutes. Data collected helped in establishing the validity and reliability of the instruments as discussed. After that, pretest consisting of forty (40) test items on the instrument, CHEMBONOT was administered to a sample size of 40 students from Gbewaa College of Education in order ascertain the respondents prior conceptions on chemical bonding and nomenclature of inorganic compounds. Again, questionnaire items comprising 20 statements based on 5-point Likert scale was administered to the same respondents. The rationale was to unearth the respondents' previous level of motivation in studying chemical bonding and nomenclature of inorganic compounds.

The Intervention was implemented after the pre-intervention. At this stage, the 40 respondents consisting of twenty (20) males and twenty (20) females were taught for nine (9) weeks using WAM via flipped classroom approach. It was a Google classroom created for the students to join.

An equivalent form of the pretest, CHEMBONOPET was used for the posttest to avoid the effect of pretest sensitisation. According to Aryl *et al.* (2002), pretest sensitisation is the effect the pretest has on the respondents which results in positive response towards the treatment and as such leads to better performance regardless of the impact of the intervention. Pretest sensitisation is a major threat to the validity of a test when very same test is repeated rather than parallel forms. It again ensured a much fairer way of assessing the effect of the intervention rather than parallel form.

Meanwhile, a post -intervention questionnaire consisting of thirty (30) items covering all the three motivation types enhancing factors namely, self-efficacy, anxiety and enjoyment levels were equally administered. The rationale for doing this was to help establish the relationship between the use of WAM via flipped classroom approach and motivation enhancing factors (self-efficacy, anxiety and enjoyment levels) of pre-service teachers after learning chemical bonding and nomenclature of inorganic compounds. The results obtained from these instruments were used for analyses.

3.13. Data Analyses Procedure

In organising data for analyses, special considerations were made to reflect the prime focus of the study. Firstly, to determine student's prior conceptions, the possible causes of conceptual errors among students, gender effect in academic performance and how motivation enhancing factors (self-efficacy, anxiety and enjoyment) affect their performance in chemical bonding and nomenclature of inorganic compounds. Student's prior conceptions, possible causes of conceptual errors, gender effects in performance and motivation enhancing factors were the independent variables or predictors while academic performance and levels of motivation of students in CHEMFONOPET were the dependent (criterion) variables. Secondly, to establish the relationship between the use of integration of exemplary materials and flipped classroom instruction (independent variables or predictors) and performance of students in CHEMFONOPET and levels of motivation were the dependent (criterion) variable.

According to Alhassan (2006), using more than one predictor variable is often preferably useful in predicting human behaviour, as one's actions, thoughts and emotions are all likely to be influenced by some combinations of several factors.

Prediction of students' performance for instance, therefore involves using multiple predictors such as the use of models, prior conceptions, gender, motivation and self-efficacy of students. The predictor variables were selected and measured on ratio, interval. A nominal predictor variable is legitimate and as such gender is accepted to be coded as 1 for male and 2 for female (Alhassan, 2006). Prior conceptions were coded as 1 and post conceptions coded as 2.

In order to organize the data collected for analysis, a code book was prepared to guide the entry of data into SPSS, windows 2007, version 21.0 for for t-test analysis. The t-test was used to compare two means. The student t–test could either be for independent samples or dependent samples. With regards to this, t –test for dependent samples was used to compare the pretest and posttest results of the chosen sample.

Pallant (2015) suggested that histograms and box plots should be inspected to identify potential outliers or out of range scores. Before analyses were ran, variables were graphically explored to ensure that, all cases entered into SPSS were correct and that there were no significant outliers. Being a parametric statistical tool, the use of dependent t-test for data analyses assumes that "the scores re reasonably normally distributed, with most of the scores occurring in the centre, tapering out toward the extremes" (Pallant, 2015). Trimpe (2017) indicated that achieving a perfect distribution is rather an uncommon occurrence in research. After data transformation to delete outliers, the dependent variable (performance of students in writing chemical bonding and their nomenclature of inorganic compounds when they are taught using integration of exemplary materials and flipped classroom instruction achieved normal distribution of scores.

However, research question 1 was qualitatively analysed by classifying the test responses into themes such as sound understanding, partial understanding, understanding with misconception and no understanding. It was followed by assessment of sound understanding of respondents using the posttests scores. The classification was done using a validated scheme. Again, the prior and post conceptions on chemical bonding and nomenclature after the intervention were classified. Frequency counts and percentages were used to tabulate the number that exhibited each degree of understanding in both tests. Research question 2 was analysed using error- contained responses to research question 1 and organizing it into a tabular form. The tables focused principally on the nature of research questionnaire used for the pretest, its respective sampled error- contained responses as well as corresponding possible causes of the error - contained responses. These parameters were again linked or associated to each of the four main types of errors identified. These included errors associated with identification of chemical symbols, errors associated with conceptualisation of ion formation, errors associated with conceptualization of oxidation states and IUPAC nomenclature and errors associated with concepts related to atomic structure. Meanwhile, research question 3 and 4, descriptive statistics such as means, modes and standard deviations for both tests were computed. These calculated values were used to determine the effect of the intervention as well as gender differences in academic performance between the males and the females in writing chemical bonding and nomenclature of inorganic compounds.

Furthermore, research question 5 was analysed to determine the relationship between students' motivation enhancing factors such as self-efficacy, anxiety and enjoyment levels and the use of integration of exemplary materials and flipped classroom instruction after learning chemical bonding and nomenclature of inorganic compounds.

The responded questionnaire items on five point Likert type scale was graded as 1,2,3,4, and 5 indicating strongly disagree (SD), Disagree (D), Undecided (U), Agree (A) and Strongly Agree (SA) respectively. However, the scoring of the statements depended on whether it was negative or positive. Positive statements were scored from highest to lowest (descending order) while negative were scored from lowest to highest (ascending order). The Likert scale was then analysed in compliance with the one of the recommendations of Churchil (1979). Churchil (1979) stated that there are two ways of analyzing attitude scales. These include either by profile analysis where the analysis is done on item-by – item basis or by aggregate analysis in which the analyses is run by summing up the numerical values of all the responses to each item there by yielding one score per research subject for the whole attitude scale. The former was used for the analyses because of its convenience to the researcher.

Pearson Correlation Coefficient was used for this analysis. The essence of this research question was to find out whether there was strong, weak or no correlation between the pre-service teachers' motivation enhancing factors such as self-efficacy, anxiety and enjoyment levels on one hand and the use of WAM after learning chemical bonding and nomenclature of inorganic compounds via flipped classroom approach on the other hand. In this analysis, the researcher opined that Pearson correlation coefficient was the most preferred choice as far as statistical tools are concerned. Specifically, self-efficacy, anxiety and enjoyment levels were continuous independent variables; while the use of WAM via flipped classroom approach was continuous dependent variable. Pallant (2015) indicates that, Pearson product-moment coefficient is designed for interval level (continuous) variables.

Preliminary analyses were performed to ensure that there was no violation of the parametric assumptions relating to Pearson product-moment correlation. These assumptions of Pearson product-moment correlation related to continuous measurement of variables, approximately normally distributed scores, relationship between variables and absence of significant outliers. On outliers, Pallant (2015) suggested that histograms and box plots could be inspected to identify potential outliers or out of range scores. “But if the scores drop away in a reasonably even slope, then there is probably not too much to worry about” (Pallant, 2015). Extreme outliers are supposed to be indicated with an asterisk. Pallant (2015) opined that in running Pearson’s correlation, variables should be approximately normally distributed. Pallant added that achieving a perfect distribution is rather an uncommon occurrence in research.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0. Overview

This chapter focuses on results and discussion. However, the results are presented in two folds aimed at addressing the research questions. These include interpretation of students' sampled preconceptions and post conceptions, possible causes of conceptual errors, statistical presentation of results, relative improvements of male and female students after integration of exemplary materials and flipped classroom instruction and effect of integration of exemplary materials and flipped classroom instruction on students' performance and motivation to study.

4. 1. Interpretation of Sampled Preconceptions and Post Conceptions

Research Question One: What preconceptions do level 100 students hold about chemical bonding and nomenclature of inorganic compounds?

The preconceptions of the respondents were analysed in terms of the requirements of the question and categorised as partial understanding, understanding with misconception, no understanding and sound understanding using a validated scheme to the pretests (Appendix C).

Partial understanding: These were responses that contained at least one of the components of the validated response, but not all the components. Here the respondents assigned varied responses which were very close to the expected or validated responses but could not be regarded as a correct response. The following are examples of such responses:

The numerical charge of an electron:- Negative (Sampled response to part one Q4). Negative was supposed to have a numerical value attached to it, say negative 1. But most of the respondents failed to indicate as -1

Misunderstanding: These responses contained unscientific, illogical or incorrect information. Examples from students' responses are shown below:

Symbol for Fluoride ion:- Fe, Fe^-, Fl (Sampled responses to part one Q 5). The symbol has no bearing on the name of the ion provided. The Fluoride ion was wrongly taken as the element Iron. The misconception may be due to inability to differentiate between ion as a charged atom or particle and the element Iron.

Definition of atom:-It is the smallest particle of matter/It is the smallest particle of an element/It is a basic unit of matter. (Sampled responses to part one Q 1).

The definition given was incomplete. Some of the defining properties that help to make the definition complete were not stated. These include (1) the atom is the smallest particle of an element, (2) the atom should be able to take part in a chemical reaction and (3) the atom should be able to keep the properties of that element. The students could not reason that to define an atom. The two defining properties were supposed to be incorporated into any one of their responses given above before scoring the required mark on that item. This lapse might be due to lack of conceptual understanding of the defining properties of an atom.

No understanding: These were made up of irrelevant or unclear responses. Respondents just repeated information in the question as if it was an answer, left a blank answer space or provided unrelated validated response. In this case respondents provided answers that were either unrelated to the validated responses or left blanks. An example of unrelated responses provided by respondents was shown below:

Definition of atomic number:- An atom of the mass number/It is the number of atoms in an atom. (Sampled response to part one Q 1). The definition provided by the respondents has no bearing on the concept. The concept has nothing to do with either the mass of an atom or the number of atoms. The students might have mistaken the definition of atomic mass for either the mass number or atomicity of a molecule.

Sound understanding: Responses that included all components of the validated response. The chemical symbol for Potassium:- K (Sampled response to part one Q 10).

Preconceptions on Writing of chemical bonding and periodic properties

Partial understanding: Respondents showed partial understanding when they failed to indicate subscripts, bonds, symbols of each element, and the appropriate cases of the symbols and the number of atoms of each element correctly. The examples of such cases as indicated by respondents were:

Chemical formula for Potassium Fluoride:- K_2F, KF2, KF^-. (Sampled responses to part two Q 4). These students were able to identify the constituents of the compound, even though their responses were not entirely correct. Their inability to identify might be due to lack of knowledge about the oxidation states of the constituents of the ionic compound (K and F) which must give a net charge of zero when combined. Knowing the oxidation number of a compound is very important when discussing ionic compounds. Ionic compounds are combinations of positive and negative ions. They are generally formed when nonmetals and metals bond. To determine which substance is formed, we must use the charges of the ions involved. To form a neutral molecule, the positive charge of the cation (positively-charged ion) must be equal to the negative charge of the anion (negatively-charged ion). In order to create a neutral charged molecule, atoms must be combined specific in proportions. Knowledge of the charges of ions is crucial to knowing the formulae of the compounds formed.

Examples of monoatomic anions**:**-CL^-, cL^- f^-, br. (Sampled answer to Q 32a). The chemical symbols of Fluorine, Bromine and Chlorine were wrongly written.

The wrong responses provided by the respondents suggested that, students might not have any knowledge about the rules guiding the writing of chemical symbols. The students' inability was again attributed to violation of one of the rules,that says that, if only one English letter of alphabet is to be used as a chemical symbol, it should be written in upper case. Additionally, where two English letters of alphabets are to be used as a symbol, the first letter must be written in upper case, whilst the second letter must be in lower case.

Misunderstanding: These responses included illogical or incorrect information as seen in examples below;

Al^{3+}+$3NO_3^-$ ⟶ **:**$Al^3 3NO_3$ /$AlNO_3$. (Sampled response to part two Q26)

Oppositely charged ions were added together to form a compound which does not exist, as the net charge in the compound is not equal to zero. The oppositely charged ions were added together as if they were carrying equal charges. Students failed to reason out that the charge carried on an ion is often equal to the valency or oxidation state of the ions concerned. These valencies should have been interchanged so as to get a compound whose net charge is zero. The students' inability was attributed to lack of knowledge on combined factors such as the rules governing oxidation numbers, law of constant composition of mass, law of definite proportion and balancing of chemical equations.

No understanding: These were made up of irrelevant or unclear responses. Respondents might just repeat information in the question as if it is an answer or leave a blank. In this case respondents gave unrelated responses or left blanks. Examples of unrelated responses given by respondents are stated below:

Molecular formula for Lead (IV) Oxide**:-** Pb_2/ PO/PLO_3. (Sampled answer to part two Q 28). From the responses provided, the first one does not contain oxygen to indicate that it is a combination of Lead and Oxygen. Added to that, Lead does not even exist as a diatomic molecule. The second and third responses revealed that the students do not even know the chemical symbol for the element, Lead. The students might have mistaken the chemical symbol of Lead for either that of Phosphorus by writing P or PL which does not exist at all. This might have pre-empted or informed them to arrive at the responses provided after adding oxygen to them. Chemical formula for Aluminium Oxide**:** - AL+O/AL (Sampled response Q12). Students did not understand what was expected of them, thus writing a formula which does not exist. This was a clear indication that there was no understanding among the students.

IUPAC Nomenclature

Most of them left blanks spaces possibly because they had no idea on what was to be done. Again it might be due to inappropriate pedagogical approaches used by the students' previous teachers in the writing and naming compounds using IUPAC Nomenclature:

Partial understanding: Name the species, HCO_3^-**:-** Hydrogen carbonate ion/Trioxocarbonate acid/Hydrogen, Carbon and Oxygen/ Hydrogen Trioxocarbonate (IV)/ Trioxohydrocarbonate/ hydrocarbonate (V) Oxide (Sampled answer to Q 27). The species is actually made up of Hydrogen, Carbon and Oxygen or hydrogen and carbonate ions as was acknowledged by the respondents in their responses. The respondents did not go by IUPAC convention in naming chemical substances and as such were not specific. Their inability to name the compounds might be due to limited knowledge with regards to the naming of compounds. They should have indicated the number of oxygen atoms present in the formula by using the prefix “trioxo”. Again, some of the respondents did not know that, the oxidation states of the central atom, carbon was to be calculated before naming the compound. Even the few respondents who were aware of this convention could not calculate the oxidation states. Finally, most of the respondents did not indicate that the species is a charged unit and as such is an ion. Some of the respondents considered the species as an acid. The respondents’ faulty rationalization might have been pre-empted by the mere presence of the incompletely replaced by hydrogen ion.

Misunderstanding: Name the compound, $CaCO_3$**:-** Calcium and Oxygen/Calcium carbon dioxide/A combination of Calcium/Carbon and Oxygen (Sampled response to Q 15). Respondents could not recognise that the compound is made up of two oppositely charged particles Ca^{2+} and CO_3^{2-}. However, it was only the calcium which was identified.

No Understanding: Name of the Compound made from Lithium and Chlorine:- Lithium/ Lithium compound/Lithium and Chlorine (Sampled response to Q 15). These responses were clearly unrelated to the validated responses. It indicated that the respondents did not understand what was expected of them.

Interpretation of Students ’Posttest Sampled Responses

This segment of the research provided examples of sampled responses from the scripts of the respondents’ posttest. The samples were presented in the same manner as the pretest. This includes prior conceptions of students in basic atomic structure and chemical bonding, periodic properties and writing of chemical formulae and IUPAC Nomenclature. Responses which included all components of the validated scheme to the posttests (Appendix J) were accepted.

Prior conceptions of students in basic atomic structure and chemical bonding

Partial understanding: Molecular formula for Lead (IV) Oxide**:** - PbO/PbO_4 (Sampled answer to part two, Q 28). From the responses provided, a few the respondents could not get it correct even though the constituting elements were identified, nonetheless, the right oxidation states not used.

Sound understanding

The responses to Q 1, Q 7, Q 1, Q 14, Q 15, Q 20, Q 12 and Q 22 among others met the following: Correction definition of atoms and terms associated with parts of the atom, differentiations of types of chemical bonds, statement of subatomic particles and their properties and writing correct ions formed from atoms.

An atom becomes an ion: An ion is formed when an atom/group of atoms loses or gains one or more electrons (Sampled answer to Q1).

Define mass number of an element**:**-Mass number of an element is the sum of protons and neutrons in the nucleus of the atom (Sampled answer to Q7).

Write down the electronic configuration for ${}_{18}Ar$**:**- 2, 8, 8 (Sampled answer to Q8).

Isotopes**:**-These are atoms of the same element having the same atomic numbers but different mass numbers due to differences in neutron numbers (Sampled answer to Q14).

The type of bond is formed when electrons are transferred between atoms:- Ionic/Eletrovalent bond (Sampled answer to Q21).

Determines the chemical properties of an element:-Valence/Outermost electrons (Sampled answer to Q22).

4.2. Statistical presentation of Results

Respondents' prior and post conceptions of chemical formulae and nomenclature after the intervention were classified. Frequency counts and percentages were used to tabulate the results (see Table 5). A total of 31 (77.5%) and 6 (15%) of the students showed sound and partial understanding of chemical bonding and nomenclature respectively after the intervention as against 2 (5%) and 3 (7.5%) in the pretest. Thus, there was an increase of 72.5% in the number that showed sound understanding.

Table 6: Frequency distribution of the respondents' understanding level in both types of test

Degree of Understanding	Post-intervention test		Pre-intervention test	
	Frequency	percentage	Frequency	percentage
Sound understanding	31	77.5	2	5
Partial understanding	6	15	3	7.5
Misconception	3	7.5	5	12.5
No understanding	0	0	30	75

Again, the number that showed misconception in the pre-intervention test decreased from 5 (12.5%) to 3 (7.5%) at the end of the intervention. Finally, no respondent showed no understanding after the post - intervention test as compared to 30 (75%) in the pre-intervention test. It was clear from the results that, the performance of students in conceptualizing chemical bonding and nomenclature were largely influenced by their alternative conceptions. These conceptions ranged from partial understanding, misconception to no understanding. Despite the seemingly improved sound understanding from pre-intervention test [5%] to Post-intervention test [77.5%] (Table 5), the inability to conceptualise and write chemical formulae and nomenclature still persists among few students.

To find out whether the performance of students was enhanced in writing chemical formulae and their nomenclature when they were taught with CMs, Research Question 2 was posed as:

1. **Research Question Two: What are the possible causes of conceptual errors amongst students in learning chemical bonding and nomenclature of inorganic compounds?**

4.3. Possible Causes of Conceptual Errors Among Students

To analyse this research question, error- contained responses to research question 1 were re-organised into a tabular form, focusing principally on the nature of research questionnaire used for the pretest, its respective sampled error- contained response as well as corresponding deduction of the possible cause of erroneous responses. These parameters were again linked or associated to each of the four main types of errors identified. These included errors associated with identification of chemical symbols, errors associated with conceptualisation of ion formation, errors associated with conceptualisation of oxidation states and IUPAC nomenclature and errors associated with concepts related to atomic structure. Same erroneous responses, expected responses and possible causes of these errors are summarised under Table 7.

Table 7: Errors associated with identification of chemical symbols

Nature of questionnaire item	Expected response	Sampled erroneous response	Possible cause of errors
Chemical symbol of Fluorine	F	f^- Fl fl. (Sampled answer to Q 32a)	Students appeared not to be conversant with the rules guiding the writing of chemical symbols.
chemical symbols of Bromine	Br	BR^-, bR br. (Sampled answer to Q 32a)	Students appeared not to be conversant with the rules guiding the writing of chemical symbols.
chemical symbols of Chlorine	Cl	CL^- cL^- CL (Sampled answer to Q 32a)	Students appeared not to be conversant with the rules guiding the writing of chemical symbols. .

Students appeared not to be conversant with the rules guiding the writing of chemical symbols as indicated by the responses in Table 7. One of the rules says that, if only one English letter of alphabet is to be used as a chemical symbol, then it must be written in upper case. If two letters are used, the first must be in upper case while the second is in lower case. There was a gross violation of this golden rule in quite a number of responses provided.

Table 8: Errors Associated with conceptualization of ion formation

Nature of questionnaire item	Expected response	Sampled erroneous response	Possible cause of errors
Symbol for Fluoride ion	F^-	Fe Fe^- Fl	The Fluoride ion was wrongly taken as the element Iron.
Name the species, HCO_3^-	Hydrogen carbonate (IV)ion	Hydrogen carbonate ion Trioxocarbonate acid Hydrogen, Carbon and Oxygen Hydrogen Trioxocarbonate (IV) Trioxohydrocarbonate/ hydrocarbonate (V) Oxide (Sampled answer to Q 27).	Students did not go by IUPAC convention in naming chemical substances.
Chemical formula for Potassium Fluoride	KF	K_2F KF2 KF^-. (Sampled responses to part two Q 4)	Students did not know that molecules are neutral compounds. Again, Students did not know that compounds are formed in definite proportions.

With respect to the Fluoride ion as shown in Table 8, it was wrongly taken as the element Iron. The misunderstanding might be due to the students' inability to differentiate between an ion as a charged atom or particle and the element iron. In another related instance, the respondents did not go by IUPAC convention in naming the species, HCO_3. This culminated in the combination of the symbols in the formula (H, C, O) without any order to name the species. In using the IUPAC convention in naming chemical substances, students needed to specify the order. In so doing, students would have realised that the species is Hydrogen trioxocarbonate (IV) ion.

In the case of the chemical formula for Potassium Fluoride, the students appeared not to know that, to form this neutral molecule, the positive charge of the cation must be equal to the negative charge of the anion. Again, the students could have used the law of definite proportions to help them write the formula correctly.

Table 9: Errors associated with concepts relating to atomic structure

Nature of questionnaire item	Expected response	Sampled erroneous response	Possible cause of errors
The numerical charge of an electron	Negative one (-1)	Negative (Sampled response to part one Q4).	Most of the students appeared not know that a numerical value is attached to the negative
Definition of atom	Is the smallest particle of an element that exhibits the properties of that element and can always take part in a chemical reaction	It is the smallest particle of matter It is the smallest particle of an element It is a basic unit of matter. (Sampled responses to part one Q 1).	Students did not take into consideration the defining properties.
Definition of atomic number	Is the number of protons present in the nucleus of a neutral atom.	An atom of the mass number Number of neutrons in an atom Sum of protons and electrons in an atom It is the number of atoms in an atom. (Sampled response to part one Q 1).	Atomic number is often mistaken for either the mass number or atomicity of a molecule

Most of the students seemed not to know that, there is a numerical value attached negative (see Table 9). This value attached to the negative must be specified. Negative could be negative one, negative two, negative three, negative four among others. Electron is one of the subatomic particles. Getting the charge of an electron implied that students were not conversant with the subatomic particles.

Furthermore, from Table 8, students had difficulties in defining an atom. A closer examination of the responses provided revealed that, the students are not conversant with the defining properties of an atom. These defining properties include:

- the atom is the smallest particle of an element,
- the atom should be able to take part in a chemical reaction,
- the atom should be able to keep the properties of that element.

Again, students had serious challenges in defining the term ‘atomic mass’. The students mistook the definition of atomic mass for either the mass number or atomicity of a molecule as shown in Table 8. Atomic mass is a term associated with the structure of the atom. Getting the definition of this fundamental concept wrong implied that students were not conversant with terms associated with the structure of the atom.

Table 10: Errors associated with conceptualization of oxidation states and IUPAC nomenclature

Nature of questionnaire item	Expected response	Sampled erroneous response	Possible cause of errors
Chemical formula for Aluminium Oxide	AL_2O_3	AL+O/AL (Sampled response Q12)	Students provided non-existent responses.
Chemical formula for Lead (IV) Oxide	PbO_2	Pb_2/ PO/PLO_3. (Sampled answer to part two Q 28).	The responses revealed that the students do not even know the chemical symbol for some element and their corresponding oxidation states
Write the product of Al^{3+}+$3NO_3{}^{1-}$	$Al(NO_3)_3$	$Al^3 3NO_3$, $AlNO_3$. (Sampled response to part two Q26)	Inadequate knowledge on combined factors such as the rules governing oxidation numbers and law of constant composition of mass and law of definite proportion

Students provided non-existent chemical formulae as responses to questionnaire items relating to conceptualization of oxidation states as indicated in Table 10. Some of the basic rules involved in determining the charge of a given element, using IUPAC nomenclature included the following. **The charge of:**

- an element in its uncombined, atomic or molecular form is zero (0).

- an ion of a single atom is equal to the charge on the ion.
- an oxygen atom is -2 except in peroxides (H_2O_2) and superoxides (KO_2) where it is -1 and -1/2 respectively.

Providing non-existent chemical formulae were a clear indication that student did not understand what was expected of them. A closer examination further revealed that the students even at their level did not know chemical symbol for the element for some of the elements in the test items. The symbol for Lead was written as PO/PLO_3.. The students might have mistaken the chemical symbol of Lead for either that of Phosphorus by writing P or PL which does not exist at all.

Again, the students' inability to respond correctly was attributed to inadequate knowledge on combined factors such as the rules governing oxidation and IUPAC nomenclature and law of constant composition of mass and law of definite proportion. Finally, in most situations after the analysis of the response provided, it was difficult classifying the errors even though there were criteria for classification. The difficulty stemmed from the fact that errors were more or less integrated or overlapped each other and hence made it difficult stating the type of error to which a particular error-contained response belonged. In such circumstances, the errors identified appeared interrelated. This meant that to rectify these four types of errors needed an all encompassing approach such as integration of exemplary materials and flipped classroom instruction.

Research Question Three: What is the effect of integration of exemplary materials and flipped classroom instruction on students' performance in chemical bonding and nomenclature of inorganic compounds?

4.4. Effect of Integration of Exemplary Materials and Flipped Classroom Instruction on Students' Performance

Descriptive statistics were used to determine the differences in performance between the pre – intervention test and the post– intervention test scores in writing chemical bonding and nomenclature of inorganic compounds. Descriptive statistics such means, modes and standard deviations for both tests were computed (see Table 11). In the pre – intervention test, the mean score was 9.83, (SD = 4.90) and a mode of 5 indicating the most frequently scored mark. However, the post– intervention test results indicated that, the mean score was 20.21, (SD = 4.5) and a mode of 23. The post– intervention test results appeared to be remarkably better than the pre – intervention test results after the intervention.

Table 11: The 2-tailed t-test for dependent samples analysis of pre-intervention test and pre-intervention test scores

Tests Compared	Test	Mean Test Scores	Standard Deviation	t- Value	p- Value
Pretest	Pretest	9.83	4.90	1.501	0.4361268086[a]
Posttest	Posttest	20.21	6.05	12.93	1.66023E-28*

a = Not Significant; $p > 0.05$. * = Significant; $p < 0.05$.

1.66023E-28*

To determine whether there was statistically significant difference in the enhanced performance of students in conceptualising and writing chemical bonds and their nomenclature when they were taught using integration of exemplary materials and flipped classroom instruction, Research Question 3 was formulated into a null hypothesis as:

H0 1. There is no statistically significant difference in the performance of students before and after the intervention.

The 2-tailed t-test for paired samples was used to determine whether existed differences between the two types of test were significant. The mean score of the post– intervention test results was unprecedentedly higher than that of the pre – intervention tests. The t-test analysis of the mean score on the post–intervention test results showed significant difference between the two types of test ($t\ (38) = -12.93$; $p < 0.05$).

This means that there was a significant difference between the performances of students in the two types of test in favour of the posttest. This indicates that, the intervention seemed to have helped to improve students' conceptualisation and understanding of chemical bonding and nomenclature as against the pretest of which the intervention had not been administered. It was concluded that, there was a statistically significant difference between students' performance in pre – intervention and post– intervention test results in favour of the post– intervention test with regards to the conceptualisation and writing of chemical bonds and nomenclature. The difference was attributed to the use of integration of exemplary materials and flipped classroom instruction. Hence the hypothesis was rejected.

Research Question Four: What are the relative improvements of male and female students when taught chemical bonding and nomenclature of inorganic compounds using integration of exemplary materials and flipped classroom instruction?

4. 5. Relative improvements of male and female students

Descriptive statistics was used to determine the relative improvement of both females and males in conceptualizing and writing chemical bonds and their nomenclature. Descriptive statistics such means, modes and standard deviations for both types of test were computed (see Table 12). The mean score for the males was 10.42, (SD = 4.93) and a mode of 9, while the mean score for the females was 7.4, (SD = 3.56) and a mode of 7 in the pretest. The mean score of the males in the pretest was higher that of the females before the intervention. However, the posttest results indicated that the mean score for the males was 20.76, (SD = 6.23) and a mode of 21, while the mean score for the females was 21.36, (SD = 5.92) and a mode of 23. The females appeared to have done better than the males after the intervention.

Table 12: The 2-tailed t-test for independent samples analysis of Scores according to gender

Gender	Number of Respondents	Test	Mean Score	Standard Deviation	t-value	p-value
Male	20	Pretest	10.42	4.93	0.029	0.007*
Female	20	Pretest	7.40	3.56		
Male	20	Posttest	20.76	6.23	0.250	0.804[a]
Female	20	Posttest	21.36	5.92		

a = not significant at 0.05; p>0.05 * = significant at 0.05; p<0.05

Research Question Five: What is the effect of the integration of exemplary materials and flipped classroom instruction on the students' motivation to study chemical bonding and nomenclature of inorganic compounds?

This research question was formulated into a null hypothesis and tested in the study:

H0 2. There is no statistically significant difference in the motivation of students before and after the integration of exemplary materials and flipped classroom instruction.

4. 6. Effect of students' Motivation Enhancing Factors (Anxiety, Enjoyment and Self-Efficacy)

Table 13: Descriptive statistics of anxiety in integration of exemplary materials and flipped classroom instruction [pre & post questionnaire]

ITEMS/CONSTRUCTS	Descriptive Statistics			
	Pre-Intque		Post-Intque	
	Mean	**SD±**	**Mean**	**SD±**
I normally think that I cannot do chemical bonding and nomenclature of inorganic compounds assignment when it seems difficult.	1.5000	1.08604	4.6250	.86787
No matter how hard I try, l cannot understand chemical bonding and nomenclature of inorganic compounds.	1.2750	.81610	4.8500	.66216
I feel tensed or confused when someone talks to me about chemical bonding and nomenclature of inorganic compounds.	1.5000	1.08604	4.6250	.70484
Working with chemical bonding and nomenclature of inorganic compounds upsets or frustrates me.	1.2500	.58835	4.6000	.84124
I do not always fidget when writing chemical bonding and nomenclature of inorganic compounds class test.	4.6250	.70484	1.7250	1.24009
It makes me nervous to even think about doing chemical bonding and nomenclature of inorganic compounds.	1.7750	1.18727	3.9500	1.01147
The only reason I am studying chemical bonding and nomenclature of inorganic compounds is because I have to.	1.1500	.36162	3.2750	1.55229
If I do not understand chemical bonding and nomenclature of inorganic compounds assignment right away, I would never understand it.	1.9500	1.19722	3.8750	1.41761
l do not do very well in chemical bonding and nomenclature of inorganic compounds assignments.	1.2000	.68687	4.5000	1.08604
I feel at ease in a chemical bonding and nomenclature of inorganic compounds class.	4.4000	1.05733	2.1250	1.34331

Data presented in Table 13 shows results from the descriptive statistics of students' motivation enhancing factors in studying chemical bonding and nomenclature of inorganic compounds during the pre-intervention and the post - intervention questionnaire. This data suggests that within the context of motivation enhancing factors and students' motivation using integration of exemplary materials and flipped classroom instruction, the majority of the students had higher levels in the post - intervention questionnaire score than in the pre-intervention (Ẍ levels of motivation in the pre-intervention questionnaire ranged between Ẍ=1.1500, SD± .36162; and Ẍ=4.6250, SD= ±.70484) and the post - intervention questionnaire (Ẍ levels of motivation in the post - intervention questionnaire ranged between Ẍ=1.7250, SD±1.24009 and Ẍ=4.8500, SD± .66216). The results indicate that the integration of exemplary materials and flipped classroom instruction significantly influenced students' levels of motivation.

4. 7. Correlation between Students' Motivation Enhancing Factors

The study also investigated the correlation between students' anxiety and integration of exemplary materials and flipped classroom instruction using Pearson Product Moment Correlation Coefficient method. The results of the correlation analysis are presented in appendix N. The result presented in appendix N shows strong correlation between the students' anxiety level and motivation to study chemical bonding and nomenclatures of inorganic compounds using integration of exemplary materials and flipped classroom instruction To evaluate whether the mean values of the test variables used to measure anxiety in the pre-intervention questionnaire differs significantly, the variables which were found to correlate with the integration of exemplary materials and flipped classroom instruction were further subjected to t-test test. The result of the t-test is presented in Table 14.

Table 14: T-Test Statistics of anxiety in integration of exemplary materials and flipped classroom instruction [Pre-Intque]

N= 40, df = 39

CONSTRUCTS	T	df	p-value	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
I normally think that I cannot do chemical bonding and nomenclature of inorganic compounds assignment when it seems difficult.	8.735	39	0.000	1.50000	1.1527	1.8473
No matter how hard I try, l cannot understand chemical bonding and nomenclature of inorganic compounds.	9.881	39	.000	1.27500	1.0140	1.5360
I feel tensed or confused when someone talks to me about chemical bonding and nomenclature of inorganic compounds.	8.735	39	.000	1.50000	1.1527	1.8473
Working with chemical bonding and nomenclature of inorganic compounds upsets or frustrate me	13.437	39	.000	1.25000	1.0618	1.4382
I do not always fidget when writing chemical bonding and nomenclature of inorganic compounds class test.	41.500	39	.000	4.62500	4.3996	4.8504
It makes me nervous to even think about doing chemical bonding and nomenclature of inorganic compounds	9.455	39	.000	1.77500	1.3953	2.1547
The only reason am studying chemical bonding and nomenclature of inorganic compounds is because I have to.	20.113	39	.000	1.15000	1.0343	1.2657
If I do not understand chemical bonding and nomenclature of inorganic compounds assignment right away, I would never understand it.	10.301	39	.000	1.95000	1.5671	2.3329
l do not do very well in chemical bonding and nomenclature of inorganic compounds.	11.049	39	.000	1.20000	.9803	1.4197
I feel at ease in a chemical bonding and nomenclature of inorganic compounds class.	26.319	39	.000	4.40000	4.0618	4.7382

The results in Table 14 above indicates significant difference in mean scores. This means that anxiety significantly influenced students' levels' of motivation in writing chemical bonding and nomenclature. Therefore, the null hypothesis is rejected.

As shown in appendix P, the calculated t-value for all the constructs used to measure anxiety in the post - intervention questionnaire were statistically significant at 0.05 significance level since the significance level of the calculated t value (p = .000) is greater than .05. This means that anxiety significantly influence students' levels of motivation to study chemical bonding and nomenclature using integration of exemplary materials and flipped classroom instruction in teaching the content. Therefore, the null hypothesis is rejected.

Comparing the pre-intervention and the post - intervention questionnaire (Table 13) students' levels of motivation in writing chemical bonding and nomenclature of inorganic compound, the results indicated that, the post - intervention questionnaire mean scores were higher than the pre-intervention questionnaire mean scores. This further suggests that, the integration of exemplary materials and flipped classroom instruction produced significant influence on students' levels of motivation in the post - intervention questionnaire.

To determine the effect size of integration of exemplary materials and flipped classroom instruction on anxiety in the post test, the variables used to measure enjoyment which correlated with the integration of exemplary materials and flipped classroom instruction were further subjected to regression analysis. The results of the regression analysis is presented in Tables 13, 14 and appendix Q.

Table 15: Summary result of regression analysis of anxiety (postintque)

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics				
					R^2	F	df1	df2	p-value F
1	.979	.959	.945	.19439	.959	67.954	10	29	.000

The R value of .979 (Table 15 above) indicates a good level of prediction. The R^2 value of .959 implies that the integration of exemplary materials and flipped classroom instruction improved students' levels of motivation to study chemical bonding and nomenclature explains 95.9% of the variability of anxiety. To explain further the implication of the results, ANOVA test was conducted and the result is presented in Table 16. The result shows that the integration of exemplary materials and flipped classroom instruction statistically significantly predict the anxiety, $F(10, 29) = 67.954$, $p (.000) < .05$.

Table 16: Summary questionnaire result of Anova on anxiety

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	25.679	10	2.568	67.954	.000
	Residual	1.096	29	.038		
	Total	26.775	39			

In appendix Q, the results of the regression analysis are displayed. The estimated regression weights (t-values), standard errors and p-values for all the predictors are given. In exception of three predictor variables (labelled with asterisks **) which showed statistically significant influence on students' motivation to study chemical bonding and nomenclature of inorganic compounds using integration of exemplary materials and flipped classroom instruction, all the other predictors produced no statistically significant effect size to report (appendix Q). The predictor variable labelled *"Working with chemical bonding and nomenclature of inorganic compounds upsets or frustrates me. **"* produced the strongest effect size as indicated by its estimated standardized regression weight ($\beta = 0.518$, $p=0.005$.

Besides the standardized weights, the squared multiple correlation were also obtained. The squared multiple correlation provides a measure of the contribution of all the predictors taken together. These results are displayed in Table 15 ($R^2 =.959$; $F (10, 29)$, $p=0.00$). The estimated standardized regression weights show the relative importance of each predictor in the model. Collectively, all the ten predictors account for about 96% of the variance in reading achievement ($R^2 = 0.959$). Therefore, the null hypothesis that all regression coefficients together are equal to zero was rejected.

4.8. The Motivation Enhancing Factor: Enjoyment

Table 17: Descriptive statistics of enjoyment in flipped classroom approach [pre-intque and post -intque]

	N = 40, Cronbach's Alpha = 0.989			
	Pre -Intque		Post -Intque	
ITEMS/CONSTRUCTS	Mean	SD±	Mean	SD
Chemical bonding and nomenclature of inorganic compounds is something that l enjoys so much.	4.6750	.82858	4.6000	.92819
l like courses that do not involve the use of any chemical bonding and nomenclature of inorganic compounds .	1.8000	1.62038	1.3000	.72324
I would like to do some extra or unassigned reading in chemical bonding and nomenclature of inorganic compounds.	1.3000	.60764	1.3000	.60764
When l hear the phrase, chemical bonding and nomenclature of inorganic compounds, I have the feeling of dislike for it.	1.5000	.75107	1.5500	.84580
I would like to spend less time in school studying chemical bonding and nomenclature of inorganic compounds.	3.6000	1.62985	3.6000	1.62985
Sometimes, I read chemical bonding and nomenclature of inorganic compounds notes in advance.	2.6500	1.40603	2.5750	1.41217
It does not disturb or upset me to do chemical bonding and nomenclature of inorganic compounds assignment	4.4000	1.08131	4.4000	1.08131
I enjoy talking to others about chemical bonding and nomenclature of inorganic compounds.	4.7500	.70711	4.7500	.70711
I enjoy watching chemical bonding and nomenclature of inorganic compounds on videos/podcast.	4.4000	1.15025	4.4000	1.15025
I have a good feeling towards chemical bonding and nomenclature of inorganic compounds.	4.2250	1.25038	4.2250	1.25038

Data presented in Table 17 shows results from the descriptive statistics of students' enjoyment in integration of exemplary materials and flipped classroom instruction and students' in pre-intervention and post- intervention questionnaire. This data suggests that within the context of enjoyment and students' motivation using integration of exemplary materials and flipped classroom instruction, the majority of the students had higher motivational levels in the post-intervention questionnaire than in the pre-intervention questionnaire (Ẍ levels of motivation in the pre-intervention questionnaire ranged between 1.3000, SD±=.60764 and 4.6250, SD± =.82858 and that of the post - intervention questionnaire ranged between 1.3000, SD±=1.3000± and 4.7500, SD±=.70711). The results indicate that, students' levels of motivation in the post -intervention questionnaire has the highest adjusted mean scores and the pre-intervention questionnaire has the lowest mean scores.

4.9. Enjoyment and Use of Integration of Exemplary Materials and Flipped Classroom Instruction

The study also investigated the correlation between students' enjoyment and integration of exemplary materials and flipped classroom instruction using Pearson Product Moment Correlation Coefficient method. The resultsof the correlation analysis is presented in appendix R. The result presented in appendix R shows strong correlation between the students' enjoyment level in writing chemical formulae and nomenclatures of inorganic compounds and the use of integration of exemplary materials and flipped classroom instruction.

To evaluate whether the mean values of the test variables used to measure anxiety in the pre-intervention questionnaire differs significantly, the variables which were found to correlate with the integration of exemplary materials and flipped classroom instruction were further subjected to t-test test. The result of the t-test is presented in Table 18.

Table 18: Enjoyment in integration of exemplary materials and flipped classroom instruction [Pre-Intque]

	N = 40,			df = 39		
CONSTRUCTS	**T**	**df**	**p- value**	**Mean Difference**	**95% Confidence Interval of the Difference**	
					Lower	**Upper**
Chemical bonding and nomenclature of inorganic compounds is something that l enjoys so much.	31.344	39	0.000	4.60000	4.3032	4.8968
l like courses that do not involve the use of any chemical bonding and nomenclature of inorganic compounds .	11.368	39	.000	1.30000	1.0687	1.5313
I would like to do some extra or unassigned reading in chemical bonding and nomenclature of inorganic compounds.	13.531	39	.000	1.30000	1.1057	1.4943
When l hear the phrase, chemical bonding and nomenclature of inorganic compounds, I have the feeling of dislike for it.	11.590	39	.000	1.55000	1.2795	1.8205
I would like to spend less time in school studying chemical bonding and nomenclature of inorganic compounds.	13.970	39	.000	3.60000	3.0787	4.1213
Sometimes, I read chemical bonding and nomenclature of inorganic compounds notes in advance.	11.532	39	.000	2.57500	2.1234	3.0266
It does not disturb or upset me to do chemical bonding and nomenclature of inorganic compounds assignment	25.735	39	.000	4.40000	4.0542	4.7458
I enjoy talking to others about chemical bonding and nomenclature of inorganic compounds.	42.485	39	.000	4.75000	4.5239	4.9761
I enjoy watching chemical formulae and nomenclature of inorganic compounds on videos/podcast.	24.193	39	.000	4.40000	4.0321	4.7679
I have a good feeling towards chemical bonding and nomenclature of inorganic compounds.	21.370	39	.000	4.22500	3.8251	4.6249

Mean difference is significant at .000 (95% CI).

Comparing the pre-intervention questionnaire scores and that of post - intervention questionnaire (Table 17) levels of motivation in studying chemical bonding and nomenclature of inorganic compound, the results indicated that, the post - intervention questionnaire scores were higher than the pre-intervention questionnaire scores. This further suggests that the integration of exemplary materials and flipped classroom instruction produced significant influence on students' levels of motivation in the post - intervention questionnaire.

As shown in appendix S, the calculated t-value for all the constructs used to measure enjoyment in the post - intervention questionnaire were statistically significant at 0.05 significance level since the significance level of the calculated t value (p = .000) is greater than 0.05. This means that enjoyment significantly influence students' levels of motivation in studying chemical bonding and nomenclature using integration of exemplary materials and flipped classroom instruction. Therefore, the null hypothesis is rejected.

To determine the effect size of integration of exemplary materials and flipped classroom instruction on enjoyment in the post - intervention questionnaire, the variables used to measure enjoyment, which correlated with the integration of exemplary materials and flipped classroom instruction were further subjected to regression analysis. The results of the regression analysis is presented in Tables 19, 20 and appendix T.

Table 19: Summary result of regression analysis (Enjoyment) Post –Intque

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics				
					R^2	F	df1	df2	p-value F
1	.962[a]	.925	.903	.25853	.925	41.178	10	29	.000

Table 20: Anova questionnaire result [Enjoyment]

Model		Sum of Squares	Df	Mean Square	F	p-value
1	Regression	24.770	9	2.752	41.178	.000
	Residual	2.005	30	.067		
	Total	26.775	39			

In appendix T, the results of the regression analysis are displayed. In the table, the estimated regression weights (t-values), standard errors and p-values for all the predictors are given. In exception of three predictor variables (labelled with asterisks **) which showed statistically significant influence on students' writing of chemical bonding and nomenclature of inorganic compounds using integration of exemplary materials and flipped classroom instruction, all the other predictors variables produced no statistically significant effect size to report (appendix T). The predictor variable (labelled with asterisks **) *"I enjoy talking to others about chemical bonding and nomenclature of inorganic compounds.* **produced the strongest effect size as indicated by its estimated standardized regression weight ($\beta = 0.821$, p=0.000.

Besides the standardized weights, the squared multiple correlation were also obtained. The squared multiple correlation provides a measure of the contribution of all the predictors taken together. These results are displayed in Table 19 (R^2 =.925; F (10, 29), p=0.00). The estimated standardized regression weights show the relative importance of each predictor in the model. Collectively, all the ten predictors account for about 93% of the variance in reading enjoyment (R^2 = 0.925). Therefore, the null hypothesis that all regression coefficients together are equal to zero was rejected in this case.

4. 10. Self-Efficacy and integration of exemplary materials and flipped classroom instruction

Table 21: Descriptive statistics of self-efficacy in integration of exemplary materials and flipped classroom instruction [pre-intque & post- intque]

	Pre-Intque	Post-Intque
I am confident that I would be able to write down all the steps involved in using WAM to name an inorganic compound.	1.6500	.83359
I am totally confident that I would be able construct WAM on my own	1.1500	.36162
I am not confident enough to write the chemical formulae and nomenclature of selected inorganic compounds.	4.6250	.80662
I am somehow confident that I would be able to use the IUPAC nomenclature to name inorganic compounds on my own	1.5500	.87560
I am not sure whether after watching television documentary concerning nomenclature of inorganic compounds, I would be able to explain its salient points to another person	4.7750	.57679
I am not sure whether I would be successful in any course that is related to the topic or not	4.8000	.60764
I am somehow confident that after participating in a lecture regarding the topic, I would be able explain its main ideas to another person	1.0500	.22072
I have very little confidence that I will be successful in any examination which draws its test items from the topic.	4.0000	1.01274
I have little confidence that I could serve as a tutor to a student on this topic	4.5750	.50064
I am not at all that confident that I would be able to critique the steps involved in using WAM.	4.1750	.87376

The result presented in appendix O shows strong correlation between the students' levels of motivation enhancing factors (self-efficacy levels) and the use of integration of exemplary materials and flipped classroom instruction after learning chemical bonding and nomenclature of inorganic compounds.

Table 22: T-Test statistics of self-efficacy in integration of exemplary materials and flipped classroom instruction [post -intque]

N= 40, df = 39

CONSTRUCTS	T	Df	p- value	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
I am confident that I would be able to write down all the steps involved in using WAM to name an inorganic compound.	12.519	39	0.000	1.65000	1.3834	1.9166
I am totally confident that I would be able construct WAM on my own	20.113	39	.000	1.15000	1.0343	1.2657
I am not confident enough to write the chemical bonding and nomenclature of selected inorganic compounds.	36.264	39	.000	4.62500	4.3670	4.8830
I am somehow confident that I would be able to use the IUPAC nomenclature to name inorganic compounds on my own	11.196	39	.000	1.55000	1.2700	1.8300
I am not sure whether after watching television documentary concerning nomenclature of inorganic compounds, I would be able to explain its salient points to another person	**52.358**	**39**	**.000**	**4.77500**	**4.5905**	**4.9595**
I am not sure whether I will be successful in any course that is related to the topic or not	**49.960**	**39**	**.000**	**4.80000**	**4.6057**	**4.9943**
I am somehow confident that after participating in a lecture regarding the topic, I would be able explain its main ideas to another person	30.087	39	.000	1.05000	.9794	1.1206
I have very little confidence that I will be successful in any examination which draws its test items from the topic.	24.980	39	.000	4.00000	3.6761	4.3239
I have little confidence that I could serve as a tutor to a student on this topic	**57.796**	**39**	**.000**	**4.57500**	**4.4149**	**4.7351**
I am not at all that confident that I would be able to critique the steps involved in using WAM	30.220	39	.000	4.17500	3.8956	4.4544

As shown in Table 22, the calculated t-value for all the constructs used to measure self-efficacy level in the post test were statistically significant at .05 significance level since the significance level of the calculated t value (p = .000) is less than .05. This means that enjoyment significantly influenced students' level of motivation in studying chemical bonding and nomenclature using integration of exemplary materials and flipped classroom instruction. Therefore, the null hypothesis was rejected.

A high level of self-efficacy is crucial as it propels one to succeed in life. Available researches on self-efficacy are based on Bandura's theory. According to Bandura (1997), self-efficacy beliefs influence persons ways of thinking and feelings, which may enable or hinder actions. This means if an individual has high self-efficacy level about his abilities, it would push him to venture into greater exploits, while low self-efficacy level will lead to inactivity and non-performance. For this reason, to determine the effect size of integration of exemplary materials and flipped classroom instruction on self-efficacy in the post test, the variables used to measure enjoyment which correlated with the integration of exemplary materials and flipped classroom instruction were further subjected to regression analysis. The results of the regression analysis are presented in Tables 23, 24 and 25.

Table 23: Summary result of regresion analysis (Self-Efficacy)

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics R^2	F	df1	df2	P-value F
1	.943[a]	.890	.857	.31528	.890	26.959	9	30	.000

Table 24: Anova[a] Summary questionnaire result of anxiety

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	25.679	10	2.568	67.954	.000[b]
	Residual	1.096	29	.038		
	Total	26.775	39			

Table 25: Anova[a] Summary questionnaire result of enjoyment (Pre-Intque)

Model		Sum of Squares	Df	Mean Square	F	P-value
1	Regression	29.139	9	3.238	21.773	.000[b]
	Residual	4.461	30	.149		
	Total	33.600	39			

a. Dependent Variable: Chemical bonding and nomenclature of inorganic compounds is something that l enjoys so much.

Table 26: Anova[a] Summary questionnaire result of self-efficacy (Pre-Intque)

Model		Sum of Squares	Df	Mean Square	F	p-value
1	Regression	24.118	9	2.680	26.959	.000[b]
	Residual	2.982	30	.099		
	Total	27.100	39			

Table 27: Linear regression analysis between the use of WAM and level of motivation to study

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	P-value.
(Constant)	-2.617	.853		-3.068	.005
I am totally confident that I would be able construct WAM on my own	-.002	.233	-.001	-.009	.993
I am not confident enough to write the chemical formulae and nomenclature of selected inorganic compounds.	.053	.198	.052	.270	.789
I am somehow confident that I would be able to use the IUPAC nomenclature to name inorganic compounds on my own.***	.619	.150	.651	4.122	.000
I am not sure whether after watching television documentary concerning nomenclature of inorganic compounds, I would be able to explain its salient points to another person	-.031	.215	-.021	-.145	.886
I am not sure whether I would be successful in any course that is related to the topic or not	.107	.251	.078	.424	.675
I am somehow confident that after participating in a lecture regarding the topic, I would be able explain its main ideas to another person.**	.726	.331	.192	2.190	.036
I have very little confidence that I will be successful in any examination which draws its test items from the topic.	-.153	.157	-.186	-.971	.339
I have little confidence that I could serve as a tutor to a student on this topic.**	.502	.164	.301	3.065	.005
I am not at all that confident that I would be able to critique the steps involved in using WAM	.061	.177	.064	.345	.733

a. Dependent Variable: I am confident that I would be able to write down all the steps involved in using WAM to name an inorganic compound.

The data presented in Table 27 shows results of the regression analysis. The estimated regression weights (*t-values (4.122), (2.190) and (3.065) with their corresponding p=0.000, p=0.03 and p=, 0.005* for all the predictors are given. In exception of three predictor variables (labelled with asterisks **) which showed statistically significant influence on students' level of motivation to study chemical bonding and nomenclature of inorganic compounds using integration of exemplary materials and flipped classroom instruction, all the other predictor variables produced no statistically significant effect size to report (Table 27). The predictor variable (labelled with asterisks ***) *"I am somehow confident that I would be able to use the IUPAC nomenclature to name inorganic compounds on my own****produced the strongest effect size as indicated by its estimated standardized regression weight ($\beta = 0.651$, $p=0.000$).

Besides the standardized weights, the squared multiple correlation were also obtained. The squared multiple correlation provides a measure of the contribution of all the predictors taken together. These results are displayed in Table 23 ($R^2 =.890$; F (9, 30), $p=0.000$). The estimated standardized regression weights show the relative importance of each predictor in the model. Collectively, all the ten predictors account for about 89% of the variance in reading enjoyment ($R^2 = 0.890$). Therefore the null hypothesis that all regression coefficients together are equal to zero was rejected in this case.

4. 11. Discussion

The results showed that, students who participated in the study had limited conceptual understanding of chemical bonding and nomenclature; and therefore possessed several misconceptions about this concept as identified in the study. The respondents' understanding of chemical bonding and nomenclature ranged from no understanding, understanding with specific misconception to partial understanding. Again, the students possessed four main types of errors which impaired their ability to provide correct responses to test items. These were errors associated with identification of chemical symbols, errors associated with conceptualisation of ion formation, errors associated with conceptualisation of oxidation states and errors associated with concepts related to atomic structure. The findings are in harmony with what Bransford, Brown and Cocking (2000) and Baroody, Cibulskis, Lai and Li (2014) referred to as lack of Conceptual Understanding in chemical bonding and nomenclature. Conceptual understanding occurs when students have the ability to use knowledge, apply it to related problems, and to make connections between related ideas. Without developing conceptual understanding in students, their performance in chemical bonding and nomenclature would fall below expectation. Furthermore, the findings corroborate the report of Ausubel (1968); Linn, Eylon and Davis (2014) and Taber (2017) that, students without organized and integrated structure of knowledge do not do well in chemical bonding and nomenclature. These researchers opined that, sense-making involved in building organized and integrated structure of knowledge involves taking newly introduced information and connecting it to existing knowledge. Thus, the respondents performed abysmally low because previous instructions might have not enabled them to connect concepts in chemical bonding and nomenclature to their existing knowledge.

The findings are connected to the research work of Sirhan (2017). Sirhan found out that, when ideas are not structured in an organized way, it is difficult for students to remember what has been taught, let alone to apply their knowledge to new situations due to lack of structure and organization; in other words, it is compartmentalised. However, the respondents had inaccurate and incomplete knowledge which was not organized into frameworks but pieces that were not put together in a systematic manner, thus making it difficult for them to remember what was taught in chemical bonding and nomenclature. The students were not able to use their fragmented pieces of knowledge to access and use their knowledge in the chemical bonding and nomenclature pre-intervention test.

Additionally, the findings on the possible causes of conceptual errors seemed to be in consonance with Bransford, Brown and Cocking's (2000) investigations into College first year students' conceptual errors in chemical bonding and nomenclature as a result of non-compliance to IUPAC nomenclature. They reported further that, students had varied conceptual errors in the chemical bonding and nomenclature due to lack of well organized and contextualized knowledge that was difficult to access and not organized along fundamental principles in chemical bonding and nomenclature.

In another instance, the finding is also in accord with Taber (2017) and Ashkenazi and Kosloff (2018) that, responses of Colleges of Education students to questions on chemical bonding and nomenclature were normally characterised by conceptual errors due to non-compliance of IUPAC convention in naming chemical substances. The findings further attributed the cause of the problem to violations of laws guiding chemical combinations as well as students' inability to imbibe key concepts due to faulty teaching methods. It also confirmed the work of Vinner (2020) that, Colleges of Education students' answer to questions on chemical bonding and nomenclature posses a lot of pseudo conceptions due to error-contained responses. To Vinner, pseudo conceptions were the use of scientific terms used by students in an examination without conceptual or scientific understanding.

The finding is connected with the report of Perkins' (2019) investigation into what was dubbed Understanding Performances. According to Perkins, understanding means being able to accomplish a variety of performances, which shows one's understanding of a concept, and at the same time, advance it. This means that understanding performances must lead students transcend what they already know. The inability of students to do well in chemical bonding and nomenclature seemed to be attributed to previous teaching which did not lead to the development of understanding performances in chemical bonding and nomenclature.

The study also revealed that there was significant improvement in the performance due to the fact that, the posttest results were better than that of the pretest. This could be attributed to the exposure of students to integration of exemplary materials and flipped classroom instruction. The integration of exemplary materials and flipped classroom instruction which served as both a medium of instruction and teaching and learning materials were physical objects which were tangible and therefore helped to reduce the level of abstraction and brought some concreteness into the learning of chemical bonding and nomenclature. This integration of exemplary materials and flipped classroom instruction allowed the students to both visualise and conceptualise the formation of chemical bonds in an improvised manner. Thus, the use of the integration of exemplary materials and flipped classroom instruction helped in organising the students' conceptual structure in a particular way to aid in better understanding. This is in consonance with the reports of Onasanya (2014); Onasanya and Adegbija (2017) and Okpala, Ambali and Alpha (2012) in their investigations of the impact of integration of exemplary materials. They found out that students exposed to integration of exemplary materials performed better in chemical bonding and nomenclature than their counterparts who have been exposed to any other intervention other than integration of exemplary materials and flipped classroom instruction.

In fact, integration of exemplary materials has been found to contribute appreciably to students academic performance at all grades levels in different disciplines or courses and in different geographical locations (Onasanya & Adegbija, 2017; Soetan, Iwokwagh, Shehu &. Onasanya, 2010). The findings seemed to suggest that, integration of exemplary materials and flipped classroom instruction could be used to assist Colleges of Education students to improve upon their performance in both content and pedagogy as preservice teachers (Teichert & Stacy 2002; Taber 2017). In addition to that, the findings seemed to corroborate the work of Aguisiobo (2012), that learning is an activity that takes place in a contact and not in a vacuum. Aguisiobo (2012) reiterated that a student with integration of exemplary materials and flipped classroom instruction does not have a blank mind but a consolidated and developed library of knowledge. The development of a mind with a consolidated and well developed library of knowledge at the time of the posttest resulted in bringing deeper understanding, thus making the respondents perform better than that of the pretest. This could be due to the fact that, the integration of exemplary materials and flipped classroom instruction was also of high quality and appropriately conveyed whatever information that was intended to the learners. This is again in consonance with the findings of Beckman (2012); Chickering and Gamson (2014); Collier (2020) ; Johnson and Johnson (2000); Okpala *et al*. 2012) and NCCE (2019) that, what students learn is greatly influenced by the interactive nature of the integration of exemplary materials used in changing the mental models of the students.

Furthermore, the finding is in harmony with Taber (2014) that, ability to improve one's performance in chemical bonding and nomenclature of inorganic compounds is not limited to brilliant students only. This means that, irrespective of students' gender, the teacher could employ integration of exemplary materials and flipped classroom instruction to enhance their performance in chemical bonding and nomenclature of inorganic compounds. Male low-achievers and their female counterparts' performance in chemical bonding and nomenclature of inorganic compounds showed that, with more cognitive efforts by such students, and perhaps more training period and exercises in chemical bonding and nomenclature of inorganic compounds, could improve their performance.

Student's performance in chemical bonding and nomenclature of inorganic compounds was observed among both male and female students. Finding revealed that, using integration of exemplary materials and flipped classroom instruction to improve academic performance is not significantly influenced by students' gender. However, the mean score of' females was slightly higher than their male counterparts. Though the difference was not statistically significant; it seemed to indicate that the females are more favourably disposed towards chemical bonding and nomenclature of inorganic compounds when integration of exemplary materials and flipped classroom instruction is used than their male counterparts. This might be attributed to several opportunities at students' disposal when integration of exemplary materials and flipped classroom instruction is used in learning chemical bonding and nomenclature of inorganic compounds. Firstly, it provided both visualisation and conceptualisation of the abstract concept taught through manipulation of the physical objects by the students and secondly sought casual explanations in the form of discussion. The integration of exemplary materials and flipped classroom instruction was designed in such a way that in the course of using it, the sticky projections of the supposed metal WAM was being inserted into holes of the supposed non-metal WAM for bonding of the atoms to occur. In fact students could visualise the bonding processes involved in bond formation. This supports Dori (2013) statement that, requesting a student to write a chemical formulae using integration of exemplary materials would provide alternative information about knowledge possessed.

Again, it is in consonance with Gilbert (2015) that, visualisation plays a major role in science education by providing simultaneous representations of the physically manifested and theoretically framed behaviours of the system under study. In addition, the integration of exemplary materials and flipped classroom instruction provided opportunity for a private dialogue with the teacher for students to share their views and more importantly unearth their misconceptions as well as conceptual errors in the process of learning.

The results agreed with Okpala et al. (2012) that, science should be taught primarily as hands-on activity using improvised materials such as integration of exemplary materials. Earlier on, Omosewo (2018) echoed that, in a modern science curriculum programme, students need to be encouraged to learn not only through their eyes, or ears, but should be able to use their hands to manipulate integrated exemplary materials. According to Pimpro (2011), the use of familiar materials and resources such as integration of exemplary materials that are found in the environment stimulated creativity and built confidence in hands-on work. Krajcik, McNeill and Reiser (2018) supported this by noting that, science education must be contextualised and linked to life experiences of the learners. The assertion was further buttressed by Taber and Coll (2012) and Coll and Taylor (2013) that, low-cost materials such as integration of exemplary materials produced through improvisation is not an attempt to provide a watered down science education, but highly creative and productive science education. The use of exemplary materials provides opportunities for creativity and development of imaginative abilities, and concepts are learnt and internalised by concrete and unspectacular work than proceeding with chalk-and-teacher-talk method of teaching science.

Conversely, the findings seemed to disagree with Okoboh, Ajere and Eule's (2017), Taber (2017) and Dun (2015) study on sex difference in academic achievement of students in CoE in science and mathematics. The study found that there was a significant difference among females and males in the two subjects and the difference was in favour of the males when exemplary materials were used. Finally, integration of exemplary materials and flipped classroom instruction provided opportunities for learning by engaging the students in active learning processes where students became responsible for their own learning; and also for self–assessment of performance and progress of work through the provision of exercises. The designed exercises provided the students with an alternative source of exercises for trial at home and school due to unavailability of workbooks.

The materials for the preparation of the integration of exemplary materials and flipped classroom instruction were very clear, appropriate for the level of the students, and presented the concepts under study in a simple and logical sequence. The integration of exemplary materials and flipped classroom instruction was very helpful in engaging students actively in the teaching and learning process and improved student's performance. This is consistent with the results of Kesidou and Roseman (2012); Levy-Nahum et al. (2014) and Taber and Coll (2012) that the use of flipped classroom instruction catalyses students' understanding of scientific concepts and therefore promotes active learning among students to improve their performance.

Again, the study investigated the effects of integration of exemplary materials and flipped classroom instruction on students' levels of motivation to study chemical bonding and nomenclature of inorganic compounds. The mediational role of anxiety, enjoyment and self-efficacy of students towards the enthusiasm to study chemical bonding and nomenclature of inorganic compounds was also examined. However, the findings indicated that anxiety (see Appendix N), enjoyment (Table 19) and self-efficacy (see Appendix O) all correlated with enthusiasm of the respondents to study chemical bonding and nomenclature of inorganic compounds using integration of exemplary materials and flipped classroom instruction. Among these three factors, self-efficacy produced the highest effect on students' levels of motivation to study to study chemical bonding and nomenclature of inorganic compounds using integration of exemplary materials and flipped classroom instruction. Also, regression analysis results indicated that anxiety, enjoyment and self-efficacy respectively produced 96%, 93%, and 89% of the variance in predicting the effect of integration of exemplary materials and flipped classroom instruction on students' levels of motivation to study chemical bonding and nomenclature of inorganic compounds (Tables 15,19 and 23).

The study assessed the effects of integration of exemplary materials and flipped classroom instruction on students' levels of motivation to study chemical bonding and nomenclature of inorganic compounds. The results presented in Tables 13 and 19 showed that there was statistically significant difference in both pre-intervention and the post - intervention questionnaire scores in all the motivation factors including anxiety, enjoyment and self-efficacy in levels of motivation to study chemical bonding and nomenclature of inorganic compounds using integration of exemplary materials and flipped classroom instruction. Comparison between students' level of motivation in pre-intervention and the post - intervention questionnaire scores also show statistically significant difference (Table 26). The post - intervention questionnaire results indicated that, students taught with integration of exemplary materials and flipped classroom instruction had the highest mean scores. This suggests that, integration of exemplary materials and flipped classroom instruction improved the students' levels of motivation to study chemical bonding and nomenclature of inorganic compounds.

The influence of flipped classroom instruction on students' motivation has been documented in several studies (Kong, Wong & Lam, 2003; Pike & Kuh, 2005; Kuh, 2009; Errey & Wood, 2011; Harbour et al., 2015). For example, one earlier study conducted by McCarthy (2016) to determine the effect of flipped classroom learning strategy on students' motivation found that, in flipped classroom environment, students showed higher level of motivation and higher morale, as well as deeper understanding of concepts. He attributed this to the fact that in flipped classroom environment, students learn at their own pace rather than moving too fast ahead or lag behind. Furthermore, students in flipped classroom environment were introduced to self-directed, independent learning techniques, as well as collaborative, group-oriented learning attitudes and all these encourage effective peer interaction and engagement.

Similar study conducted by Nederveld and Berge (2015) and Onasanya and Adegbija (2017) to determine the effect of flipped classroom strategy on students' motivation in learning concepts in chemistry (chromatography and IUPAC nomenclature of inorganic compounds) found that, in flipped classroom learning model, students activities were spent on higher level implementation than listening to lectures and other lower order thinking tasks of Bloom's taxonomy. Flores (2016) corroborated the claim made by Nederveld and Berge (2015) by stating that, when flipped classroom strategy is used, the face to face activity with students in the classroom is filled with tasks that require problem solving, conjecture, experiment, exploration, creation, implementation, and communication of issues related to the material being studied in the classroom. This situation largely makes students become more motivated to learn.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0. Overview

This chapter provides summary of major findings, conclusion, recommendations and suggestions for further studies.

5. 1. Summary of Major Findings

The study revealed that most students lack scientific and complete conception of basic concepts in atomic structure. Further analysis revealed that, the most frequent difficulties students had with this concept included the use of unscientific or incomplete definition which does not include all the defining properties of the concepts. In most situations definition of terms like atom, element and ions were interchanged. For instance some students defined an atom as the smallest particle of matter; charged species or a piece of an element. Other forms of misconceptions include the definition of an ion as a negatively charged particle or an atom with a positive charge. It is clear that many students have no sound understanding of these basic concepts. The common problems that emerged from the students' responses included:

i. Misconception of the definition of the atom, ions and elements.
ii. Wrong conception of the meaning of mass number, atomic number and proton number.
iii. Wrong conception of the charges of the subatomic particles such as electron, proton and neutron.

iv. It was clear from the sampled responses that, students had various conceptions on the writing of chemical bonding and nomenclature of inorganic compounds.

v. Four types of errors were identified. These included errors associated with identification of chemical symbols, errors associated with identification of ion formation, errors associated with identification of oxidation states and IUPAC nomenclature and errors associated with concepts related to atomic structure. In fact, some of the errors overlapped each other and as a result, it was not easy stating clearly the type of error to which such a particular error-contained response belonged.

The following accounted for respondents' partial, misconception or no understanding in writing IUPAC names:

- The use of wrong prefixes like mono, di, tri, tetra to indicate the number of oxygen atoms in the given compounds.
- Inability to identify the constituting ions present in the given compounds and naming each accordingly.
- Inadequate skills in determining the oxidation states or valencies of central atoms with respect to polyatomic ions or oxoanions.
- Lack or inadequate knowledge in using capital Roman numerals to designate oxidation states for central atoms and placing these in parenthesis.
- The types of conceptions students showed in some of their answers clearly indicated that, they had problem in learning the rules governing the IUPAC system of naming chemical bonding and nomenclature of inorganic compounds.

The results from the pretests showed that students' prior conception levels in the use of IUPAC rules were very low.

From the study and the review of literature, it appears the problem of poor conception of chemical bonding and nomenclature of inorganic compounds can also be explained by three factors related to instruction:

- First, chemical bonding and nomenclature of inorganic compounds is an abstract concept like the atom itself and if appropriate mental models are not used in teaching, the subject matter becomes incomprehensible.
- Second, it seems that previous instructions have failed to help students make meaning of the concept and assimilate it into their knowledge structure.
- Third, students tended to use unrelated correct ideas from their conceptual structure to answer questions related to the chemical bonding and nomenclature of inorganic compounds.
- The four types of errors identified appeared to overlap each other and this requires the use an integrated approach to rectify these errors.
- Integration of exemplary materials and flipped classroom instruction improved students' academic performance, because there was statistically significant difference in performance between the pre -intervention test scores and that of the post - intervention test scores. The difference was in favour of the post – intervention test.
- Integration of exemplary materials and flipped classroom instruction was user-friendly to both male and female students. Both males and females had their pre – intervention test scores remarkably improved after the intervention. This means that the use of integration of exemplary materials and flipped classroom instruction is recommended for every student.

- The findings indicated that anxiety, enjoyment and self-efficacy all correlated with conceptualisation and writing of chemical bonding and nomenclature of inorganic compounds using integration of exemplary materials and flipped classroom instruction.
- Among the three motivational factors, self-efficacy produced the highest effect on students' conceptualization and writing of chemical bonding and nomenclature of inorganic compounds using integration of exemplary materials and flipped classroom instruction. However, regression analysis results indicated that anxiety, enjoyment and self-efficacy respectively produced 96%, 93%, and 89% of the variance in predicting the effect of integration of exemplary materials and flipped classroom instruction.

5. 2. Conclusion

- Teaching using integrating exemplary materials and flipped classroom instruction at Gbewaa College of Education improved students' understanding of chemical bonding and nomenclature of inorganic compounds which led to higher achievement.
- Students' engagement with integrating exemplary materials and flipped classroom instruction in learning chemical bonding and nomenclature of inorganic compounds in Gbewaa College of Education yielded favourable higher levels of motivation to study chemical bonding and nomenclature of inorganic compounds.
- Previous approaches used in teaching the chemical bonding and nomenclature of inorganic compounds at the SHS level seemed to have led to the development of misconceptions and conceptual errors among the students.

- The integrating exemplary materials and flipped classroom instruction help students to improve upon their academic performance regardless of gender differences.
- The exemplary materials (Wooden Atomic Models) should be used as teaching and learning materials to teach chemical bonding and nomenclature of inorganic compounds.
- To ensure higher levels of motivation and better learning outcomes, tutors of Gbewaa College of Education should the increase self-efficacy level in the classroom and at the same time reduce anxiety level among the students.

5.3. Implications for Science Teaching and Learning

The results of this study indicated that many students in CoE have challenges with the learning of chemical bonding and nomenclature of inorganic compounds due to difficulty associated with conceptualisation of the concept and difficulty in manipulating ions or atoms together to form compounds. It appears this problem is common to other concepts in chemistry. As a result, many students resort to the memorization of concepts in chemical bonding and nomenclature of inorganic compounds and thus find it difficult applying the concepts to solve problems or relating the concepts to real life situations. It is therefore necessary that innovative ways of teaching chemical bonding and nomenclature of inorganic compounds have to be developed to make learning meaningful. Integration of exemplary materials have proven to be a useful method of diversifying the teaching and learning of chemical bonding and nomenclature of inorganic compounds. With the introduction of integration of exemplary materials and flipped classroom instruction in all Ghanaian Junior and senior high schools, better method of teaching can be explored in our schools as an innovation in the teaching and learning not only in the area of chemical bonding and nomenclature of inorganic compounds but in other abstract concepts in chemistry. When this is done, the teaching and learning of integrated science and chemistry as well as other science subjects will become meaningful and interesting and students will be able to apply the concepts learnt in solving problems academically and in real life situations.

5.4. Contributions of the Study to Science Education

Despite its numerous limitations, the strength of the study lies in its contribution to science education in Ghana. It is envisaged that the success of science education depends principally on the pedagogies used by the science teachers, and curriculum developers to enhance understanding of various scientific concepts. Therefore, reflecting on the challenges Ghanaian CoE teachers and students face in teaching and learning of chemical bonding and nomenclature of inorganic compounds, the designed and developed integration of exemplary materials and flipped classroom instruction is intended to help teachers and students in teaching and learning of chemical bonding and nomenclature of inorganic compounds in science and chemistry classes particularly in lesson presentation, group work and assessment of students learning.

5.5. Recommendations

Based on the findings of this study, the following recommendations were made to enhance the teaching and learning of chemical bonding and nomenclature of inorganic compounds:

Based on the findings of this study, the following recommendations were made to enhance the teaching and learning of chemical bonding and nomenclature of inorganic compounds:

1. Gbewaa College of Education should ensure that integration of exemplary materials and flipped classroom instruction is used to enhance students' performance in chemical bonding and nomenclature of inorganic compounds other related topics on the course outline.
2. Gbewaa College of Education should set up a committee of experts responsible for integrating exemplary materials and flipped classroom instruction for other courses in the curriculum.This would help the students to be actively involved in constructing and organising knowledge in a way that can help them solve problems in real life situations.
3. Gbewaa College of Education e should explore the use of integration of exemplary materials and flipped classroom instruction as an instructional aid in teaching and learning of chemical bonding and nomenclature of inorganic compounds and other related topics such as qualitative analysis, balancing of chemical equations among others.
4. Gbewaa College of Education should provide enabling environment for teachers to design and produce science teaching pedagogies such as integration of exemplary materials and flipped classroom instruction.
5. Gbewaa College of Education should solicit funds from donors for more comprehensive work to be done on the development and trials of more integration of exemplary materials and flipped classroom instruction.

5. 6. Suggestions for Further Studies

1. Due to time constraints, the study was carried out only in one college of education. A study should therefore be conducted with a larger and more representative sample in other colleges of education and schools in Ghana.
2. It is suggested that a study of the effect of integration of exemplary materials and flipped classroom instruction from different socio-economic backgrounds should be done to assess the suitability of integration of exemplary materials and flipped classroom instruction in all Colleges of Education in Ghana.
3. The applicability of integrating exemplary materials and flipped classroom instruction to other levels of education is yet to be tested in Ghana. Therefore, a study focused on selected topics in the science curriculum should be conducted at the Senior High Schools level.
4. It is suggested that the study be conducted using computer animations instead of integrating exemplary materials and flipped classroom instruction.

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APPENDICES

Appendix A

Pre-intervention test

CHEMBONOT

Section A: Instructions

Thank you for taking time to complete this questionnaire. Please respond to each item to the best of your knowledge. Your thoughtful and truthful responses will be greatly appreciated. You are not obliged to provide your individual name or identification number and will not at any time be **associated** with your responses. Your responses will be kept completely confidential and will not influence your course grade and any of your examination results anywhere.

Please read the following statements and kindly provide the information required.

SECTION B: Biodata

Name---------------------------- Name of college----------------------

Sex------------------------ Level----------------------------

Section C: part One

1. What is an atom?

2. What is an ionic bonding?

3. Why is it that a non-metal ion always has a negative charge?

4. What is the numerical charge on an electron?

5. Write down the symbol for Fluoride ion.

6. Valency of an element is synonymous with

7. Define atomic number of an element.

8. Write down the electronic configuration for $_{17}Cl$?

9. What is the oxidation state of H_2?

Appendix A continued

10. What is the chemical symbol for Potassium?

Part Two

1. How does an atom become an ion?
2. What is the difference between an atom and an ion?
3. What is a polyatomic ion?
4. Write the chemical formula for Potassium fluoride.
5. What is the relationship between atomic number and proton number of an atom?
6. What type of ions are formed by metals in group 1?
7. Give an example of a noble gas.
8. To which group in the periodic table does Calcium belong to?
9. Give the formula for trioxonitrate (V) ion.
10. Name the element that appears not to belong to any group.
11. What is the name of the compound formed, if Lithium reacts with Chlorine?
12. What is the formula of Aluminium Oxide?
13. Give one Properties of ionic Compounds.
14. What are isotopes?
15. What is the formula of Calcium Carbonate?
16. What makes a compound different from an element?
17. Which group of elements forms only positive ions?
18. Name the group of chemical substances that has a high melting point and conducts electricity when melted.
19. Identify the group of elements that hardly react to form compounds.

20. What type of bond is formed when pairs of electrons are equally shared by atoms?
21. What type of bond is formed when electrons are transferred between atoms?
22. What determines the chemical properties of an element?
23. The chemical formula, NaCl is a formula unit. Explain.
24. Write down the molecular formula for ammonia.
25. Give two examples of monatomic anion.
26. $Al^{3+} + 3NO_3^- \longrightarrow$
27. Name the species HCO_3^{-}.
28. What is the formula for lead (II) oxide?
29. What is the chemical formula for Iron (III) tetraoxosulphate (VI)?
30. The total …… of a compound is equal to the sum of charges for each atom present in a compound.

Appendix B

Post-intervention test

Section A: Instructions

Thank you for taking time to complete this questionnaire. Please answer each question to the best of your knowledge. Your thoughtful and truthful responses will be greatly appreciated. You are not obliged to provide your individual name or identification number and will not at any time be associated with your responses. Your responses will be kept completely confidential and will not influence your course grade and any of your examination results anywhere.

Please read the following statements and kindly provide the information required.

Section B: Biodata

Name--------------------------- Name of college------------------

Sex------------------------ Level----------------------------

Section C: Part One

1. The smallest particle of an element that cannot be broken down into simpler units by any means is known as ……

2. What is an ionic bonding?

3. Why is it that a non-metal ion always has a negative?

4. What is the numerical charge on an electron?

5. Write down the symbol for Iodide ion.

6. Valency of an element is also known as………

7. Define mass number of an element.

8. Write down the electronic configuration for $_{18}Ar$.

9. What is the oxidation state of N_2?

Appendix B continued

10. What is the chemical symbol for Potassium?

Part two

1. How does an atom become an ion?
2. What is the difference between an atom and an element?
3. What is a polyatomic ion?
4. Write the chemical formula for Potassium Iodide.
5. What is the relationship between atomic number and proton number of an atom?
6. What type of ions are formed by metals in group 2?
7. Give an example of a halogen.
8. To which group in the periodic table does Magnesium belong to?
9. Give the formula for trioxosulphate (IV) ion.
10. Name the element that appears not to belong to any group.
11. What is the name of the Compound made from Lithium and Fluorine?
12. What is the formula of Aluminium Sulphide?
13. Give one Property of ionic Compounds.
14. What are isotopes?
15. What is the formula of Magnesium Carbonate?
16. What makes a compound different from an element?
17. Which group of elements forms only negative ions?
18. Name the group of chemical substances that has a high melting point and conducts electricity when melted.
19. Identify the group of elements that never form compounds.

20. What type of bond is formed when pairs of electrons are equally shared by atoms?

Appendix B continued

21. What type of bond is formed when electrons are transferred between atoms?

22. What determines the chemical properties of an element?

23. The chemical formula, KCl is a formula unit. Explain.

24. Write down the molecular formula for ammonia.

25. Give two examples of monatomic anion.

26. $Al^{3+} + 3NO_3^{-} \longrightarrow$

27. Name the species HCO_3^{-}.

28. What is the formula for lead (II) oxide?

29. What is the chemical formula for Iron (III) tetraoxosulphate (VI)?

30. The total …… of a compound is equal to the sum of charges for each atom present in a compound.

Appendix C

Validated scheme to pre-intervention test

Part one

1. An atom is the smallest particle of an element that exhibits the properties of that element and can always take part in a chemical reaction.
2. Ionic bonding is the formation compounds where two or more ions are held together by electrostatic force of attraction. One of the ions has a positive charge (called a "cation") and the other has a negative charge ("anion").
3. A non-metal ion is negatively charged because it gains electrons.
4. The charge of an electron is -1.
5. The symbol for Fluoride ion is I^-
6. The valency of an element is also known its combining power.
7. Atomic number of an element is the number of protons present in the nucleus of a neutral atom.
8. Electronic configuration for $_{18}Cl$ is 2, 8, and 7.
9. The charge of H_2 is zero (0).
10. The chemical symbol for Potassium is K

Part two

1. An atom becomes an ion when it loses or gains one or more electrons.
2. An atom has no charge and cannot move about in a solution to conduct electricity whereas an ion has a charge and can move about in a solution to conduct electricity.

3. A polyatomic ion is a tightly bound group of atoms that behave as a unit and carry a charge.

Appendix C continued

4. The chemical formula for Potassium Fluoride is KF.
5. Atomic number is equal to proton number if the atom is neutral.
6. A metal in group one will form cation or positive ion.
7. Examples of noble gases include Helium, Neon and Argon among others.
8. Calcium belongs to group 2.
9. The formula for trioxonitrate (V) ion is NO_3^-
10. The element is Hydrogen.
11. The compound formed if Lithium reacts with chlorine is Lithium Chloride (LiCl).
12. The formula of Aluminium Sulphide is Al_2S_3.
13. Properties of ionic compounds are: Crystalline solids at room temperature, high melting point, soluble (dissolves) in water, well-defined crystals and molten form conducts electricity.
14. Isotopes are atoms of the same element having the same atomic number but different mass numbers due to differences in neutron numbers.
15. The formula of Calcium Carbonate is $CaCO_3$.
16. An element is different from a compound because it has only one kind of atom, whereas a compound is made of two or more different kinds of atoms.
17. The group of elements which form only positive ions include group I, II and III.
18. The group of chemical substances that has a high melting point and conducts electricity when melted ionic compounds /crystals.

19. The groups of elements that hardly react form compounds are called noble/inert/rare gases.

Appendix C continued

20. The type of bond formed when pairs of electrons are equally shared by atoms is a covalent bond.
21. The type of bond formed when electrons are transferred between atoms is an ionic bonding.
22. The chemical properties of an element are determined by the number of valence electrons it has.
23. The chemical formula, NaCl is a formula unit because it consists of one Sodium ion and one Chloride ion.
24. The molecular formula for ammonia is NH_3.
25. Two examples of monatomic anions include F^-, Cl^-, Br- and I^-.
26. $Al^{3+} + 3NO_3^- \longrightarrow Al(NO_3)_3$.
27. The species, HCO_3^- is Hydrogentrioxocarbonate (IV) ion.
28. The formula for lead (II) oxide is PbO.
29. The chemical formula for Iron (II) tetraoxosulphate (VI) is $FeSO_4$.
30. The total **charge** of a compound is equal to the sum of the charges for each atom present in a compound.

Appendix D

Validated responses to post-intervention test

Part One

1. An atom.
2. Ionic bonding is the formation compounds where two or more ions are held next to each other by electrical attraction. One of the ions has a positive charge (called a "cation") and the other has a negative charge ("anion").
3. A non-metal ion is negative because it gains electrons.
4. The charge of an electron is -1.
5. The symbol for Iodide ion is I^-
6. The valency of an element is also known its oxidation number.
7. Mass number of an element is the sum of protons and neutrons in the nucleus of an atom.
8. Electronic configuration for $_{18}Ar$ is 2, 8, and 8.
9. The oxidation number of N_2 is zero (0).
10. The chemical symbol for Potassium is K

Part two

1. An atom becomes an ion when it loses or gains one or more electrons.
2. An atom is the smallest particle of an element that exhibits the properties of that element and can always take part in a chemical reaction whereas an element is the smallest particle of matter that cannot be broken down into any simpler units.
3. A polyatomic ion is a tightly bound group of atoms that behave as a unit and carry a charge.

Appendix D continued

4. The chemical formula for Potassium Iodide is KI
5. Atomic number is equal to proton number if the atom is neutral.
6. A metal in group 2 will form cation or positive ion.
7. Examples of halogen include Fluorine, Chlorine, Bromine and Iodine.
8. Magnesium belongs to group 2
9. The formula for trioxosulphate (IV) ion is SO_3^{2-}
10. The element is Hydrogen.
11. The Compound made from Lithium and Fluorine is Lithium Fluoride (LiF).
12. The formula of Aluminium Sulphide is Al_2S_3.
13. Properties of ionic compounds are crystalline solids at room temperature, high melting point, soluble (dissolves) in water, well-defined crystals and molten form conducts electricity.
14. Isotopes are atoms of the same element having the same atomic number but different mass numbers due to differences in neutron numbers.
15. The formula of Magnesium Carbonate is $MgCO_3$.
16. An element is different from a compound because it has only one kind of atom, whereas a compound is made of two or more different kinds of atoms
17. The group of elements which form only negative ions include group V, VI and VII.
18. The group of chemical substances that has a high melting point and conducts electricity when melted ionic compounds /crystals.
19. The groups of elements that never form compounds are called noble/inert/rare gases.

20. The type of bond formed when pairs of electrons are equally shared by atoms is a covalent bond.
21. The type of bond formed when electrons are transferred between atoms is an ionic bonding.
22. The chemical properties of an element are determined by the number of valence electrons it has.
23. The chemical formula, KCl is a formula unit because it consists of one Potassium ion and one Chloride ion.
24. The molecular formula for ammonia is NH_3.
25. Two examples of monatomic anions include F^-, Cl^-, Br- and I^-.
26. $Al^{3+} + 3NO_3^- \longrightarrow Al(NO_3)_3$.
27. The species HCO_3^- is Hydrogen trioxocarbonate (IV) ion.
28. The formula for lead (II) oxide is PbO.
29. The chemical formula for Iron (III) tetraoxosulphate (VI) is $Fe_2(SO_4)_3$.
30. The oxidation number of a compound is equal to the sum of the oxidation numbers for each atom in the compound.

Appendix E

Students' Pre-Intervention Questionnaire

INSTRUCTIONS

Thank you for making some time to complete this questionnaire. Please answer each of the following questions to the best of our ability. Thoughtful and truthful responses to these questions would be very much appreciated. **Your individual names or students' identification number is not needed and will not be associated with your response in any way.** Your response will be handled completely confidential. Please read the below statements and kindly provide the answers required.

A. Background information

Please tick [✓] in the appropriate space provided below and supply the answers where required.

1. Gender ( ) Male ( ) Female

STUDENTS' ATTITUDE TOWARDS FLIPPED CLASSROOM APPROACH

Please, tick [✓] the option that shows how you describe each of the following statements; Rating scale: Strongly Agree (SA=5). Agree (A=4), Not Sure (NS=3), Disagree (D=2),Strongly Disagree (DA=1)

STUDENTS' MOTIVATION LEVEL						
STUDENTS' INSTRUCTION	**SA**	**A**	**N**	**D**	**SD**	**TOTAL**
SECTION A						
ANXIETY IN FLIPPED CLASSROOM APPROACH						
1. I normally think that I cannot do chemical bonding and nomenclature of inorganic compounds assignment when it seems difficult.						
2. No matter how hard I try, l cannot understand chemical bonding and nomenclature of inorganic compounds.						
3. I feel tensed or confused when someone talks to me about chemical bonding and nomenclature of inorganic compounds.						
4. Working with chemical bonding and nomenclature of inorganic compounds upsets or frustrate me						
5.. I do not always fidget when writing chemical bonding and nomenclature of inorganic compounds class test.						
6.. It makes me nervous to even think about doing chemical bonding and nomenclature of inorganic compounds						
7. The only reason am studying chemical bonding and nomenclature of inorganic compounds is because I have to.						
8. If I do not understand chemical bonding and nomenclature of inorganic compounds assignment right away, I would never understand it.						
9. l do not do very well in chemical bonding and nomenclature of inorganic compounds.						
10. I feel at ease in a chemical bonding and nomenclature of inorganic compounds class.						
SECTION B	**SA**	**A**	**N**	**D**	**SD**	
ENJOYMENT IN FLIPPED CLASSROOM APPROACH						
1. Chemical bonding and nomenclature of inorganic compounds is something that l enjoys so much.						

2. l like courses that do not involve the use of any chemical bonding and nomenclature of inorganic compounds .						
3. I would like to do some extra or unassigned reading in chemical bonding and nomenclature of inorganic compounds.						
4. When l hear the phrase, chemical bonding and nomenclature of inorganic compounds, I have the feeling of dislike for it.						
5. I would like to spend less time in school studying chemical bonding and nomenclature of inorganic compounds.						
6. Sometimes, I read chemical bonding and nomenclature of inorganic compounds notes in advance.						
7. It does not disturb or upset me to do chemical bonding and nomenclature of inorganic compounds assignment						
8. I enjoy talking to others about chemical bonding and nomenclature of inorganic compounds.						
9. I enjoy watching chemical bonding and nomenclature of inorganic compounds on videos/podcast.						
10. I have a good feeling towards chemical bonding and nomenclature of inorganic compounds.						

Appendix F

Students' Post-Intervention Questionnaire

INSTRUCTIONS

Thank you for making some time to complete this questionnaire. Please answer each of the following questions to the best of our ability. Thoughtful and truthful responses to these questions would be very much appreciated. **Your individual names or students' identification number is not needed and will not be associated with your response in any way.** Your response will be handled completely confidential. Please read the below statements and kindly provide the answers required.

A. Background information

Please tick [✓] in the appropriate space provided below and supply the answers where required.

1. Gender ( ) Male ( ) Female

STUDENTS' MOTIVATION LEVEL						
STUDENTS' INSTRUCTION	**SA**	**A**	**N**	**D**	**SD**	**TOTAL**
SECTION A						
ANXIETY IN FLIPPED CLASSROOM APPROACH						
1. I normally think that I cannot do chemical bonding and nomenclature of inorganic compounds assignment when it seems difficult.						
2. No matter how hard I try, l cannot understand chemical bonding and nomenclature of inorganic compounds.						
3. I feel tensed or confused when someone talks to me about chemical bonding and nomenclature of inorganic compounds.						
4. Working with chemical bonding and nomenclature of inorganic compounds upsets or frustrates me.						
5.. I do not always fidget when writing chemical bonding and nomenclature of inorganic compounds class test.						
6.. It makes me nervous to even think about doing chemical						

bonding and nomenclature of inorganic compounds.						
7. The only reason am studying chemical bonding and nomenclature of inorganic compounds is because I have to.						
8. If I do not understand chemical bonding and nomenclature of inorganic compounds assignment right away, I would never understand it.						
9. l do not do very well in chemical bonding and nomenclature of inorganic compounds assignments.						
10. I feel at ease in a chemical bonding and nomenclature of inorganic compounds class.						
SECTION B	**SA**	**A**	**N**	**D**	**SD**	
ENJOYMENT IN FLIPPED CLASSROOM APPROACH						
1. Chemical bonding and nomenclature of inorganic compounds is something that l enjoys so much.						
2. l like courses that do not involve the use of any chemical bonding and nomenclature of inorganic compounds .						
3. I would like to do some extra or unassigned reading in chemical bonding and nomenclature of inorganic compounds.						
4. When l hear the phrase, chemical bonding and nomenclature of inorganic compounds, I have the feeling of dislike for it.						
5. I would like to spend less time in school studying chemical bonding and nomenclature of inorganic compounds.						
6. Sometimes, I read chemical bonding and nomenclature of inorganic compounds notes in advance.						
7. It does not disturb or upset me to do chemical bonding and nomenclature of inorganic compounds assignment						
8. I enjoy talking to others about chemical bonding and nomenclature of inorganic compounds.						
9. I enjoy watching chemical bonding and nomenclature of inorganic compounds on videos/podcast.						
10. I have a good feeling towards chemical bonding and nomenclature of inorganic compounds.						
SECTION C						
STUDENTS' SELF-EFFICACY IN USING FLIPPED CLASSROOM APPROACH						
1. I am **confident** that I would be able to write down all the steps involved in using WAM to name an inorganic compound.						
2. I am totally confident that I would be able construct WAM						

on my own						
3. I am **not confident enough** to write the chemical bonding and nomenclature of selected inorganic compounds.						
4. I am **somehow confident** that I would be able to use the IUPAC nomenclature to name inorganic compounds on my own						
5. I am **not sure** whether after watching television documentary concerning nomenclature of inorganic compounds, I would be able to explain its salient points to another person						
6. I am **not sure** whether I will be successful in any course that is related to the topic or not						
7. I am **somehow** confident that after participating in a lecture regarding the topic, I would be able explain its main ideas to another person						
8. I have **very little** confidence that I will be successful in any examination which draws its test items from the topic.						
9. I have **little** confidence that I could serve as a tutor to a student on this topic						
10. I am **not at all that** confident that I would be able to critique the steps involved in using WAM						

Appendix G

Specification Table

Thinking Levels	Know-Ledge	Compre-hension	Application	Analysis	Synthesis	Evalua-tion	Total
Atomic Structure	4	2	2	1	-	-	9
Bonding	2	2	1	1	-	-	6
Molecular Formula	3	1	3	1	1	1	10
IUPA Nomenclature	2	2	2	1	1	1	9
Periodic Properties	2	1	1	1	1		6
Total	13	8	9	5	3	2	40

Appendix H

Summary results of scale and item reliability

Scale Statistics		ANOVA Results					Test item Reliability	
Mean	SD±	Sum of Squares	Df	Mean Square	F	p-value	Cronbach's Alpha Statistics	N of Items
103.8000	22.86886	1187.70	19	75.441	155.23	.000	.833	30

Summary Results of Scale and Test Item Reliability

Scale Statistics		ANOVA Results					Test item Reliability	
Mean	SD±	Sum of Squares	Df	Mean Square	F	p-value	Cronbach's Alpha Statistics	N of Items
113.4000	22.86886	1287.88	19	75.441	152.35	.000	.824	30

Scale Statistics		ANOVA Results					Test item Reliability	
Mean	SD±	Sum of Squares	Df	Mean Square	F	p-value	Cronbach's Alpha Statistics	N of Items
106.5000	22.86886	1487.66	19	75.441	163.53	.000	.794	30

Appendix I

A Simplified periodic table for some elements

Group	Element	Valence electrons	Charge	Ionic form
IA	$_{3}Li$	1	1	Li^{+}
	$_{11}Na$	1	1	Na^{+}
	$_{19}K$	1	1	K^{+}
IIA	$_{12}Mg$	2	2	Mg^{2+}
	$_{20}Ca$	2	2	Ca^{2+}
IIIA	$_{13}Al$	3	3	Al^{3+}
VA	$_{7}N$	5	5-8 = -3	N^{3-}
	$_{15}P$	5	5-8 =-3	P^{3-}
VI	$_{8}O$	6	6-8 =-2	O^{2-}
	$_{16}S$	6	6-8 =-2	S^{2-}
VII	$_{9}F$	7	7-8 =-1	F^{-}
	$_{17}Cl$	7	7-8 =-1	Cl^{-}

Appendix J

Evaluation Exercise based on Simplified periodic table

Assignments: What are the charges of the following elements?

(a) Magnesium

(b) Sodium

(c) Aluminium

(d) Chlorine

(e) Sulphur

Validated Responses

(a) Mg^{2+} = +2

(a) Na^{+} = +1

(b) Al^{3+} = +3

(c) Cl^{-} = -1

(d) S^{2-} = -2

Assignment: What are the oxidation numbers of the following substances?

(a) Br_2

(b) Na

(c) S_8

(d) N^{3-}

(e) Al^{3+}

Validated responses

(a) 0

(b) 0

(c) 0

(d) -3

(e) +3

Appendix K

Evaluation Exercise and validated scheme based on oxidation numbers

1. What are the oxidation numbers of the following polyatomic ions?

(a) SO_4^{2-}

(b) NH_4^+

(c) H_3O^+

(d) CO_3^{2-}

(e) NO_2^-

Validated responses

(a) -2

(b) +1

(c) +1

(d) -2

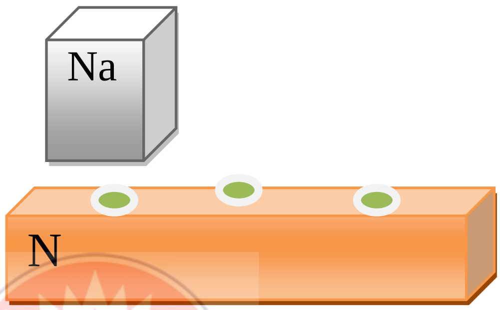
(e) -1

Appendix L(L_1):

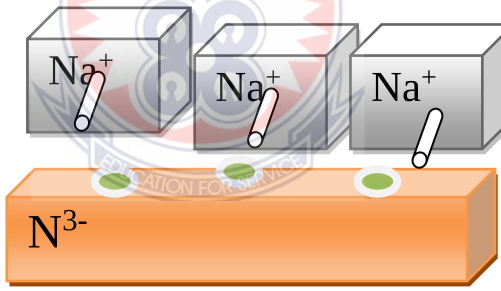
Group 1 Elements bond with non-metals and oxoanions to form inorganic compounds using WAM

(a) Write the chemical formula for Sodium Nitride using wooden atomic models Sodium.

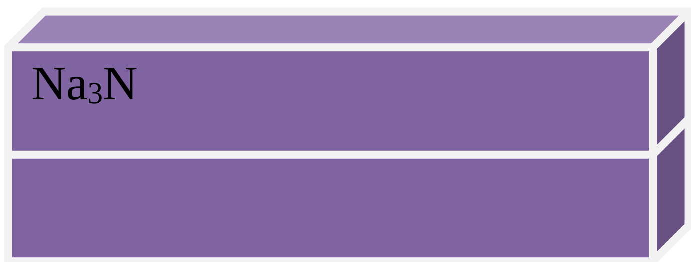
Step 1. Identify the constituents of Sodium Nitride as Sodium and Nitrogen atoms.



Step 2. Identify the Wooden Atomic Models constituting Sodium Nitride as Na^{+} and Cl^{-} ions.



Step 3. Fit the Wooden Atomic Models into each other side by side to form a fully overlapped block.



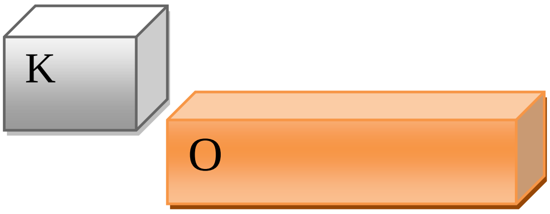
Step 4. Write the ratio of the metal Wooden Atomic Models to that of the non-metals one as Na: N =3:1

Step 5. Since the ratio is 3:1, the formula should be Na_3N.

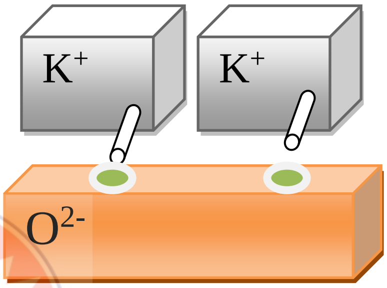
Appendix L_1 Continued

(b). Write the chemical formula for Potassium Oxide using wooden atomic models

Step 1. Identify the cconstituents of a Potassium Oxide as Potasssium and Oxygen atoms.



Step 2. Identify the Wooden Atomic Models representing Potassium and Oxide ions as K^+ and O^{2-}.



Step 3. Fit Potassium and Oxide Wooden Atomic Models into each other side by side to form a fully overlapped block.

Step 4. Write ratio of the number of Potassium Wooden Atomic Models used to that of Oxide

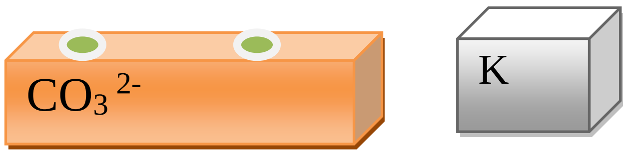
as K: O =2: 1.

Step 5. Since the ratio is 2:1,then, the formula for Potassium and Oxide should be K_2O.

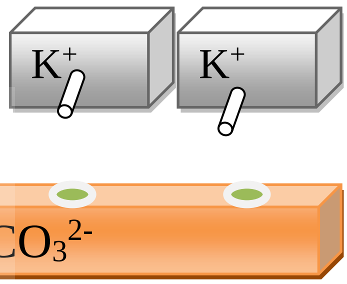
Appendix L_1 Continued

(c). Write the chemical formula for Potassium trioxocarbonate (IV) using Wooden Atomic Models.

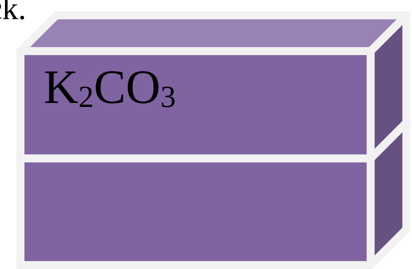
Step 1. Identify the constituents of Potassium trioxocarbonate (IV) as Potasssium atoms and trioxocarbonate (iv) ions.



Step 2. Identify the Wooden Atomic Models representing Potassium and trioxocarbonate (IV) ions as K^+ and CO^{2-}.



Step 3. Fit the Potassium and trioxocarbonate (IV) ions Wooden Atomic Models into each other side by side to form a fully overlapped block.



Step 4. Write ratio of the number of Potassium Wooden Atomic Models used to that of trioxocarbonate (IV) ions

as K: $CO_3{}^{2-}$ =2: 1.

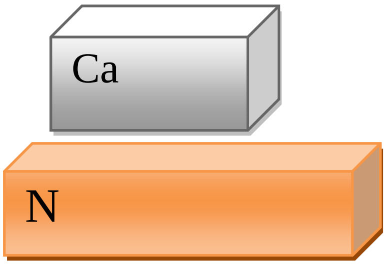
Step 5. Since the ratio is 2:1,then, the formula for Potassium trioxocarbonate (IV) is K_2CO_3.

Appendix L_2

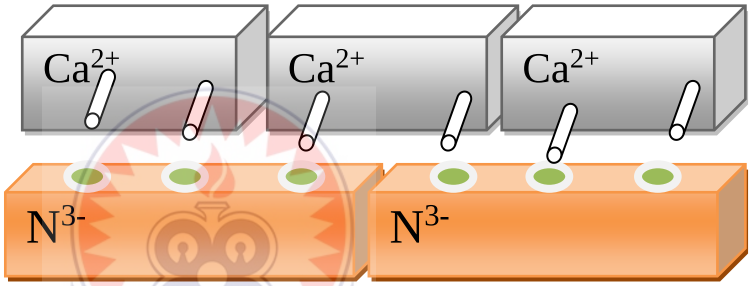
Group 2 Elements bond with non-metals and oxoanions to form inorganic compounds using WAM

(a) Write the chemical formula for Calcium Nitride using wooden atomic models.

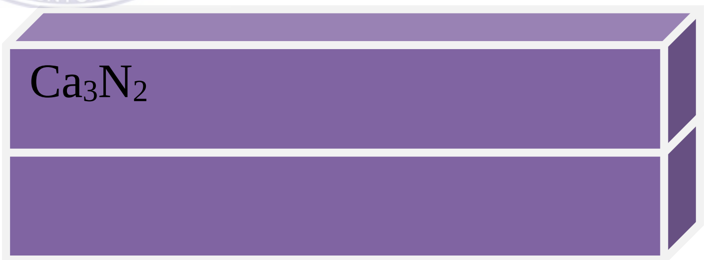
Step 1. Identify the constituents of Calcium Nitride as Calcium and Nitrogen atoms.



Step 2. Identify the Wooden Atomic Models representing Calcium and Nitride ions as Ca^{2+} and N^{3-}.



Step 3. Fit the Calcium and Nitride Wooden Atomic Models into each other side by side to form a fully overlapped block.



Step 4. Write ratio of the number of Calcium Wooden Atomic Models used to that of Nitride

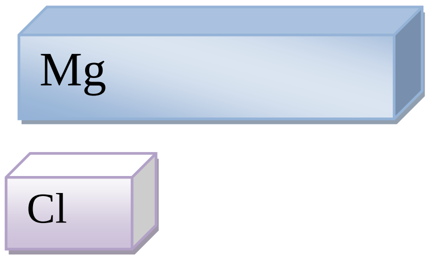
as Ca: N =3: 2.

Step 5. Since the ratio is 3:2,then, the formula for Potassium and Oxide is Ca_3N_2.

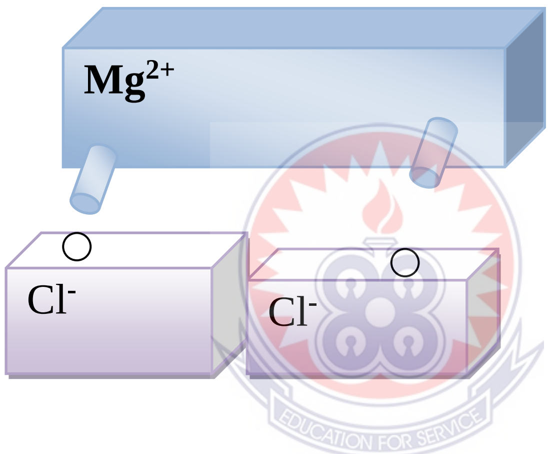
Appendix L_2 Continued

(b) Write the chemical formula for Magnesium Chloride using wooden atomic models.

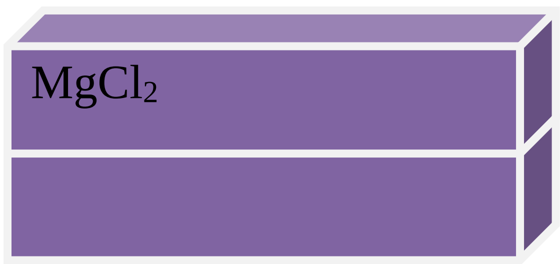
Step 1. Identify the constituents of Magnesium Chloride as Magnesium and Chloride atoms.



Step 2. Identify Wooden Atomic Models representing Magnesium Chloride as Mg^{2+} and Cl^-



Step 3. Fit the Wooden Atomic Models into each other side by side to form a fully overlapped block.



Step 4. Write ratio of the number of Magnesium Wooden Atomic Models used to that of Chloride ion as Mg^2: CI^- =1:2

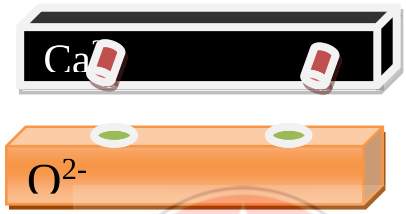
Step 5. Since the ratio is 1:2, hence the formula is $MgCl_2$

Appendix L_2 Continued

(c). Write the chemical formula for Calcium Oxide using Wooden Atomic Models.

Step 1. Identify the constituents of a Calcium Oxide as Calcium and Oxygen atoms.

Step 2. Identify the Wooden Atomic Models representing Magnesium and Oxide ions as Ca^{2+} and O^{2-}.



Step 3. Fit Calcium and Oxide Wooden Atomic Models into each other side by side to form a fully overlapped block.

Step 4. Write ratio of the number of Calcium ions Wooden Atomic Models used to that of Oxygen

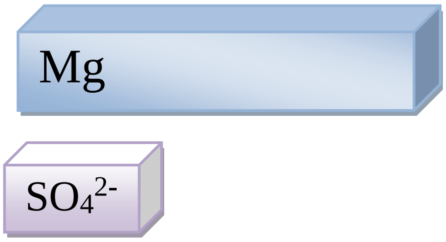
as Mg: O =1:1.

Step 5. Since the ratio is 1:1, subscripts are not written for them, hence the formula is CaO.

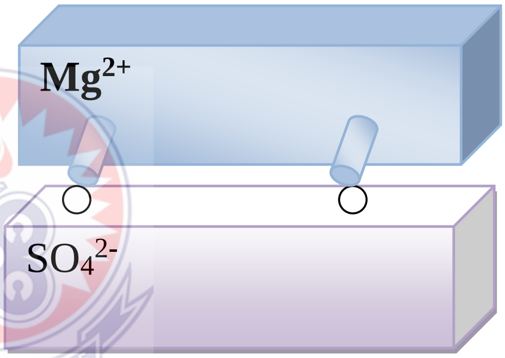
Appendix L_2 Continued

(d). Write the chemical formula for Magnesium tetraoxosulphate (VI) using wooden atomic models

Step 1. Identify the constituents of Magnesium tetraoxosulphate (VI) as Magnesium atom and tetraoxosulphate (VI) ions.



Step 2. Identify Wooden Atomic Models representing Magnesium tetraoxosulphate (VI) as Mg^{2+} and SO_4^{2-}



Step 3. Fit the Wooden Atomic Models into each other side by side to form a fully overlapped block.

Step 4. Write ratio of the number of Magnesium Wooden Atomic Models used to that of tetraoxosulphate (VI) ion as Mg^{2}: SO_4^{2-} =1:1

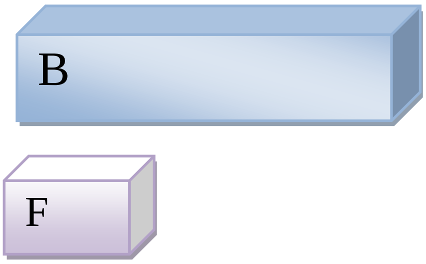
Step 5. Since the ratio is 1:1, subscripts are not written for them, hence the formula is $MgSO_4$

Appendix L_3

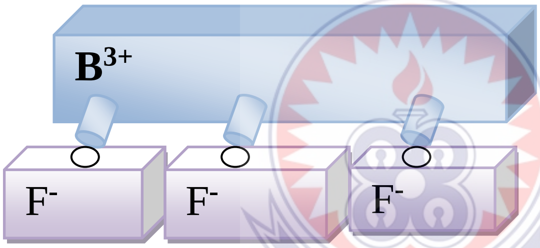
Group 3 elements bond with non-metals and oxoanions to form inorganic compounds

(a). Write the chemical formula for Borontrifluoride using wooden atomic models.

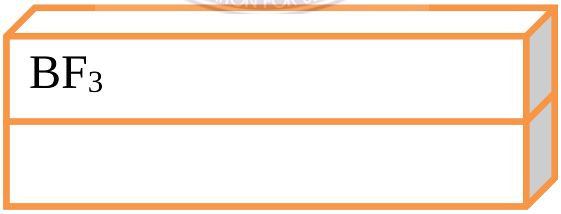
Step 1. Identify the constituents of Borontrifluoride as Boron and Fluorine atoms.



Step 2. Identify the Wooden Atomic Models representing Borontrifluoride as B^{3+} and F^- ions.



Step 3. Fit the Wooden Atomic Models into each other side by side to form a fully overlapped block.



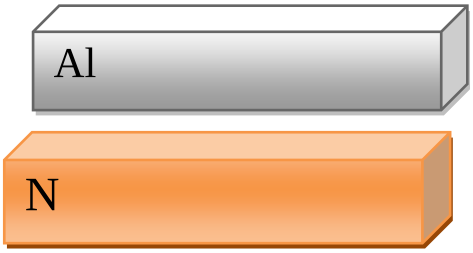
Step 4. Write ratio of the number of Boron ions Wooden Atomic Models used to that of Fluoride ions as B^{3+} : F^- = 1:3

Step 5. Since the ratio is 1:3, then the formula is BF_3

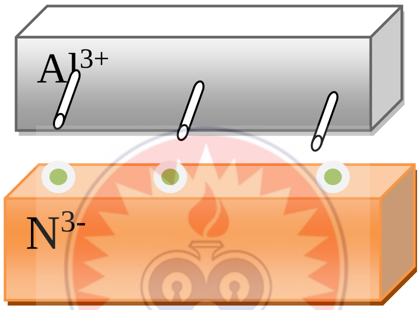
Appendix L_3 Continued

(b). Write the chemical formula for Aluminium Nitride using wooden atomic models**.**

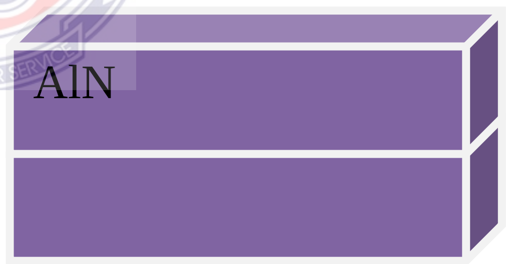
Step 1. Identify the constituents of Aluminium Nitride as Aluminium and Nitrogen atoms.



Step 2. Identify the Wooden Atomic Models representing Aluminium and Nitride ions as Al $^{3+}$ and N^{3-}.



Step 3.Fit the Aluminium and Nitrogen Wooden Atomic Models into each other side by side to form a fully overlapped block.



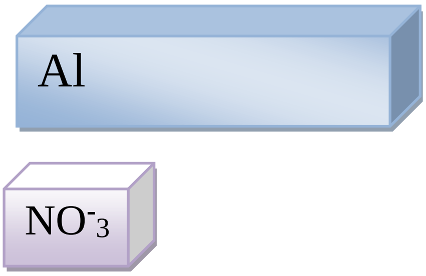
Step 4. Write the ratio of the number of Aluminium ion Wooden Atomic Models used to that of Nitrogen as Al: N =1:1.

5. Since the ratio is 1:1, subscripts are not written for them, hence the formula is AlN.

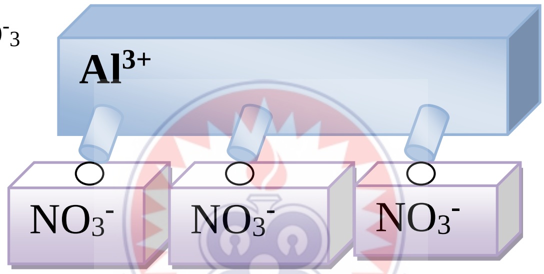
Appendix L_3 Continued

(c). Write the chemical formula for Aluminium trioxonitrate (V) using wooden atomic models

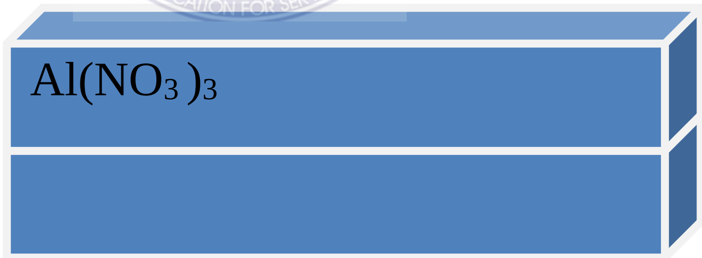
Step 1. Identify the constituents of Aluminium trioxonitrate (V) as Aluminium atoms and Trioxonitrate (V) ions.



Step 2. Identify the Wooden Atomic Models representing Aluminium Trioxonitrate (V) as Al^{3+} and NO^{-}_3



Step 3. Fit the Wooden Atomic Models into each other side by side to form a fully overlapped block.



Step 4. Write the ratio of the number of Aluminium ion Wooden Atomic Models used to that of trioxonitrate (V) ions as Al: NO_3^{-} =1:3

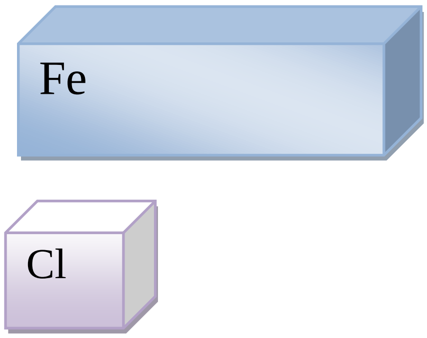
5. Since the ratio is 1:3, then, the formula is Al $(NO_3)_3$

Appendix L_4

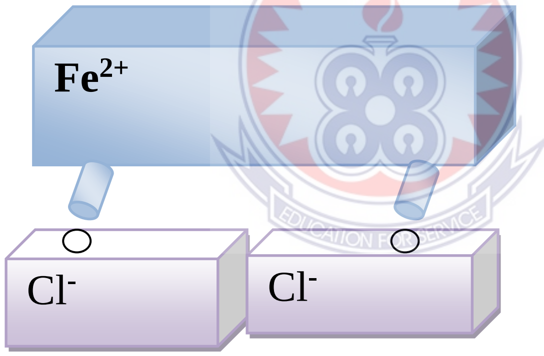
Transition elements bond with non-metals and oxoanions to form inorganic compounds

(a). Write the chemical formula for Iron (II) Chloride using wooden atomic models **.**

Step 1. Identify the constituents of Iron (II) Chloride as Iron and Chlorine atoms.



Step 2. Identify Wooden Atomic Models representing Iron (ii) Chloride as Fe^{2+} and Cl^{-}



Step 3. Fit the Wooden Atomic Models into each other side by side to form a fully overlapped block.

Step 4. Write ratio of the number of Iron (II) Wooden Atomic Models used to that of Chloride ion as Fe^{2}: Cl^{-} =1:2

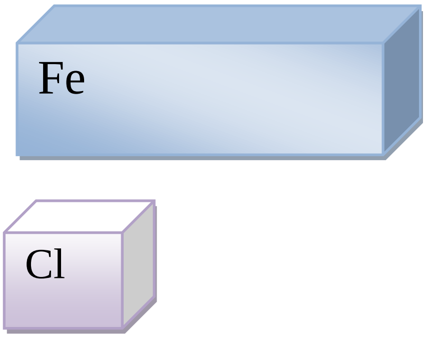
Step 5. Since the ratio is 1:2, then, the formula is $FeCl_2$

Appendix L_4 Continued

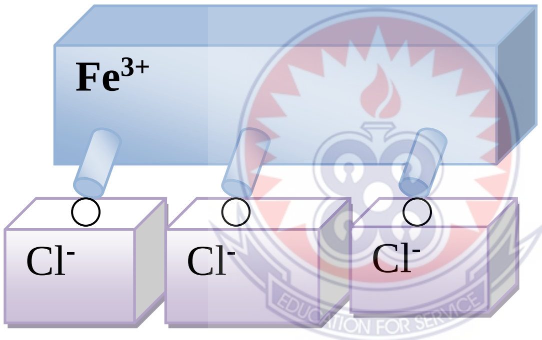
(a). Write the chemical formula for Iron (III) Chloride using wooden atomic models **.**

Step 1. Identify the constituents of Iron (III) Chloride as Iron (III) and Chlorine atoms

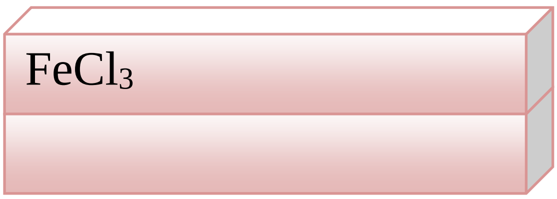
.



Step 2. Identify Wooden Atomic Models representing Iron (III) Chloride ions as Fe^{3+} and Cl^-.



Step 3. Fit the Wooden Atomic Models into each other side by side to form a fully overlapped block.



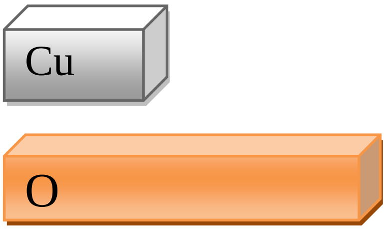
Step 4. Write the ratio of the number of Iron (iii) ion Wooden Atomic Models used to that of Chloride ions as Fe^{3+}: Cl^- =1:3.

Step 5. Since the ratio is 1:3, hence the formula is $FeCl_3$

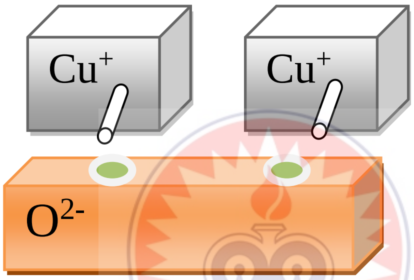
Appendix L_4 Continued

(c). Write the chemical formula for Copper (I) Oxide using wooden atomic models**.**

Step 1. Identify the constituents of Copper (I) Oxide as Copper (I) and Oxygen atoms.



Step 2. Identify WAMs representing Copper (I) and Oxide ions as Cu^{+} and O^{2-}.



Step 3. Fit the Copper (I) and the Oxide Wooden Atomic Models into each other side by side to form a fully overlapped block.

Step 4. Write ratio of the number of Copper (I) Wooden Atomic Models used to that of Oxide

as Cu: O =2: 1.

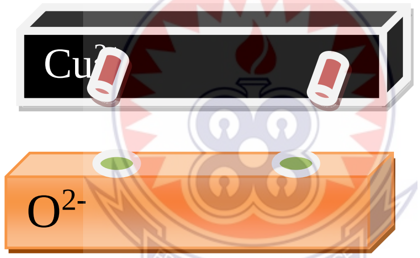
Step 5. Since the ratio is 2:1,then, the formula for Copper (I) and Oxide is Cu_2O.

Appendix L_4 Continued

(d). Write the chemical formula for Copper (II) Oxide using wooden atomic models**.**

Step 1. Identify the cconstituents of Copper (II) Oxide as Copper (II) and Oxygen atoms.

Step 2. Identify the Wooden Atomic Models representing Copper (II) and Oxide ions as Cu^{2+} and O^{2-}.



Step 3. Fit the Copper (II) and the Oxide Wooden Atomic Models into each other side by side to form a fully overlapped block.

Step 4. Write the ratio of the number of Copper (II) Wooden Atomic Models used to that of Oxide as Cu: O =1: 1.

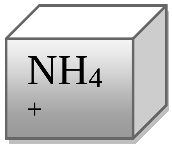
Step 5. Since the ratio is 2:1,then, the formula for Copper (II) and Oxide should be CuO.

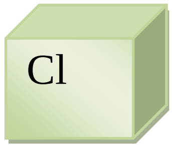
Appendix L 5

Ammonium ion and hydrogen bond with non-metals and oxoanions to form inorganic compounds

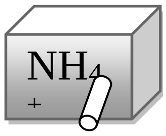
(a). Write the chemical formula for Ammonium Chloride using wooden atomic models**.**

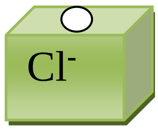
Step 1. Identify the constituents of Ammonium Chloride as Ammonium ions and Chlorine atoms.





Step 2. Identify Wooden Atomic Models constituting Ammonium Chloride as NH_4^+ and Cl^- ions.





Step 3. Fit of the Wooden Atomic Models into each other side by side to form a fully overlapped block.

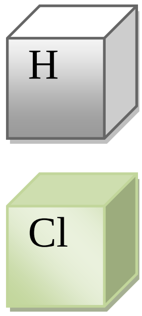
Step 4. Write the ratio of the Ammonium Wooden Atomic Models used to that of the chloride as NH_4^+ : Cl^- =1:1

Step 5. Since the ratio is 1:1, no subscripts are written for them and for that matter the formula is NH_4Cl.

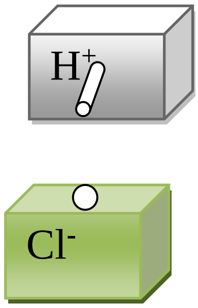
Appendix L $_5$ Continued

(a) Write the chemical formula for Hydrogen Chloride using wooden atomic models.

Step 1. Identify the constituents of Hydrogen Chloride as Sodium and Chlorine atoms.



Step 2. Identify the Wooden Atomic Models constituting Hydrogen Chloride as H^+ and Cl^- ions.



Step 3. Fit the Wooden Atomic Models into each other side by side to form a fully overlapped block.

Step 4. Write the ratio of the metals Wooden Atomic Models to that of the non-metals one as

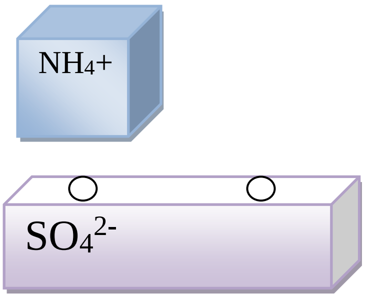
H: Cl =1:1

Step 5. Since the ratio is 1:1, no subscripts are written for them, hence the formula is HCl.

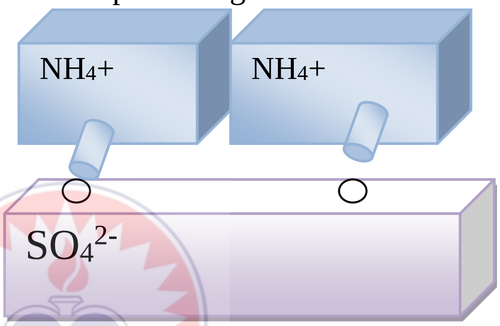
Appendix L_5 Continued

(b). Write the chemical formula for Ammonium tetraoxosulphate (VI) using wooden atomic models.

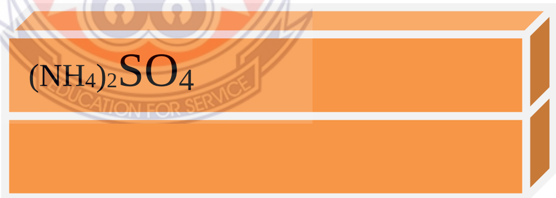
Step 1. Identify the constituents of Ammonium tetraoxosulphate (VI) as Ammonium and tetraoxosulphate (VI) ions.



Step 2. Identify Wooden Atomic Models representing Ammonium tetraoxosulphate (VI) as NH_4+ and $SO_4{}^{2-}$ ions.



Step 3. Fit the Wooden Atomic Models into each other side by side to form a fully overlapped block.



Step 4. Write ratio of the number of Ammonium Wooden Atomic Models used to that of tetraoxosulphate (VI) ion as $NH_4{}^{+}$: $SO_4{}^{2-}$ =2:1

Step 5. Since the ratio is 2:1, the formula is $(NH_4)_2SO_4$.

Appendix M

Letter of introduction

University of Education,
Winneba

Department of Science
Education

Post Office Box 25
Winneba.
15-12-2018

THE PRINCIPAL
GAMBAGA COLLEGE OF EDUCATION
P. O. BOX 15
GAMBAGA.

LETTER OF INTRODUCTION -MR. EMMANUEL AZUUGA ISSAH

The bearer of this letter, Mr. Emmanuel Issah Azuuga is a second year Doctor of Philosophy of Science Education student of University of Education, Winneba. He wishes to undertake action research in your college. It is my fervent hope that he would be accepted and be given the necessary assistance. Thank for your co-operation.

Yours faithfully,

Signed

PROF. JOHN K. EMINAH
(Head of Chemistry
Department)

Appendix N

Correlation between the students' anxiety levels and the use of integration of exemplary materials and flipped classroom instruction

	VARIABLES	1	2	3	4	5	6	7	8	9	10
1	I normally think that I cannot do chemical bonding and nomenclature of inorganic compounds assignment when it seems difficult.	--									
2	No matter how hard I try, l cannot understand chemical bonding and nomenclature of inorganic compounds.	.837**	--								
		.000									
3	I feel tensed or confused when someone talks to me about chemical bonding and nomenclature of inorganic compounds.	.938**	.755**	--							
		.000	.000								
4	Working with chemical bonding and nomenclature of inorganic compounds upsets or frustrates me.	.948**	.718**	.951**	--						
		.000	.000	.000							
5	I do not always fidget when writing chemical bonding and nomenclature of inorganic compounds class test.	.259	.136	.319*	.285	--					
		.106	.403	.045	.075						
6	It makes me nervous to even think about doing chemical bonding and nomenclature of inorganic compounds.	.825**	.639**	.800**	.820**	.561**	--				
		.000	.000	.000	.000	.000					
7	The only reason am studying chemical bonding and nomenclature of inorganic compounds is because I have to.	.649**	.341*	.753**	.695**	.626**	.728**	--			
		.000	.032	.000	.000	.000	.000				
8	If I do not understand chemical bonding and nomenclature of inorganic compounds assignment right away, I would never understand it.	.774**	.471**	.901**	.839**	.476**	.747**	.902**	--		
		.000	.002	.000	.000	.002	.000	.000			
9	l do not do very well in chemical bonding and nomenclature of inorganic compounds assignments.	.911**	.677**	.888**	.898**	.276	.887**	.692**	.791**	--	
		.000	.000	.000	.000	.085	.000	.000	.000		
10	I feel at ease in a chemical bonding and nomenclature of inorganic compounds class.	.371*	.195	.457**	.408**	.929**	.646**	.795**	.641**	.395*	--
		.018	.229	.003	.009	.000	.000	.000	.000	.012	

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Appendix O

Correlation between the students' self-efficacy level and the use of integration of exemplary materials and flipped classroom instruction

	VARIABLES	1	2	3	4	5	6	7	8	9	10
1	I am confident that I would be able to write down all the steps involved in using WAM to name an inorganic compound.	1									
2	I am totally confident that I would be able construct WAM on my own	.689**	1								
		.000									
3	I am not confident enough to write the chemical formulae and nomenclature of selected inorganic compounds.	.372*	.198	1							
		.018	.221								
4	I am somehow confident that I would be able to use the IUPAC nomenclature to name inorganic compounds on my own	.903**	.786**	.300	1						
		.000	.000	.060							
5	I am not sure whether after watching television documentary concerning nomenclature of inorganic compounds, I would be able to explain its salient points to another person	.312	.166	.861**	.251	1					
		.050	.306	.000	.118						
6	I am not sure whether I will be successful in any course that is related to the topic or not	.263	.140	.889**	.212	.893**	1				
		.101	.389	.000	.189	.000					
7	I am somehow confident that after participating in a lecture regarding the topic, I would be able explain its main ideas to another person	.655**	.546**	.108	.650**	.091	.076	1			
		.000	.000	.507	.000	.578	.639				
8	I have very little confidence that I will be successful in any examination which draws its test items from the topic.	.547**	.420**	.879**	.549**	.790**	.833**	.229	1		
		.000	.007	.000	.000	.000	.000	.154			
9	I have little confidence that I could serve as a tutor to a student on this topic	.679**	.361*	.548**	.547**	.460**	.388*	.197	.607**	1	
		.000	.022	.000	.000	.003	.013	.223	.000		
10	I am not at all that confident that I would be able to critique the steps involved in using WAM	.650**	.402*	.823**	.608**	.742**	.695**	.219	.869**	.761**	1
		.000	.010	.000	.000	.000	.000	.174	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Appendix P

T-test statistics of anxiety in integration of exemplary materials and flipped classroom instruction [post test]

ITEMS/CONSTRUCTS	N= 40, df = 39					
	T	df	p- value	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
I normally think that I cannot do chemical bonding and nomenclature of inorganic compounds assignment when it seems difficult.	33.704	39	.000	4.62500	4.3474	4.9026
No matter how hard I try, l cannot understand chemical bonding and nomenclature of inorganic compounds.	46.324	39	.000	4.85000	4.6382	5.0618
I feel tensed or confused when someone talks to me about chemical bonding and nomenclature of inorganic compounds.	41.500	39	.000	4.62500	4.3996	4.8504
Working with chemical bonding and nomenclature of inorganic compounds upsets or frustrates me.	34.583	39	.000	4.60000	4.3310	4.8690
I do not always fidget when writing chemical bonding and nomenclature of inorganic compounds class test.	8.798	39	.000	1.72500	1.3284	2.1216
It makes me nervous to even think about doing chemical bonding and nomenclature of inorganic compounds.	24.699	39	.000	3.95000	3.6265	4.2735
The only reason am studying chemical bonding and nomenclature of inorganic compounds is because I have to.	13.343	39	.000	3.27500	2.7786	3.7714
If I do not understand chemical bonding and nomenclature of inorganic compounds assignment right away, I would never understand it.	17.288	39	.000	3.87500	3.4216	4.3284
l do not do very well in chemical bonding and nomenclature of inorganic compounds assignments.	26.206	39	.000	4.50000	4.1527	4.8473
I feel at ease in a chemical bonding and nomenclature of inorganic compounds class.	10.005	39	.000	2.12500	1.6954	2.5546

Appendix Q

Coefficients (Anxiety)

Model		Unstandardized Coefficients		Standardized Coefficients	t	p-Value.
		B	Std. Error	Beta		
1	(Constant)	.587	.405		1.451	.158
	I normally think that I cannot do chemical bonding and nomenclature of inorganic compounds assignment when it seems difficult. **	1.315	.190	1.377	6.917	.000
	No matter how hard I try, I cannot understand chemical bonding and nomenclature of inorganic compounds.	-.046	.143	-.036	-.319	.752
	I feel tensed or confused when someone talks to me about chemical bonding and nomenclature of inorganic compounds.	.089	.300	.076	.296	.769
	Working with chemical bonding and nomenclature of inorganic compounds upsets or frustrates me. **	.510	.167	.518	3.062	.005
	I do not always fidget when writing chemical formulae and nomenclature of inorganic compounds class test.	-.023	.080	-.035	-.291	.773
	It makes me nervous to even think about doing chemical formulae and nomenclature of inorganic compounds. **	.226	.112	.275	2.013	.053
	The only reason am studying chemical formulae and nomenclature of inorganic compounds is because I have to.	-.022	.070	-.040	-.309	.760
	If I do not understand chemical formulae and nomenclature of inorganic compounds assignment right away, I would never understand it.	.049	.109	.083	.446	.659
	I do not do very well in chemical formulae and nomenclature of inorganic compounds assignments.	-.157	.116	-.206	-1.355	.186
	I feel at ease in a chemical formulae and nomenclature of inorganic compounds class.	-.047	.108	-.076	-.434	.668

Appendix R

Correlation between the students' enjoyment Level and the use of integration of exemplary materials and flipped classroom instruction

VARIABLES	1	2	3	4	5	6	7	8	9	10
1. Chemical formulae and nomenclature of inorganic compounds is something that I enjoys so much.	1									
2. I like courses that do not involve the use of any chemical bonding and nomenclatur of inorganic compounds .	.183	1								
	.257									
3. I would like to do some extra or unassigned reading in chemical bonding and nomenclature of inorganic compounds.	.218	.840**	1							
	.176	.000								
4. When I hear the phrase, chemical bonding and nomenclature of inorganic compounds, I have the feeling of dislike for it.	.287	.813**	.768**	1						
	.072	.000	.000							
5. I would like to spend less time in school studying chemical bonding and nomenclature of inorganic compounds.	.654**	.365*	.435**	.573**	1					
	.000	.020	.005	.000						
6. Sometimes, I read chemical bonding and nomenclature of inorganic compounds notes in advance.	.493**	.605**	.660**	.866**	.827**	1				
	.001	.000	.000	.000	.000					
7. It does not disturb or upset me to do chemical bonding and nomenclature of inorganic compounds assignment	.879**	.236	.281	.370*	.806**	.618**	1			
	.000	.143	.079	.019	.000	.000				
8. I enjoy talking to others about chemical bonding and nomenclature of inorganic compounds.	.899**	.150	.179	.236	.578**	.404**	.838**	1		
	.000	.354	.269	.143	.000	.010	.000			
9. I enjoy watching chemical bonding and nomenclature of inorganic compounds on videos/podcast.	.898**	.222	.264	.348*	.771**	.597**	.981**	.883**	1	
	.000	.169	.100	.028	.000	.000	.000	.000		
10. I have a good feeling towards chemical bonding and nomenclature of inorganic compounds.	.853**	.264	.314*	.413**	.876**	.665**	.918**	.819**	.916**	1
	.000	.100	.049	.008	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Appendix S

T-test stastistics of enjoyment in flipped classroom approach [Post-Intque]

	N = 40, df = 39					
CONSTRUCTS	t	df	p- value	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Chemical bonding and nomenclature of inorganic compounds is something that I enjoys so much.	35.684	39	0.000	4.62500	4.4100	4.9400
I like courses that do not involve the use of any chemical bonding and nomenclature of inorganic compounds .	7.026	39	.000	1.80000	1.2818	2.3182
I would like to do some extra or unassigned reading in chemical formulae and nomenclature of inorganic compounds.	13.531	39	.000	1.30000	1.1057	1.4943
When I hear the phrase, chemical formulae and nomenclature of inorganic compounds, I have the feeling of dislike for it.	12.631	39	.000	1.50000	1.2598	1.7402
I would like to spend less time in school studying chemical formulae and nomenclature of inorganic compounds.	13.970	39	.000	3.60000	3.0787	4.1213
Sometimes, I read chemical formulae and nomenclature of inorganic compounds notes in advance.	11.920	39	.000	2.65000	2.2003	3.0997
It does not disturb or upset me to do chemical formulae and nomenclature of inorganic compounds assignment	25.735	39	.000	4.40000	4.0542	4.7458
I enjoy talking to others about chemical formulae and nomenclature of inorganic compounds.	42.485	39	.000	4.75000	4.5239	4.9761
I enjoy watching chemical formulae and nomenclature of inorganic compounds on videos/podcast.	24.193	39	.000	4.40000	4.0321	4.7679
I have a good feeling towards chemical formulae and nomenclature of inorganic compounds.	21.370	39	.000	4.22500	3.8251	4.6249

Appendix T

Linear regression analysis between the use of WAM and level of motivation

Model		Unstandardized Coefficients		Standardized Coefficients	t	p-value
		B	Std. Error	Beta		
1	(Constant)	-.431	.400		-1.078	.290
	I like courses that do not involve the use of any chemical bonding and nomenclature of inorganic compounds .	-.007	.043	-.014	-.164	.871
	I would like to do some extra or unassigned reading in chemical bonding and nomenclature of inorganic compounds.	.008	.137	.006	.057	.955
	When I hear the phrase, chemical bonding and nomenclature of inorganic compounds, I have the feeling of dislike for it.	-.068	.130	-.061	-.519	.607
	I would like to spend less time in school studying chemical bonding and nomenclature of inorganic compounds.	-.129	.083	-.253	-1.556	.130
	Sometimes, I read chemical bonding and nomenclature of inorganic compounds notes in advance.	.109	.089	.186	1.236	.226
	It does not disturb or upset me to do chemical bonding and nomenclature of inorganic compounds assignment	.203	.225	.265	.903	.374
	I enjoy talking to others about chemical bo nding and nomenclature of inorganic compounds. **	.962	.150	.821	6.413	.000
	I enjoy watching chemical bonding and nomenclature of inorganic compounds on videos/podcast.	-.248	.235	-.344	-1.053	.301
	I have a good feeling towards chemical bonding and nomenclature of inorganic compounds.	.240	.122	.362	1.958	.060
	Dependent Variable: Chemical bonding and nomenclature of inorganic compounds is something that I enjoys so much.	.207	.085	.176	1.216	.326

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