UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECTS OF A FLIPPED CLASSROOM ON TEACHER TRAINEES' ACADEMIC PERFORMANCE IN CHEMISTRY

GEORGE AGBENYEGA NYAGBLORMASE

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GEORGE AGBENYEGA NYAGBLORMASE

(202139550)

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JANUARY, 2023

DECLARATION

STUDENT'S DECLARATION

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

SIGNATURE:…………………………

DATE:………………………………..

SUPERVISOR'S DECLARATION

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

NAME OF SUPERVISOR: **PROFESSOR RUBY HANSON**

SIGNATURE: ……………………………

DATE: ……………………………………

DEDICATION

I dedicate this work to my late grandmother, Korkor Nutoegbah who was the foundation block of my education.

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ABSTRACT

This study was carried out at Kibi Presbyterian College of Education, Eastern Region of Ghana. A single group pre- and post-test action research design was employed in the study. The sample involved 72 Elective Chemistry students in level 100, whose other major subject areas were Mathematics and ICT. The participants were purposively selected in an intact class. The study examined the effects of the flipped classroom pedagogical approach on the performance of the students in Elective Chemistry. The effects examined refers to performance of the students in terms of four levels of the cognitive domain in Bloom's taxonomy. Four weeks was used to implement the intervention by the six-step approach to implementing the flipped classroom, that is plan, record, share, change, group and regroup. The topic was kinetic molecular theory of matter. The study assessed students' pre-existing knowledge on Kinetic molecular theory, using a Kinetic Molecular Theory Diagnostic Test. During the intervention observation data was collected to assess their engagement and students' class exercise data tabulated. A post-intervention test was conducted using a modified version of the diagnostic test, followed by a survey on the students' perception of the teaching strategy. The study found an improved academic performance of students at the four levels of the cognitive domain examined, with a large effect size. The results also indicated a high level of interest, collaboration and motivation among the students and they perceived that the flipped classroom is a useful teaching strategy that improved their learning in the classroom. The students preferred the flipped classroom model to traditional teaching methods. However, a few constraints of the method were identified and solutions suggested. This method is a useful teaching strategy, and as such, science tutors in Kibi College of Education should integrate the various forms of the flipped classroom in their lesson deliveries in order to improve students' performance and knowledge generation. Tutors therefore need to learn the various forms of the flipped strategy and apply it in their teaching.

CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter introduces the research study on the use of flipped classroom teaching strategy to teach chemistry in Kibi Presbyterian College of Education. The chapter consists of the background to the study, statement of the problem, objectives of the study, research questions and significance of the study. The other sub-headings include delimitations of the study, definition of terms and organisation of the study.

1.2 Background to the Study

Instructional strategies are techniques that educators use to ensure that students learn academic content. The goal of instructional strategies is to produce independent learners who are able to apply what is learned and expand upon it as necessary (Hill & Jordan 2015). In classroom instruction teachers use several strategies in order to drive home lesson content. Some strategies include collaborative relationships, lecture (teacher-centred), hands-on-activities, project based learning, peer-lead learning, flipped learning (student centered) and differentiated learning.

Building collaborative relationships is a form of learning with and from other students that builds communication and social skills along with content knowledge. Collaborative skill models and monitoring group behavior allow teachers to guide and influence this form as a powerful active learning tool.

In lecture (teacher-centred), the teacher is the focus. Students either passively take notes or ask questions through the teacher's presentation. It is useful for large groups of students or for when you need to get through a large body of information.

Hands-on activities (student-centred) involves experiment with materials. The lesson has a clear question that students need to find an answer to, whether in small groups or by themselves, with the teacher acting as a facilitator. Project Based learning (student-centred) draws on the hands-on nature of the activity method and extends this to involve students in a deep dive into a given topic over an extended period of time in researching their topic. Peer-led team learning (student-centred) is about empowering the students to teach other students

Flipped learning (student-centred) is that the instructional content is given to the students outside of normal school time, with the intention that students can then come to school with deeper questions for teacher clarification. The content is present through a series of videos, articles and books to read, podcasts to listen to, investigating a problem and so on. Differentiation (student-centred) is about ensuring that students of all levels can be involved in your lesson. Using tasks with different levels of difficulty, or have a variety of activities for students to choose from.

The focus of this study is the flipped classroom approach. The flipped classroom uses digitized or online lectures in videos as pre-class homework, then spend in-class time engaged in active learning experiences such as discussions, peer teaching, presentations, projects, problem solving, computations, and group activities. The overall goal of the flipped method is to foster self-directed learning, critical thinking and problem-solving skills in students. Another goal was also to create interest in learning by making it more interactive (Patkar, Patkar & Kolte, 2021).

Studies have shown that the flipped classroom method is effective in improving learning outcomes in terms of performance, motivation and confidence in self learning and active engagement. Learners have positive perception about the flipped classroom because of the method's advantage in practical in-class activities, as well as increased self-autonomy in learning. The flipped classroom has potential benefits that make it a form of education that teachers should not overlook (Szparagowski, 2014).

Chemistry is a critical aspect of science that is fundamental to our world because of the crucial roles it plays in the lives of humanity, as it touches almost every aspect of human existence. We see the valuable nature of chemistry in the satisfaction of our basic needs such as clean air, food, health, clothing, shelter, energy, clean water, and soil suitable for agriculture and construction. Chemical technologies enrich the quality of our life in several ways, such as the continuous provision of new solutions to problems in health, materials for trade and development, as well as how we use and exploit new forms of energy. It will, therefore, not be out of place to argue that studying Chemistry is useful since it prepares us for the real world.

As a central science, Chemistry works hand-in-hand with Physics, Mathematics, Biology and Medicine, as well as the earth and environmental sciences. We gain insight into nature by knowledge of chemicals and chemical processes, thus we understand a variety of physical and biological phenomena. Chemistry is worthwhile because it provides an excellent foundation for understanding the physical universe in which we live.

Background knowledge in Chemistry is a requirement for basic-school teachers, as well as those who want to pursue careers in the chemical industry to develop chemical commodities such as polymeric materials, pharmaceuticals, flavorings, preservatives, dyestuffs, or fragrances. There are other highly rewarding science-related careers such as environmental scientists, chemical oceanographers, chemical information specialists, chemical engineers, and chemical salespersons. A significant knowledge of chemistry is also required in such professions as medicine, pharmacy, medical technology, nuclear medicine, molecular biology, biotechnology, pharmacology, toxicology, paper science, pharmaceutical science, hazardous waste management, art conservation, forensic science and patent law.

The learning and understanding of scientific concepts, especially concepts in chemistry, become challenging at higher levels of education when the foundation of the concepts at the basic levels is not well established. Windschitl, Thompson, Braaten, and Beyond, cited in Talanquer (2018) argued that the central goal of science and chemistry education at all levels of education is the development of the students' ability to explain natural phenomena. The students should be involved in science activities that will allow them to observe phenomena and use their own experiences rooted in scientific knowledge to construct their own meaning. The professionalism of the Chemistry teacher is thus required in adopting effective pedagogies that will allow students to develop and understand scientific concepts, instead of the teacher telling them.

The teaching of science in the Colleges of Education in Ghana aims at equipping teacher-trainees with scientific literacy and other core competencies relevant for teaching. Over the years, Chemistry tutors at Kibi College of Education have noticed lack of understanding of basic chemistry concepts by students who were admitted (from senior secondary schools) to do various programmes that have General Chemistry as core. There are research reports on the phenomenon of lack of understanding of basic scientific concepts. Woldeamanuel, Atagana and Engida (2014) reported that many students do not correctly understand fundamental chemistry concepts due to the abstract nature of the chemical concepts and the mathematical content of chemistry.

Kibi College of Education is one of the fifteen Colleges of Education in Ghana designated as Science Colleges. It therefore offers both core and Elective Chemistry. Core chemistry is a general chemistry course designed for students offering Primary

Education, Home Economics and Early Childhood Education, while elective chemistry is designed for students majoring in Mathematics/ICT, Mathematics/ Science or ICT/Science. It is therefore a requirement for students majoring in Information and Communication Technology (ICT) and Mathematics to take elective chemistry in the second semester of the first year and first semester of the second year. The elective chemistry course has both theory and practical aspects.

The researcher, after taking the learners through the second semester course of the first year Braaten, and Beyond (2008), that the students have inadequate content and practical knowledge in basic chemistry concepts. The researcher realized the inadequacy through face-to face interactions with the learners in the forms of lecture, student presentations as well as group discussions. Students' work output in the forms of class exercises, assignments and quizzes indicated low level of performance in the chemistry concepts studied.

Students gave several reasons for the poor performances observed. The students majoring in ICT complained that they were not Elective Science students back at the secondary school, they rather offered technical and agricultural courses, while some of them indicated that they did not have Chemistry teachers during their initial levels of secondary education.

The predominant mode of delivering the second semester course of the first year was the usual lecture method (face-to-face interaction in the classroom). However, the performance of the students in class tests, mid-semester quizzes and end of semester examinations had not shown in-depth understanding of the chemistry concepts by the students. The researcher, therefore, thought there was the need to explore another teaching approach that could enhance the performance of students in the chemistry concepts specified in the course outline of elective chemistry in the first semester of the second year.

In this action research, the researcher sought to find out the effect of flipped classroom on the performance of learners at higher cognitive levels of the Bloom's taxonomy. Students majoring in ICT Education and Mathematics Education served as participants in the study.

The use of the conventional lecture model of instruction has been the ageless norm. In this approach, the teacher explains the content of every lesson as the sole source of knowledge in the delivery of every lesson. Students are often passive participants in the conventional lecture class, and teaching often involves the introductory aspects of the concept. The students' contributions are few; however, the teachers assign the difficult aspects of the concepts to the students to be done at home as homework. Class activities are mostly directed and dependent on the teacher's opinion as s/he coordinates and controls the flow and direction of the entire lesson (Dzakpasu & Adjartey, 2020).

Educators used the conventional lecture approach to teaching at all levels (basic to tertiary) since formal education began. However, there have been criticisms against the approach. The method is teacher-centered and portrayed the instructor as the "sage on the stage" (Morrison, 2014 p. 2). There is growing research for alternative methods of teaching that will place the learner at the centre of the knowledge generation process.

The flipped classroom teaching strategy is a new (emerging) teaching approach that turns around the teaching done in class time to the home or the learners' convenient learning time, and bringing the more difficult aspect done at home into the classroom. With this, the teacher has more time to engage learners in tasks that are more difficult, tasks that need practical applications, as well as higher cognitive activities. Flipped classroom is about how to best use in-class time with students, (Bergmann & Sams, 2012), after the students have read or watched videos about the lesson at home. This equips learners with basic information about the lesson before in-class time.

Different researchers define the flipped classroom teaching approach variously. Educause (2012) and Arnold-Garza (2014) likened it to a kind of hybrid or blended learning and problem-based learning that actively engages students in the learning process with the help of technology. Others see it as a situation where the direct instructions by a teacher in the classroom and homework elements of a subject or course are reversed (Educause, 2012; Bergmann & Sams, 2014). The flipped classroom was also defined by van Altern, Phielix, Jansen and Kester (2018) as a teaching approach in which students study instructional material before class (for example, by watching online videos and lectures) and apply the learning material during class. The understanding therefore is that in the flipped classroom approach, the learners take the responsibility of learning the fundamental concepts at their convenient time while the teacher assists the learner to learn the challenging parts during in-class time.

1.3 Statement of the Problem

Many learners regard Chemistry as a difficult subject (Cardellini, 2012; Gafoor & Shilna, 2013), and so are apprehensive towards its study. Students in Kibi College of Education taking Chemistry as an elective course are no exception. Over the years, tutors have noticed that students' performance in the course, as seen in their work output in class exercises and quizzes, have been on the decline.

This observation was evident in the students' performance at the end of first semester examination in General Chemistry Theory I (EBS 115) and General Chemistry Practical 1 (EBS 115), conducted by University of Cape Coast as a mentor university to the College. Table 1 shows the performance of the students in the end of second semester examination.

Table 1: Performance of Students in End of Second Semester Examination (2021)

Grade	Range	Number of Students	
		EBS 115	EBS115P
A	80 - 100	3	6
B+	75 - 79	6	17
B	70 - 74	11	12
C+	65 - 69	22	15
C	60 - 64	24	17
D+	55 - 59	5	3
D	50 - 54	1	0
E	below 50	0	0

[Source: Institute of Education, UCC B. Ed first Year End of Second Semester Examination 2020/2021]

This performance, in the context of the researcher, was not satisfactory; hence, there was the need to adopt prudent teaching strategies that could possibly help learners to understand the concepts specified in their second semester course adequately.

The efficacy of the flipped learning approach, which is underutilised by Ghanaian teachers, cannot be overemphasized. Many studies have proved the efficacy of the flipped learning approach. Yu et al., 2019 suggested that flipped classroom enhances learners' motivation positively. Learners are motivated to do in-class discussions in flipped classrooms. There is an upsurge in student motivation because of students' satisfaction with their experiences of flipped learning (Zhou 2023). Fan and Wang, (2022) reported a significant and positive effect of flipped learning on learners' level of self-efficacy and emotion regulation (Yorganci, 2020). Zhou (2023) suggested that flipped learning can provide students with more than expected opportunities for success.

Further studies on self-efficacy of the flipped classroom again highlighted positive attitudes because it met the basic cognitive needs such as a sense of competence, autonomy and social interaction (Ha et al., 2019), hence learners derive a lot of satisfaction in the knowledge generating process. There is an overall increase in self-efficacy, especially in technology-integrated classes where students are encouraged to apply the flipped learning strategy. Han and Wang, (2021) claimed that students became autonomous, self-regulated and self-confident through participation and interactions in a technology-enhanced learning environment.

Yu et al., (2019) suggested that flipped learning can improve learner engagement, while Xie and Derakhshan, (2021) claimed that positive collaboration, as well as peer teaching and learning, were highly encouraged through the flipped approach, and also observed increased enjoyment, participation, and improved student-teacher relationships. The flipped classroom teaching approach is a prominent learning strategy that needs to be mastered by the teaching staff, especially tutors at Kibi Presbyterian College of Education. It is therefore necessary to develop learning activities anchored on flipped classroom approach in order to enhance students' learning.

Flipped classroom is an innovative student-centered teaching and learning approach that shifts the learning focus to students, facilitates students' participation in lessons and the development of practical thinking skills. However, this teaching strategy is scarcely used by science instructors in Ghana. The researcher, in this study, used the flipped classroom approach in an action research to find out if it will have positive effects on students' performance in Chemistry.

1.4 Purpose of the Study

The purpose of this study was to determine the effect of flipped classroom approach on students' performance at higher cognitive levels of Bloom's taxonomy, namely understanding, application, analysis and synthesis levels.

1.5 Objectives of the Study

The objectives that guided this research were:

1. To determine the pre-existing knowledge of students offering Elective Chemistry on Kinetic Molecular Theory of matter.
2. To determine the effect of flipped classroom on students. Performance,
3. To determine the extent of learners engagement in the use of the flipped classroom approach
4. To determine learners' perception of the use of the flipped classroom approach.

1.6 Research Questions

The research questions that guided this research were:

1. What is the pre-existing knowledge of elective Chemistry students in kinetic molecular theory of matter?
2. What is the effect of the flipped classroom approach on students' performance in the study of kinetic molecular theory at the cognitive levels of understanding, application, analysis and synthesis?
3. What is the extent of engagement of students during the use of the flipped classroom approach?
4. What are the perceptions of students of the use of the flipped classroom?

1.7 Significance of the Study

The output of this study will give direction to tutors on the emerging instructional strategy, that is, the flipped classroom approach. The manual to be produced from this research will promote the use of the new learning approach, that is, the flipped classroom strategy among tutors and learners. This will improve performance of learners in the study of scientific concepts, especially in Chemistry. Students can also transfer the learning strategy to other subject areas while instructors increase their knowledge in instructional design using technology.

1.8 Delimitations of the Study

This study was conducted in Kibi Presbyterian College of Education, one of fifteen Colleges of Education designated as science colleges. The research excluded other science colleges due to the study approach adopted, which is action research. Action research aims at solving a problem identified in a local setting. The participants were elective science students majoring in Mathematics and ICT. Students offering General Chemistry were not included in the study.

The Elective Chemistry course for the second semester of the first year consisted of three units, namely kinetic molecular theory of matter, rate of chemical reactions and chemistry of carbon. This study, however, considered kinetic molecular theory of matter, because the researcher realized that students' performance in this topic, over the years, was very poor. Since the flipped classroom approach requires a lot of time in planning, preparation of teacher-made videos and writing of lesson content, including other units will compound the study.

The researcher selected the flipped classroom approach out of the several teaching approaches because it is an emerging learning approach and least common among tutors in Colleges of Education. Most of the students also possessed the technological gadgets needed to access information for the study and employing the flipped approach was not going to be bothersome for students.

1.9 Limitations of the Study

The use of the flipped classroom strategy requires the use of technological gadgets such as smart phones, laptops and tablets in order to access lessons, write-ups or teacher made videos online. Absence of these gadgets in the hands of the learners affected the result of the study.

In addition, the approach requires data and the presence of reliable internet facility. Absence of these factors limited students' access to information and hence this affected the results of the study. The teacher's technological knowhow was also a limiting factor. The method requires resourceful teachers who are also competent in the use of internet teaching resources and technological proficiency. The introduction of the track system into Colleges of Education delayed data collection and the administration of the interventions because students at different academic levels reported to school on different dates.

1.10 Key Terms as Applied in this Report

Entry behaviour: the pre-existing knowledge of learners on Kinetic molecular theory.

Flipped classroom: a learning situation in which learners learn the fundamental aspects of a lesson at home and solve problems in the classroom.

Technological gadgets: tools that students use to access information online such as mobile phones, laptops and tablets.

Conventional classroom: a learning situation where teachers teach the fundamental aspects of a lesson in class and learners do the difficult aspect such as homework

Colleges of Education: institutions that give initial teacher education to pre-service teachers

Understanding: second level of the cognitive domain in Bloom's taxonomy

Application: third level of the cognitive domain in Bloom's taxonomy

Analysis: fourth level of the cognitive domain in Bloom's taxonomy

Synthesis: fifth level of the cognitive domain in Bloom's taxonomy.

1.11 Organisation the Study

This study consists of five chapters. Chapter One consists of background to the study, statement of the problem, purpose of the study and significance of the study. The others are objectives of the study, research questions, limitations and delimitations of the study, definitions of terms, abbreviations and acronyms and organisation of the study.

Chapter Two is about literature review. Literature was reviewed on the use, benefits and shortcomings of the flipped classroom teaching approach. There was also literature on the theoretical, conceptual and empirical frameworks related to the study.

Chapter Three of the study consists of the methodology employed in the research. It is about research design, research instruments, validity and reliability of research instruments, materials, data collection procedures and data analysis procedures. The study discussed ethical consideration and suggested expected results.

Chapter Four consists of the presentation and analysis of the data collected. Data was presented using frequency tables and diagrams. The section provided answers to the research questions, presented and discussed the findings as well. Chapter Five consists of the summary of the research, conclusion and recommendations. The references and appendixes then followed.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Overview

This chapter reviewed literature related to the current study. The review covered the traditional classroom, its benefits and shortcomings. It also reviewed instructional technology that is driving education and making it accessible everywhere and the flipped classroom approach. It talks about the historical background of the flipped classroom, the theoretical and conceptual framework of the study, and outlined the knowledge gap, which the study sought to address.

2.2 The Conventional Classroom

The conventional lecture classroom is a teaching environment where learning of new knowledge occurs. Classroom instruction all over the world employs this method where the teacher occupies the centre of knowledge dissemination. In the traditional classroom, students spend most classroom time on acquiring knowledge through lecture activities at lower cognitive levels, while, in most of the cases, little time is made available for practical and problem solving activities.

Lag and Saele (2019) define traditional teaching as predominantly teacher-centered, lecture-based information transfer. The 'one-size-fits-all' element of the traditional classroom limits the possibilities for the students to interact with the teacher during the lecture, and can lead to a lack of student engagement, as well as how they actively construct knowledge (Schmidt, Wagener, Smeets, Keemink, & Van Der Molen, 2015).

A traditional (conventional) classroom is an educational place where the teacher delivers knowledge to the students in person without any third-party medium. The traditional classroom is again viewed as a system in which a teacher controls and moderates the flow of knowledge and information. In this system, the expectation is that students will continue developing their knowledge of a subject or concept outside of school through homework exercises. Here, the teacher (instructor) is the students' main resource, and only teaches them face-to-face.

A traditional classroom is highly interactive for the reason that the teacher transfers knowledge and information to the students, and addresses misunderstanding or difficulty that flows from the students to the teacher in that same environment. Center for Excellence in Learning and Teaching (CELT) (2020) indicated that traditional teaching focuses on several elements: lectures, labs, capstones, team projects, studios, etc., and teaching is done synchronously in a physical learning environment. The traditional lecture-style class feeds information to the students and the students in turn pass back the information to the instructor through written or oral assessment.

Paduraru (2020) listed four advantages of the traditional classroom, which are:

Interactive: learners can interact with the teacher and their classmates through cooperative activities and group work.

Motivating: traditional classroom learning atmosphere helps them to stay focused and keeps them motivated.

Accessible: the teacher shares knowledge with students and there is active discussion between the teacher and the students. The students then write new information learned in notebooks at the end of the lesson.

Organised: there is a fixed schedule and specific periods dedicated exclusively to learning.

From the descriptions given above, we can make the assertion that in a traditional classroom, the teacher has complete control and authority over all instructional duties. In addition to serving as the class lecturer and knowledge giver, the teacher also makes all decisions regarding what to teach and how to teach it.

A drawback of traditional training is that it inherently places the most value on standards, curriculum and passing tests as opposed to student-focused learning. Student-oriented learning places value on the student and builds the curriculum around the questions young people ask in order to understand the material. Constructivist learning builds on the knowledge students already have, allowing them to form concrete associations to new information, which improves retention. The basis of traditional learning is repetition and memorisation of facts, as such; students' in–depth acquisition of knowledge is compromised, leading to lower rates of knowledge retention.

Jaeb (2020) pointed out some disadvantages of the traditional classroom. To him, the traditional classroom emphasises passing tests, irrespective of whether the students understand the material or not. It does not encourage students to understand the approaches, skills and strategies required to find answers to concept problems. Again, traditional classroom does not encourage critical thinking skills and the application of knowledge gained through experience and reasoning. The traditional classroom does not equip students with the deeper levels of skills required for understanding complex concepts and lifelong learning.

Even though Paduraru (2020) listed interactivity as a feature of the traditional classroom, students receive few opportunities to practice group dynamics and teamwork. The trend in modern education emphasises working in teams and collaborating with colleagues. Above all, the focus of the traditional classroom is the acquisition of fundamental or basic skills, the development of which must be gradual, and culminate into a whole. It does not cater for innovation and creativity because its main resource is a teacher.

In the current era of abundance of technology, researchers are advocating a move away from traditional, teacher-centered, direct instruction, where students imbibe knowledge passively, toward more student-centered teaching that focuses on exploration, experimentation and self-directed activities that reinforce lifelong learning skills. The time has come for teachers to support learners to generate knowledge in individual study and in collaborative interactions. This research tested the effectiveness of the flipped classroom in the study of kinetic molecular theory (KMT) with level 200 Elective Chemistry students of Kibi Presbyterian College of Education, an initial teacher training institution in Ghana.

2.3 Instructional Technology

Research has shown that technology influences students' achievement and academic performance. Technology integration, in conjunction with collaborative learning, improves students' achievement in content area learning, higher-order thinking and problem - solving skill (Cradler, McNabb, Freeman & Burchett, 2002), and interactive video programmes have been demonstrated to increase problem-solving skills of learners.

Technology is rapidly changing the way students learn and how instructors teach. South University (2016) intimated that the continuous evolution of technology brings with it new opportunities and challenges for educators and students. One such opportunity is social networking which can help education when integrated into teaching plans. Social networking also affords students the opportunity to collaborate and work together in a completely new way.

According to American University School of Education (2020), technology tremendously provides students with easy-to-access information, accelerated learning, and fun opportunities to practice what they learn. Digital learning, when effectively used in classrooms, can increase student engagement, facilitate individualized learning, and help teachers to improve their lesson designs. As a powerful tool, technology can support and transform education in several ways: teachers can create instructional materials with ease, and enabling new ways for people learning and working together.

The improvement in technology has made many communication gadgets and tools available and this has tremendously improved education. Technology, in modern times has helped to transform teaching from the traditional lecture style, with the teacher as the fountain of knowledge, and which is limited to teaching within the classroom, to a more interactive and a joyous one, with the learner taking a more active and responsible role in the process of learning (Mahasneh, 2020). The broad adoption of flipped classrooms is possible by the development of technical tools like interactive movies and interactive in-class activities, among others.

2.4 The Flipped Classroom Teaching Approach

A flipped classroom is an instructional approach in which instructors aim to increase student engagement and learning by making learners complete readings or watching instructional videos at home and work on problem-solving activities during class time. Researchers in this field define the flipped classroom variously. van Alten, Phielix, Janssen and Kester (2019) define flipped classroom as students preparing instructional material before class, such as by watching a lecture video and applying the instructional material during class such as working on problem solving assignments. When students prepare materials for learning, they take the responsibility to study the fundamentals of a concept by reading or watching assigned videos at home or in the student's leisure time before class time. According to Lag and Saele (2019), the flipped classroom is a teaching model that moves most of the teacher-centered instruction out of the classroom to free up time in the classroom for more student-centered learning activities. Johnson, Becker, Estrada and Freeman (2014) state that flipped learning integrates interaction between the teacher and the learners by activating technology and its tools for effective learning.

2.4.1 Historical background of flipped classroom

During the early times of the establishment of universities in Europe, printing press was not available, so the main tool for sharing knowledge was the human voice. The philosopher or scholar used to stand in front of students and taught them his thought or read from a source (often rare), while the students listened and tried to memorise what the scholar said. Even after the establishment of the printing press some five hundred years later, which led to the production of books, lecture continued to be the dominant knowledge transmission method, flowing from scholars to learners. In a White Paper developed by University of Waterloo (2015), it was noted that this "transmission pedagogy", most of the times, did not work well.

Criticisms about the lecture approach led researchers to begin thinking about new pedagogical approaches that could increase learning. Advances in technology in the 21st century created opportunity for creative teachers to explore technology to advance learning. In 2007, Jonathan Bergmann and Aaron Sams, high school teachers in Colorado discovered a software tool that allowed them to narrate and record PowerPoint presentations. They used this tool to record their lectures and then posted them online as video tutorials so that students who missed classes could catch up. Before long, they realized that not only their students who missed class accessed their video tutorials, but also by other students who wanted to review the lectures that they had already attended (University of Waterloo, 2015).

Around the same time, a financial analyst named Salman Khan began creating short video tutorials in mathematics for his nephew, which he posted on YouTube. These video tutorials soon developed a larger following of other students who needed tutoring in math. Khan resigned from his job to establish the Khan Academy, whose mission was to create numerous video tutorials in all kinds of disciplines. The new learning approach has shifted the role of the scholar as 'sage on stage' to a 'guide on the side.' Learning has become student-driven, while teachers help learners to reach the sources of knowledge on their own, rather than the teacher being the sole source.

2.4.2 The four pillars of flipped classroom

Lynch (2015) stated that a flipped classroom has four pillars – flexible learning environment, reversed learning culture, intentional content and professional educators. Walsh (2016) relates the flexible environment to a flexible learning space and flexibility in lessons delivery and assessment. The flexible assessment system must be appropriate to measure learners' understanding in a meaningful way. Lynch (2015) regards the flexible learning environment to mean that learners chose when and where to learn, while Cavage (2020) explains flexibility to include small groups and pair work, as well as how the lesson imparted knowledge both inside and outside the classroom. The type of learning culture in flipped classroom is the reverse of what happens in the traditional classroom. Walsh (2016) said that this culture moves the teacher from the 'sage on the stage' to the 'guide on the side' approach. To Lynch (2015), the flipped classroom dedicates in-class time to in-depth exploration of topics and rich learning opportunities. Cavage (2020) explained it in the perspectives of the teacher, learner and nature of lesson content. The teacher is not the deliverer of the lesson but a facilitator of the lesson, with reduced involvement; the students take active role in learning than being passive recipients of knowledge, and the lesson content more approachable and meaningful to learners.

The intentional content pillar mandates that the instructor chooses and directs the course of study both within and outside of the classroom. It is the teacher who chooses the best content to be delivered in classroom time and outside classroom time. (Cavage, 2020); contents that enhance the development of conceptual understanding and procedural fluency (Conkle, 2014); what teachers have to teach and what materials students have to handle on their own (Lynch, 2015). According to Walsh (2016), the intentional content must play a central role than a supporting role, that is, the maximisation of classroom time in various interactive activities.

The professional educators' pillar stipulates that teachers must be facilitators rather than information givers. According to Walsh (2016), the professional educators in flipped classrooms work with students and ensure they learn materials to be learnt, and inspires them to take control of their learning. Lynch (2015) states that the professional educators observe students, provide instant feedbacks and assess their work in the flipped classroom. These four pillars facilitate the effectiveness of the flipped classroom.

This study was anchored on all the four pillars of the flipped classroom. The freedom given to students to watch the videos and or read the study material at home or their free time provided the flexible learning environment for students. The in-class activities also afforded learners to interact freely with peers and instructor in discussions, group works, solution of problems and hands-on activities. Since there were online tools available, the flexible learning environment satisfied students' desire for greater flexibility and autonomy in determining how they learn. It enabled the delivery of content in a range of instructional formats. The flexible environment also enabled me to choose either online or offline forms of instruction depending on the subject's complexity and the needs of their pupils. Prior to the classroom sessions, the students had the opportunity to better prepare.

In this study, the reversed learning culture shifted the teacher-centered approach of the conventional classroom to the learner-centered model where greater responsibility was bestowed on the students and they were encouraged to participate in in-class activities and interact with teacher and peers, and this fostered collaborative learning and problem solving.

In the study I determined what to teach and what materials students should handle on their own at home. I used the intentional content pillar to maximize classroom time in order to encourage active learning of the student in and outside the classroom.

As a professional educator in this study, I acted as a facilitator or coach, and allowed students to construct their own knowledge and engaged learners in collaborative learning. I made the lessons engaging and clear. I explained to them that the video's content will be fully discussed in class. Since they viewed the videos at their own convenient times, they were prepared to actually go more in-depth than ever before. They discussed the topics in separate groups as I assigned them tasks to perform. The four pillars of the flipped classroom therefore formed the platform for this study.

2.4.3 Advantages of the emerging teaching approach

Flipped learning has been gaining popularity among researchers recently. The popularity of this pedagogical approach, also known as flipped learning or the inverted classroom, has been growing rapidly during the last decade and has been applied and investigated in a wide variety of educational contexts (Bergmann & Sams, 2012). To reshape the educational process and to change the traditional role of the school and home, flipped learning is one of the surest approaches in this process within the background of technological support.

The flipped classroom is an active learning environment because it requires learners to engage in discussions and activities that put the lecture materials into practice individually and collaboratively. Since instructors give direction to learners to access all the fundamental information on a topic or concept in advance, they enter the classroom prepared and ready to contribute or take part in interactive learning activities.

The flipped classroom has the advantage of improving higher order thinking. A research conducted by Supiandi, Sari, and Subarkah (2018) found an increase in higher order thinking skills in chemistry education in learners after implementing an Instagram-based flipped classroom learning model. Liu and Zhang (2022) found that student achievements and higher order thinking skills were significantly better when they implemented a WeChat-based flipped classroom approach. Amanisa and Maftuh (2021) observed that flipped classrooms allow students to have more learning opportunities both online and offline and opined that the approach can assist learners in developing their higher-order thinking skills. Ghoneim and Badawy (2018) found in a study that the utilisation of flipped learning method improved students' higher order thinking skills and engagement significantly. Lee and Lai (2017) were of the view that it is possible to improve the capability of students’ higher-order thinking when we use the flipped classroom approach in teaching. These findings showed that the flipped classroom approach had provided tremendous benefit to learners.

A lot more researchers have found positive effects in the use of the flipped classroom learning approach. Mahasneh (2020), in a study investigated the effectiveness of the flipped learning strategy in the development of scientific research skills in a procedural research course among higher education diploma students. He found that the flipped learning method was more effective than the conventional teaching method in gauging students' scientific research skills.

Other positive effects of flipped classrooms reported include problem-solving, development of skills, as well as gaining more understanding of the subjects taught (Bergmann & Sams, 2012). Flipped classrooms create a student-centered learning environment that increases technology usage and emphasises collaboration. Using this approach, learners can study at their own pace, and can view lectures on a personal computer and mobile devices whenever it is convenient for them to do so.

Flipping a classroom results in a more engaging learning experience for students because the strategy introduces student-centered teaching approaches.

They learn the material more deeply, and they learn how to apply their knowledge to real problems. It also leverages the power of peer instruction. All of these factors, as studies have shown, lead to improved learning outcomes.

Rosenberg (2013, p. SR12), reported that "the failure rate in English dropped from 52 percent to 19 percent; in mathematics, it dropped from 44 percent to 13 percent; in science, from 41 percent to 19 percent; and in social studies, from 28 percent to 9 percent".

2.4.4 Challenges to the flipped classroom approach

The Flipped Classroom also presents some challenges. For example, it can initially take significant time to create or locate the video tutorials that one's students will watch outside of class. Additionally, if a classroom is to be flipped, there will be the need to implement strategies to ensure that students actually watch video tutorials before coming to class.

Flipped classrooms delegate much of the learning responsibility to learners. Teachers who apply the approach over rely on students' diligence to watch prescribed videos or review important materials before each face-to-face interaction. This creates the wrong impression that all the students watched the prescribed videos, irrespective of the challenges they may face. Kenney (2019) listed among other things unfamiliar instructional approach, disengagement during pre-class activities, overwhelming workload for students, lack of out-of-class support as well as overwhelming work for teachers among the challenges of the flipped classroom.

2.4.5 Flipped classroom and student engagement

Researchers have reported that students who learn in flipped classrooms have greater engagement and better results in performance. Vergroesen (2020) wrote that student engagement is increased in flipped classrooms for the reason that lower-order learning activities are relegated to the student's own time while space is made for collaborative, higher-level learning during class time. Lo and Hew (2021) suggest that using the flipped classroom approach may increase behavioural, emotional and cognitive engagements of learners in mathematics. Jamaludin and Osman (2014) found in a study that emotional engagement is an important factor for an active learning to occur during the flipped classroom. Emotional engagement defines how actively a student is involved in, and enthused for school. Bond (2020) in a review of researches on flipped classroom found the approach to support student engagement in at least one dimension. Thus, it could be seen that students in the flipped classroom experience an increase in their engagement (behavioural, cognitive and emotional), and improved communication when compared to the traditional classroom approach.

2.4.6 Students' perception about the flipped classroom

As an emerging concept in learning, researchers have reported positive perceptions of the flipped classroom. Aljaraideh (2019) reported that students in Jordanian private universities had high perceptions of flipped classroom and recommended the use of flipped learning technique in universities. The study by Musdi, Agustyani, and Tasman (2018) showed that students were interested with the approach because they were able to learn the material at any place or time of their choice. Flipped classrooms affect student engagement, collaboration and critical thinking positively.

Strohmyer (2016) found in a study that students perceived increased engagement and interactions, increased critical thinking, ability to self-regulate learning as well as increased peer collaboration. Seitz and Orsini (2014) found in their study that students felt the out-of-class activities of the flipped classroom were convenient, conducive to different styles of learning, and are important preparations for class time. In-class activities were interactive and enjoyable, but anxiety provoking. The findings cited show that the flipped classroom teaching approach has the advantage of increasing learners' performance, critical thinking abilities and collaborative work. To the researcher, these perceptions from the students are positive.

2.5 Theoretical Framework

A theoretical framework is a structure that supports a theory of a research study. It provides the blueprint for the research inquiry and serves as the guide on which to build and support the entire study. The researcher based this study on Bloom's taxonomy of cognitive domain and the Piagetian social constructivist theory.

The relevance of Bloom's Taxonomy to flipped learning is that in flipped learning, the learner obtains transmission of information independently and outside of class, while the assimilation of information occurs during class under the guidance of an instructor or mentor (Eppard & Rochdi, 2017). Assimilation of information requires greater critical reasoning than transmission of information: because the learner can achieve it independently.

On the Bloom's pyramid, assimilation occupies a higher level, which means support from instructor or peers is required; whereas the transmission of information at the lower level can be reached through the learner's independent effort. Thus, flipped learning relates to Bloom's taxonomy in that students are actively supported during in-class activities that require higher order thinking. Instructors assign problem-solving tasks to students in the flipped classroom, and the tasks require them to utilise the information they learnt through watching the video outside of the classroom. Students solve these tasks by either working individually or in groups under the supervision of the teacher.

The flipped classroom inverts traditional classroom approach by taking learners through the fundamentals of concepts for the lesson such as definitions, principles and laws. These fundamentals are at the lower levels of the taxonomy and teachers spend most of the instructional time teaching the basic concepts. The higher cognitive levels must be accomplished by the student themselves through the completion of assignments and homework.

The Piagetian cognitive constructivist theory emphasises assimilation and accommodation. According to constructivists' theory, to reach a higher level of learning, students must interact with peers to reach accommodation of knowledge. Assimilation and accommodation are two key principles of cognitive constructivism that learners practice in the flipped classroom. The first principle is that learning is active because prior to class time, the teacher gives the students a video that introduces the information for the lesson. The introduction of the information serves as a tool that facilitates problem solving. Grooming and cultivation of higher-order thinking takes place in a flipped classroom with peers, a practice which lends itself to constructivist theory, which asserts that learning is not isolated but a socially interactive construction that authentically explores real-time and real-world problems in order to find solutions (Wilson & Peterson, 2006).

2.6 Conceptual Framework

Many educators regarded the prevailing teacher centered and teacher-directed teaching model, its activities and decisions as passive, and that they deprive learners of comprehensive educational experiences. The inability of teachers today to tap into the digital learning approaches available to their students is a sign perpetuating the old passive method.

Amidst these on-going concerns and calls for changes within education instructional practices, a lot of potential solutions have been suggested, one of them being the flipped classroom model (Khan, 2012; Strayer, 2007). There is growing bud of literature that suggests that the flipped classroom may be a viable option that can facilitate an active learning classroom. Figure1 shows the framework of the flipped classroom model that was used in this study.

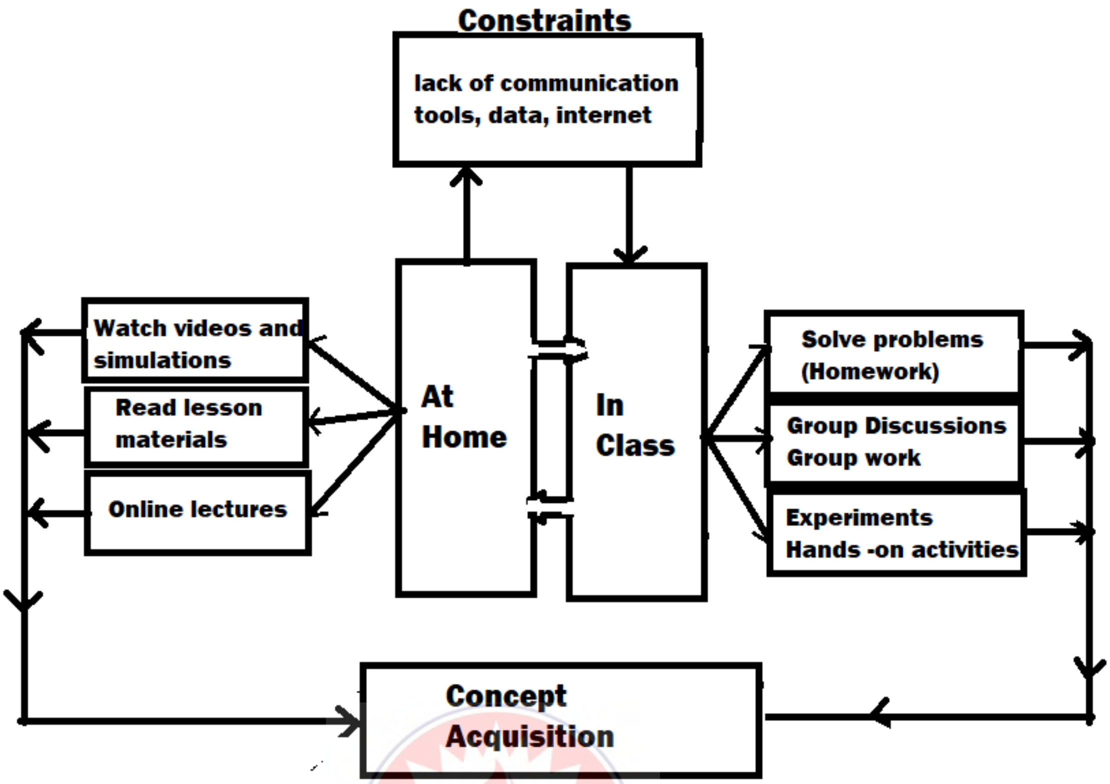

Figure 1: Conceptual Framework for the Flipped Approach

In this framework, the home provided one flexible learning environment for fundamental concept transmission and acquisition. Students learn basic concepts at home in the learners' convenient time. They learn the fundamental concepts by reading learning materials or watching simulations, downloaded teacher-made videos or online lectures and videos. In the home part of the flipped classroom, students watched pre-recorded video, simulations or read lesson materials to gain fundamental concepts. They are expected to arm themselves with questions and have some background knowledge. When students encounter information before class, class time is freed for more engaging and challenging aspects of the lesson.

The constraints to the home aspect of the flipped classroom includes the challenges of data, poor internet access and lack of or faulty communication gadgets. In the research area, data for internet service is not free. Students have to purchase their own data bundles, which was quite expensive. When the student do not have enough money to buy data, they do not access the lesson or videos posted to them.

The other frustrating constraint is poor internet connectivity. Sometimes the students may have the gadget and data, but due to poor internet services, they were not be able to access the information posted to them.

Some of the learners do not have the needed communication gadgets (android phones, laptops, tablets), or what they had were faulty. This situation made it difficult for them to access the videos and other information posted to them.

The constraints associated with the home aspect of the flipped learning was addressed in the in-class aspect of the flipped classroom. Here, the disadvantaged students had the opportunity to watch the videos from their friends and participate in the group discussion and other collaborative activities. They however did not have prepared questions or prior ideas to share.

In the in-class time of the flipped classroom approach, much time is made available for more engaging activities that will drive home and consolidate the fundamental knowledge that the learners acquired while watching the videos. Such activities include collaborative active learning, whole class discussions, group discussions, quizzes, games, presentations, case studies, problem based learning, hands-on activities, debate, interactive demonstrations, experiments, question of the day, and many others. The chances are that many of the concepts that are not already existing in the learners' schema are accommodated. The problem based learning activities take away the solitary attempts that students grapple with at home, and the interactive demonstrations clarify concepts. The in-class activities create opportunities for learners to reason at higher cognitive levels. This enhances their engagement and improves their performance at higher cognitive levels.

The flipped classroom method is therefore a desirable teaching strategy to improve performance and which is being used in this study to investigate pre-service teachers' performance in chemistry. The effects being expected in this study include the students' ability to learn at their own pace, obtain fundamental information independently, active engagement in learning activities, improved performance in tests and performing well at higher cognitive levels.

2.7 Knowledge Gap

Research on the use of flipped classroom in Ghana is scanty. Dzakpasu and Adjartey (2020) investigated the impact of flipped learning in students of Colleges of Education in Computer literacy course and reported a significant difference in performance over the conventional method. Yeboah, Ampadu, Ahwireng and Okrah (2020) surveyed the views of teachers on the use of flipped classroom and reported that majority of the teachers surveyed acknowledged that they have not experienced or have been introduced to the method and hence have never used it in teaching. Oppong, Quansah and Boachhie (2022) studied the effect of the flipped classroom approach in hydrocarbons nomenclature classes with pre-service teachers and recorded an improvement in their performance.

Overmyer (2014) found no statistically significant difference in performance of students in college algebra when compared to the conventional lecture method. Mensah, Yeboah and Adom (2017) solicited the views of leatherwork teachers and students in selected secondary schools in Kumasi Metropolis and reported that the flipped classroom model facilitated communication between teachers and students.

Literature search has not, however, revealed any research in the use of the flipped classroom strategy in teaching Kinetic Molecular theory to pre-service teachers in the Colleges of Education in Ghana. This research sought to provide insight into the effect of the flipped classroom teaching approach on students' performance. The study examined learners' performance of level 200 elective chemistry students in Kinetic Molecular Theory at the cognitive levels of understanding, application, analysis and synthesis at Kibi Presbyterian College of Education.

2.8 Summary

The review explained works done by researchers in the use of flipped classroom. The review also included the traditional classroom, educational technology, theoretical and conceptual frameworks. However, little work on the flipped classroom strategy is available in Ghana and the research will provide knowledge to fill this gap.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter presents the methods used in this research. It details the research design, population and sampling procedure as well as research instruments used in the study. The other aspects include validity and reliability of the research instruments, materials and procedures and course structure. It also contains explanation of data collection procedures, and data analysis procedures enumerated as well. The chapter also contains ethical considerations and predicted expected results.

3.2 Research Design

A research design is a comprehensive and well-organised procedure used by a researcher to carry out a research study. For every research study, the choice of design must be appropriate to the intended investigation. The research design used in this study was action research. According to McCallister (2014), action research is an interactive method of collecting information which is used to explore topics of teaching, curriculum development and student behaviour in the classroom.

Riel (2019) sees action research as a systematic and reflective study of an individual's actions and the results of these actions in a workplace. In education, action research is a systematic enquiry method that researchers carry out to appraise or assess their own pedagogical process.

In schools, educators that engage in action research based inquiry have the intention of improving knowledge, generating knowledge or improving their pedagogical processes. Researchers use the data (mostly subjective) collected in action research to examine personal experiences of the teacher's instructional processes.

Action research is beneficial because it always gives room for improvement in teaching and offers opportunity for reflecting on instructions offered. When new areas of teaching need exploration, action research comes in handy and beneficial. Action research is often the choice in education and many other development domains with the goal of enhancing performance. This research explored a new and emerging teaching approach – flipped classroom, with the purpose of improving the performance of elective chemistry students in chemistry, hence the use of action research in this study.

McCallister (2014) listed three types of action research. These are individual action research that involves working independently on a project, collaborative action research that involves a group of teachers or researchers working together to explore a problem that might be present beyond a single classroom, and school-wide action research that generally focuses on issues present throughout an entire school or across the district. School-wide research involves teams of staff members working together to solve an identified problem that is generally permeating the district.

For this study, I used the individual action research to find remedy to performance in a chemistry course on elective chemistry students. It is a single group-pretest-intervention-posttest action research carried out for six weeks. Four weeks was used for the intervention using flipped classroom as the teaching method. Seventy two (72) elective science students were purposively selected for the sample.

3.3 Research Area

The area of this research is Kibi Presbyterian College of Education, located in Kibi, a town in Abuakwa South Municipality in the Eastern Region of Ghana. The school was established in 1963 as Presbyterian Women's Training College through the collaboration between the Government of Ghana, the Presbyterian Church of Ghana and Akyem Abuakwa State.

Kibi Presbyterian College of Education belongs to a cluster of Colleges of Education (8 in all) in the Eastern and Greater Accra (EAGA) zone and is one of three colleges in this zone that offers elective science. The college is under the mentorship of University of Cape Coast for its transition to autonomy.

There is gradual rectification of the inadequate facilities for science education that existed previously in the school. The school has a one-storey laboratory building that houses Biology, Chemistry, Physics and Agriculture units. Management continues to provide funds for the purchase of necessary equipment and materials for science learning. The school is a promising centre for science learning. For this reason, the University of Cape Coast currently uses it as a centre for some of its sandwich programmes

3.4 Population

The target population of this study was level 100 students admitted into Kibi Presbyterian College of Education in the 2021/22 academic year to pursue teacher education programmes. The accessible population was about 600 level 100 students pursuing educational causes in several disciplines to teach at the basic levels of education in Ghana.

3.5 Sample and Sampling Procedure

The sample for this study was 72 students from Mathematics and ICT majors that were studying elective chemistry course for the semester. The sample consisted of fifty-nine (59) males and thirteen (13) females. For this study, the researcher sampled the entire class of students taking the elective chemistry course for the semester purposively. Purposive sampling is a non-probability sampling technique in which researchers rely on their discretion to choose variables for the sample population.

Lavrakas (2008) describes purposive sampling as a judgmental or expert sampling that has the main objective of producing a sample assumed as representative of a population.

Purposive sampling mainly focuses on particular characteristics of a population that are of interest to the researcher, and which will best enable the researcher to answer the stated research questions. Purposive sampling has the advantage of helping the researcher to gather qualitative responses, which gives better insights and more precise research results, and lowers the margin of error in data because of the close-fitness with the research context.

The reason for using this sampling method was that since the teaching approach is novel, it would not be fair to leave any student behind. All learners must benefit from the new approach in order to improve their performance. Another reason for this purposive sampling is to identify the patterns of performance that cut across the learner groups and the selection of uniform cases for facilitating the data collection and the analysis processes.

3.6 Research Instruments

A research instrument is any tool used for collecting, measuring and analyzing data that is relevant to the subject or intent of a research. A good research instrument is one which is validated and its reliability is proven. Researchers design research instruments as measurement tools to obtain information (data) on a topic of interest from research subjects. A good research instrument is one that can collect data in a way appropriate to the research question of the study. The research instruments used to collect data for this research were test, observation and questionnaire.

3.6.1 Pre –test

The researcher used pre-intervention test in this study to determine the existing knowledge on kinetic theory of molecules and gas laws. Berry (2008) described pre-test as a non-graded assessment tool used to determine pre-existing subject knowledge, and administered prior to a course to determine knowledge baseline. The concept was not new to the students because it was a review of what they studied at the secondary school.

The test used in this study was the Kinetic Molecular Theory Diagnostic Test (KMTDT). The test items constructed examined the understanding, application, analysis and synthesis levels of performance of students in the Bloom's taxonomy of cognitive domain (Appendix A). Table 2 shows the cognitive domains and number of items.

Table 2: The Cognitive Domains and Number of Items

Domain	Number of Items
Understanding	5
Application	5
Analysis	4
Synthesis	5

Understanding is the ability to comprehend and make meaning of concept taught. It manifests in the forms of translation of the concept, interpretation of the concept and ability to interpolate and extrapolate knowledge gained from the concept. Shabatura (2013) and Kurt (2020) define understanding as constructing meaning from messages (graphic, oral, written) by way of classifying, exemplifying, inferring and explaining, among others. The understanding section of the pre-test consisted of five items. Each item had four options and a reason for choosing that option. The student achieves complete understanding when the correct option is selected and a correct explanation is given. A student achieved partial understanding when s/he provided the correct option but gave a wrong reason. When both option and reason were wrong, it was interpreted as lack of understanding.

The five items in the understanding domain examined students' pre-existing knowledge on differences between boiling and evaporation, force of attraction between molecules, pressure of states of matter, temperature and interconversion of states of matter and postulates of kinetic molecular theory. The total score for the understand session was 10.

Application as applied to the Bloom's Taxonomy refers to the ability to show the pertinence of the principles of the concept learnt to different and novel situations. Methods, laws or theories are applied in this situation to actual and concrete problems. Shabatura (2013) described application as carrying out or using a procedure for executing, or implementing a task, while Kurt (2020) defined it as executing or implementing acquired knowledge to real situations.

There were five items in the application section of the pre-test. Some of the items had four plausible options from which the students could select the correct option, while they supplied the answer to some of the questions. Additionally, the student was required to explain their choice of alternative. Students achieve complete application when they select the correct option and provide a correct explanation. When a student select the correct option but give wrong reason, the researcher interprets the response as partial application. When both the option and reason are wrong, the researcher interprets the response as lack of concept of application.

The five items in the application domain examined students' pre-existing knowledge on kinetic energy of gases, usefulness of boiling and melting points, diffusion of molecules, temperature and reaction rates, the kinetic molecular theory bases of boiling, as well as melting and evaporation. The total score for this section was 10 marks.

Apart from knowledge, understanding and application, analysis also requires an understanding of the underlying structure of materials (concepts). In analysis, materials are broken down into their fundamental elements for better understanding of the concept. Armstrong (2010) posits that analysis is the breakdown of communication into its constituent elements such that the hierarchy of ideas becomes clear, and the relations between ideas made explicit. Kurt (2020) explained it as determining how the constituent parts of material related to one another when it was broken down. You can see its overall structure or purpose through differentiating, organizing and attributing.

The analysis section of the pre-test consisted of four items. The students were required to supply the correct responses to the items and justify their answers through further explanation. A student achieves complete analysis when correct answers are provided and with correct explanation. The researcher interprets correct answer with wrong explanation as partial analysis. Furthermore, the researcher interprets as lack of the concept of analysis when neither the answer nor the explanation is correct.

The concepts in kinetic molecular theory examined at this level included dissolution of solutes in solvents, characteristics of states of matter and a temperature time graph on change of state of water. The total score for this level was 15 marks.

Synthesis is the reorganisation of scientific systems into a new whole or new pattern. It requires the formulation of new understandings of scientific systems and stresses whole instead of parts. Learning at the higher level of synthesis occurs when one combine scientific ideas to create a singular pattern or notion. Thus, synthesis refers to the ability to put parts together to form a new whole. Kelly (2018) states that synthesis is the result when students assemble the parts of information they have reviewed into a whole, in order to generate meaning or a new structure.

The synthesis section of the pre-test consisted of four items. The student was required to supply the correct responses to the items and justify their answers through further explanation. A student achieves complete synthesis when the correct answer to the item is provided and with correct explanation. A student who provided a correct answer but wrong explanation achieves partial synthesis. When neither the answer nor the explanation is correct, the researcher interpreted the response as lack of the concept of synthesis.

The concepts in kinetic molecular theory examined at this level included kinetic energy of water particles, change of state of matter, sublimation of ammonium chloride and gas laws. The total score for this session was 10 marks.

3.6.2 Questionnaire

A questionnaire is a research tool that contains specific questions used to conduct surveys, with the goal of understanding a phenomenon from the point of view of respondents. Bhandari (2022) describes a questionnaire as a list of questions or items used to gather quantitative or qualitative data from respondents about their attitudes, experiences, or opinions. A well-designed questionnaire is the creation of valid and reliable questions that address the objectives of the research.

The researcher constructed a perception questionnaire to examine students' perception after the implementation of the flipped classroom strategy. The items in the questionnaire was adapted from Jaster (2017). There was modification of the items to suit the level of respondents.

The questionnaire consisted of 20 items, on a five-point Likert scale. Students were to indicate how they perceived the flipped classroom approach by ticking the box that corresponded with their level of agreement. Due to time constraints associated with the track system operating in colleges of education in Ghana, the researcher designed the questionnaire to take about 10 minutes to answer.

3.6.3 Observation checklist

An observation checklist is a set or list of questions that an observer scores when doing a specific observation of an event. It helps an observer assess an individual's or a group of people's performance and conduct. To better enhance teaching methods and student learning growth, a teacher employs an observation checklist in the classroom to pinpoint student learning needs, skill gaps, and problem areas. Observation checklists provide a structure and framework for an observation as well as acting as a contract between the observer and the teacher. Hong, Ye, Chen, and Yu (2020) state that classroom observation is generally regarded as an important tool for improving the professional development of teachers, hence a good checklist is needed for teachers and observers to communicate those performed and missed points to improve teaching practice. The researcher constructed an observation checklist to record the students' engagement in the flipped classroom.

3.7 Validity of Instruments

The validity of an instrument is the idea that the instrument measures what it intends to measure. This pertains to the connection between the purpose of the research and the type of data the researcher chooses to quantify that purpose. Taherdoost (2016) cites Ghauri and Gronhaug (2005) as saying that validity explains how well the data collected covers the actual area of investigation. Validity, therefore, is the degree to which an instrument accurately measures what it intends to measure.

For this study, the researcher addressed the content validity of the data collecting instruments carefully. Content validity is the extent to which items adequately measure the content of the trait that the researcher wishes to measure (Li, 2016). To ensure validity, the items in the tests and questionnaire, four chemistry tutors from sister colleges of education examined the items for validation. The supervisor of this research also reviewed the items. The validators determined the appropriateness of the content material, clarity of the items and instructions. Their comments resulted in the rewording of some of the items and withdrawal of some of the items.

3.8 Reliability of Instruments

Reliability of an assessment tool refers to the consistency of results. It concerns the extent to which a measurement of a phenomenon provides stable and consist result. Li (2016) refers to reliability as the degree to which an instrument yields consistent result. The researcher also considered the internal consistency reliability of the test items carefully. Internal consistency assesses the correlation between multiple items in a test intended to measure the same construct.

To ensure reliability of the instruments, the constructed tests and questionnaire were trial tested. The results of the trial test were subjected to Cronbach's α test. Internal consistency estimate of reliability procedure was used to determine the reliability of the test instrument. Tavakol and Dennick (2011) indicated that the acceptable range of test items that measure intellectual ability is between 0.7 and 0.95. Cronbach's alpha coefficient for the KMTDT instrument was 0.81.

Again, Zeller (2005) considered α value of 0.9 or higher as excellent, 0.8 to 0.9 as adequate, 0.7 to 0.8 as marginal, 0.6 to 0.07 as seriously suspect, and less than 0.6 as unacceptable. The alpha value for this questionnaire after trial tested was 0.86 and the researcher considered it adequate for data collection.

3.9 Course Structure

EBS 254 is an Elective Chemistry course designed by the Institute of Education, University of Cape Coast for their affiliated colleges of education. The course is for the first semester of the second year of the bachelor degree programme. The course has been designed to "consolidate and expand on the content students have acquired from their lessons in the Elective Chemistry at the senior high school level" (Institute of Education, 2019, p. 2). It is also meant to bridge the gap between industrial and academic chemistry.

Topics that were treated in this course for the entire semester included kinetic molecular theory, chemical kinetics, chemical equilibrium and chemistry of carbon. The period allocated for teaching the course was sixteen (16) weeks. The roles of the tutors were to encourage students to obtain their own data, and guided to analyse them in the course of their studies. They were also encouraged to apply concepts and information in useful context. The expectations from students included regular participation in interactive groups where "sharing, communicating and responding to the important concepts and decision making occur" (Institute of Education, 2019, p. 1).

In this current study, the researcher specifically taught the kinetic molecular theory (KMT). The aspects of this unit are as follow: postulates of kinetic molecular theory, nature of solids, liquids and gases with respect to the KMT, properties and behaviour of plasma, changes of state of mater and Brownian motion. The others are diffusion, gases and gas laws, liquids (vapour pressure) and solids – ionic, covalent, metallic and molecular solids. The teaching approach used to treat this unit for three weeks was the flipped classroom.

3.10 Intervention

The researcher used the 6-step guide for implementing flipped classroom, proposed by Dunn (2014), to implement the intervention of this study. The six steps included the processes of plan, record, share, change, group and regroup. In the plan stage, the researcher figured out the lesson to flip by outlining the learning outcomes and prepared a lesson plan.

At the record stage, the researcher downloaded YouTube videos and/or links, made sure they contained all the key elements and concepts to be mentioned in the lesson. Where possible reading materials on the topic for the learners were included.

At the share stage, the researcher sent the videos to the students through Telegram and WhatsApp platforms. The learners were informed through those same platforms that the class would discuss the content video and or reading material fully during in-class time. At the change/flip stage, the students had viewed the lesson, so the class actually went more in-depth than the fundaments concepts that the students watched in the video.

At the grouping stage, the researcher initiated discussion on the topic in separate groups into which the students were placed and given a task to perform. During the final stage, that is the regroup stage, the researcher got the class back together to share the individual group's work with everyone. Reflective questions were asked by the researcher and students from other groups to get better understanding of each group's work. Samples of lessons that were executed during the intervention stage are presented.

Lesson 1: Kinetic Molecular Theory

Plan	Topic: Kinetic molecular theory Learning outcomes: students to state the postulates of the KMT, explain the nature of solids, liquid and gas with respect to KMT, explain changes od state of matter and explain Brownian motion
Record	Video links: https://www.youtube.com/watch?v=lYvIyLlYJA4 https://www.youtube.com/watch?v=gPMVaAnij88
Share	Watch the two videos with the links above at home. One is on change of state of matter and one on Brownian motion. The videos will be discussed at class during the science lesson period.
Change	You have done well in watching the videos. What is the nature of solids, liquids and gas? How does Brownian motion occur? Etc.
Group	Be in your groups. Group leaders come and pick your aspect to study (postulates, nature of solid, nature of liquid, nature of gas, property and behaviour of plasma, change of state of water, change of state of naphthalene change of state of sulphur, Brownian motion). After 10 minutes, you present your work to the class.
Regroup	Group work is over. Go back to your places. Group 1: let us hear from you.
Assessment	Write five things you have learnt today about kinetic molecular theory.

Lesson 2: Gas Laws

Plan	Topic: Gas laws Learning outcomes: students use kinetic model to explain Charles', Boyle's. Dalton's, Graham's, Avogadro's laws and the idea gas equation; derive the mathematical relations of the gas laws; perform calculations based on the gas laws.
Record	Video links: https://www.youtube.com/watch?v=a06fAmMv1n8 https://www.youtube.com/watch?v=f7f24DtTlKQ
Share	Watch the two videos with the links above at home. They are on the gas laws. We will discuss the videos at class during the science lesson period.
Change	You have done well in watching the videos. Which law have you learnt well and can share with us? Can you support your answer with a solved question?
Group	Be in your groups. Group leaders come and pick your aspect to study (Boyle's Law, Charles' Law, Avogadro,s Law, Ideal gas Equation, Dalton's Law of partial pressure). It is collaborative work, so I will call any member of your group after 20 minutes to present your work to the class.
Regroup	Group work is over. Go back to your places. Selected member from group 3 should present group three's work. Your friends from other group may ask questions or seek clarification from the presenter's group.
Assessment	Solve the following problems on the gas laws:

Lesson 3: Liquids and Vapour Pressure

Plan	Topic: Gas laws Learning outcomes: students explain the concept of vapour pressure; solve problems based on vapour pressure.
Record	Video links: https://www.youtube.com/watch?v=iZqsQhZ1CAs https://www.youtube.com/watch?v=BilG1GpeRvY
Share	Watch the two videos with the links above at home. They are on vapour pressure of liquids. We will discuss the videos at class during the science lesson period.
Change	You have done well in watching the videos. Which law have you learnt well and can share with us? Can you support your answer with a solved question?
Group	Solve the following questions in your groups 1. The vapor pressure of water at 25 degrees Celsius is 22.8mmHg. If three moles of a nonvolatile solute adds to twelve moles of water, what is the new vapor pressure of the solution? 2. Calculate the vapor pressure of a mixture containing 252 g of n-pentane (Mw = 72) and 1400 g of n-eptane (Mw = 100) at 20°C. The vapor pressure of n-pentane and n-eptane are 420 mm Hg and 36 mm Hg respectively. 3. What is the vapor pressure of an aqueous solution that has a solute mole fraction of 0.1000? The vapor pressure of water is 25.756 mmHg at 25 °C
Regroup	Group work is over. Go back to your places. Past your solutions on the marker board for gallery walk. Correct procedures will attract marks.
Assessment	How relevant is Raoult's Law?

Lesson 4: Solids – Ionic, Covalent, Metallic and Molecular Solids

Plan	Topic: Solids Learning outcomes: students to describe ionic, metallic, covalent and molecular solids
Record	Video links: https://www.youtube.com/watch?v=iZqsQhZ1CAs https://www.youtube.com/watch?v=BilG1GpeRvY
Share	Watch the two videos with the links above at home. They are on solids and their types. We will discuss the videos at class during the science lesson period.
Change	You have done well in watching the videos. Soot, graphite and diamond are allotropes of carbon. Why are their structures different?
Group	Solve the following question in your groups: on one foolscap page describe, with example, the types of solids. A member of your group will read out your write up. I will allow five minutes for questioning.
Regroup	Group work is over. Go back to your places. Read out your write-up. Any member of the group can answer the follow-up questions.
Assessment	Differentiate between crystalline and amorphous solids. Give two examples of each.

All the assessment questions in the four lessons were answered and discussed in the classroom in groups. The result of the group performances were presented in Table 12.

3.11 Observation

The researcher prepared an observation checklist detailing behaviours to check during the instructional period. Fellow tutors sat in the classroom and checked the activities of the learners as the instruction progressed through the stages. After the lesson, the checklist was collected and studied. The researcher then added reflective notes on the lesson of the day. All the four lessons were observed and records taken.

3.12 Post-intervention Test

After implementing the intervention, the researcher administered the post – intervention test, an equivalent form of the Kinetic Molecular Theory Diagnostic Test used in the pre-test in order to avoid the problem of pretest sensitisation. Bryne (2010) refers to pretest sensitisation as the potential of a pretreatment assessment to affect subjects in an experiment. That is, when participants in an experiment take a pretest, they may become alert and sensitive to the constructs that the pretest is measuring and this may affect the posttest scores.

The purpose of the post-intervention test was to collect relevant data pertaining to their performance. The researcher conducted the test in the College's examination hall to ensure reliability. Tutors in the science department assisted in the supervision of the post-intervention test that lasted for one hour.

3.13 Questionnaire Administration

For the purpose of freedom of participation, the researcher introduced the questionnaire to the students and asked volunteers to answer the items. The questionnaire was administered to the student volunteers to gather information about their perception about the use of the flipped classroom teaching. In all, 58 students volunteered to answer the questionnaire; however, 53 out of the 58 submitted their questionnaire, giving a return rate of 91%.

3.14 Data Analysis Plan

The study used frequency tables to present the data collected with the tools, using the necessary statistical methods to analyse it. The statistical tools used were simple frequency counts and one sample t-test for the analysis of the hypothesis that was formulated.

3.15 Ethical Considerations

The researcher ensured the protection of the identity of the students. The questionnaire bore no names of the respondents. Furthermore, the work did not publish or rank the results of the tests.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This section presents the results of the study in three sections. The subsections reflected the results and discussion on students' existing knowledge on the kinetic molecular theory before and after the implementation of the flipped classroom approach. Discussions of participants' responses to the questionnaire and findings of the study were done in light of available literature.

4.2 What is the pre-existing knowledge of elective chemistry students' on concepts of kinetic molecular theory?

4.2.1 Pre-existing knowledge on KMT at understanding level

Even though all the respondents completed elective chemistry course in secondary school, their performance in the pretest showed they lacked complete understanding of the basic concepts of boiling and evaporation, the forces of attraction between states of matter and the temperature at the interconversion states of matter (Table 3). They could not also understand the postulates as enshrined in the kinetic molecular theory of matter. In the table, a score of zero means complete lack of understanding, a score of one means partial understanding and a score of two shows complete understanding. A large number of students demonstrated lack of understanding in test items 1, 4 and 5 (Appendix A) and a high percentage also showed partial understanding in the listed items. However, a good number of the showed complete understanding of items 2 and 3 (Appendix A).

Some wrong answers provided by students to some of the questions (Appendix A) were: *NaCl has a high force of attraction because of the presence of covalent bond; iron fillings exert more pressure on the walls of the container; iron fillings have volume* *and density*; among others. Temperature remains constant during interconversion of states of matter - *because of decrease in pressure; so that pressure and volume can be clearly recorded and noticed; because it lowers the activity energy for the reactions.* These responses showed complete lack of understanding and partial understanding of the KMT concepts examined. It is therefore found that majority of students showed partial and complete lack of understanding of concepts of evaporating and boiling, interconversion of state and calculation of kinetic energy in the kinetic molecular theory.

Table 3: Scores of Students at the Understanding Level

Score/ Item	1	%	2	%	3	%	4	%	5	%
0	28	38.9	11	15.3	8	11.1	40	55.6	54	88.9
1	26	36.1	18	25.0	14	19.4	32	44.4	02	2.8
2	18	25.0	43	59.7	50	69.5	-		06	8.3

Source: Field Data, 2022

The summary of students' performance is shown in table four. The result indicated high percentages of partial (38.9%, 31.9% and 45.9%) for items 1, 4 and 5 respectively, and complete lack of understanding (35.5%, 30.6% and 31.9%) respectively for items 1, 4 and five. Of the five concepts of kinetic molecular theory examined (Appendix A), students demonstrated poor understanding of most of the concepts. (Table 4). It was therefore found that students pre-existing knowledge n some basic concepts in kinetic molecular theory was poor.

Table 4: Summary of Students' Performance at the Level of Understanding

Item	Complete Understanding	%	Partial Understanding	%	Lack of Understanding	%
1	17	23.6	28	38.9	27	35.5
2	38	52.8	23	31.9	11	15.3
3	38	52.8	18	25.0	16	22.2
4	27	37.5	23	31.9	22	30.6
5	16	22.2	33	45.9	23	31.9

Source: Field Data, 2022

4.2.2 Pre-existing knowledge on KMT at application level

Table five shows the performance of students at the application level. The results revealed that students' prior knowledge on application on some of the test items was low. Learners displayed poor concept application with regard to items on kinetic energy of gases, usefulness of boiling and melting points, diffusion of molecules (Table five). Some of the wrong answers provide by the students on the usefulness of boiling and melting points of substances (Appendix B) were: *they help in reducing or decreasing down large particles; helps to know a particular state of matter; helps to convert from one state to the other; melting points help in the preservation of food;* among others. On the question of the substance of the lowest diffusion (fanta, honey, ethanol), the wrong responses include: *fanta because there are more gas molecules in fanta; ethanol because the OH in the ethanol helps to bond with water; water will separate from the alcohol.* These responses showed lack of application of scientific concept in KMT by the students.

However, it was observed that students had appreciable prior knowledge in the areas of temperature and reaction rates as well as the kinetic molecular theory bases of boiling, melting and evaporation (Appendix B).

Table 5: Students' Scores at the Application Level

Score /Item	1	%	2	%	3	%	4	%	5	%
0	38	52.8	19	26.4	26	36.2	29	40.3	25	34.7
1	20	27.8	34	47.2	05	6.9		-	22	30.6
2	14	19.4	19	26.4	41	56.9	43	59.7	25	34.7

Source: Field Data, 2022

Table 6 is a summary of students' performance at the application level. Comparing the students' performance at the understanding and application levels, the researcher realized that students had a higher mean at the application level than the understanding level (Table 11). However, the standard deviation at the application level was wider as compared to the understanding level (Table 11). The study therefore found that students showed high levels of complete lack of application of concepts in kinetic molecular theory (35.5%, 30.6% and 31.9%) respectively for items 1, 4 and 5 (Appendix B) and partial understanding (38.9%, 31.9%, 31.9% and 45.9%) respectively for items 1, 2, 4 and 5 in usefulness of boiling and melting properties of matter, rate of diffusion and the kinetic molecular theory bases of boiling, melting and condensation (Appendix B). Most students however had complete application of Charles' Law (Appendix B).

Table 6: Summary of Students' Performance at the Application Level

Item	Complete Application	%	Partial Application	%	Lack of Application	%
1	10	13.9	28	38.9	27	35.5
2	15	20.8	23	31.9	11	15.3
3	19	26.4	18	25.0	16	22.2
4	36	50.0	23	31.9	22	30.6
5	34	47.2	33	45.9	23	31.9

Source: Field Data, 2022

4.2.3 Pre-existing knowledge on KMT at analysis level

Table 7 presents the scores of students in the pretest at the analysis level. The result showed that apart from item 4, students showed lack of the concept of analysis records of data on change of state, dissolution of crystalline solids and how gases can be liquefied (Appendix C). In fact no student was able to answer item number 12 (100% lack of understanding). On the question of conditions under which gas can be liquefied, the wrong answers provided include, among others, *through condensation; by evaporation; by melting; by vaporization; high temperature*. They were unable to analyse the table in Item 11 and did not know the from liquefied petroleum gas (LPG) exist in the cylinder (Appendix C). These responses showed that the students could not analysed the KMT concepts tested.

Students however had complete application of concepts of states of matter in terms of rigidity, compressibility, fluidity, kinetic energy and density.

Table 7: Scores of Students at the Analysis Level

Score/ Item	1	%	2	%	3	%	4	%
0	37	51.4	72	100	47	65.3	1	9.8
1	23	31.9	-		16	22.2	16	22.2
2	12	16.7	-		09	12.5	25	34.7
3	-		-		-		24	33.3

Source: Field Data, 2022

The result in (Table 8) showed the summary of students' performance at the analysis level in the pretest. Students that showed complete analysis of basic concepts in kinetic molecular theory was less than 40% in all the four items. More than 70% of them showed partial and lack of analytical content in the items cumulatively (Appendix C). The study therefore found that majority of the students examined in the pretest showed complete lack of analysis (63.9% and 55.5%) in items 2 and 3 (Appendix C) and partial analysis (all four items) in the concepts of changes of state, dissolution of ionic crystals and how gases can be liquefied in the kinetic molecular theory of matter.

Table 8: Summary of Students' Performance at the Analysis Level

Item	Complete Analysis	%	Partial Analysis	%	Lack of Analysis	%
1	21	29.2	37	51.4	14	19.4
2	08	11.1	18	25.0	46	63.9
3	13	18.1	19	26.4	40	55.5
4	28	38.9	25	34.7	19	26.4

Source: Field Data, 2022

4.2.4 Pre-existing knowledge on KMT at synthesis level

The results show high percentages of complete lack of synthesis of concepts in kinetic molecular theory (Table 9). Synthesis of kinetic energy of particles in described containers, postulates of the kinetic theory, sublimation and specific gas laws (Appendix D) was a challenge to students. They were not able to explain the KMT basis of the sublimation of ammonium chloride. Students did not reasoned that the response "the average kinetic energies of different gases are different at the same temperature" is inconsistent with the kinetic molecular theory, they therefore chose options that are rather consistent.

However, most of the students were able to interpret the temperature versus time graph given in item 2 (Appendix D).

Table 9: Scores of Students at the Synthesis Level

Score /Item	1	%	2	%	3	%	4	%	5	%
0	57	79.2	18	25.0	13	18.1	66	91.7	37	51.4
1	03	4.2	22	30.6		-	04	5.6	11	15.3
2	12	16.6	32	44.4	59	81.9	02	2.7	24	33.3

The results in table 10 summarised the students' performance at the synthesis level in the pretest. Partial ability to synthesize and lack of that ability dominated students' performance. The table shows that the mean was comparatively low and that the standard deviation was relatively small. The study therefore found that reasoning at this higher level of Bloom's cognitive domain was a challenge to students. Also, it was found that majority of the students can interpret temperature versus time graph of the kinetic molecular theory.

Table 10: Summary of Students' Performance at the Synthesis Level

Item	Complete Analysis	%	Partial Analysis	%	Lack of Analysis	%
15	16	29.2	18	51.4	38	19.4
16	20	11.1	25	25.0	27	63.9
17	15	18.1	17	26.4	40	55.5
18	23	38.9	16	34.7	33	26.4
19	30	41.7	24	33.3	18	25.0

[Source: Field Data]

Results in Table 11 summarized the means and standard deviations of the students' performance at the four levels of Bloom' taxonomy. The mean and standard deviation of students' performance at the understanding level was 4.82 and 1.84 (Table 11). This mean score was considered low due to the fact that understanding is regarded as a lower level in the cognitive domain. The researcher expected that the students would score higher marks at this level. The mean and standard deviation of students' performance at the application level was 5.11 and 2.359 respectively (Table 11). This mean was regarded as average. However, the large standard deviation means that the students' scores were not close to each other. At the analysis level, the mean and standard deviation calculated was 6.0 and 2.589 respectively (Table 11). The performance at this level was appreciable considering the fact that analysis is a higher level of the cognitive domain. The calculated mean and standard deviation were 2.88 and 1.883 respectively (Table 11). The researcher regarded the students' performance at this level as very low. The results implied that the students were unable to synthesise scientific concepts in the kinetic molecular theory.

Table 11: Table of Means and Standard Deviations of Students' Scores at the Four Levels

Level	Mean	Standard Deviation
Understanding	4.82	1.841
Application	5.11	2.359
Analysis	6.0	2.589
Synthesis	2.88	1.883

Source: Field Data, 2022

Findings:

1. Students demonstrated poor understanding of concepts in kinetic molecular theory when the concepts were operationalized.
2. Students demonstrated poor application of many concepts in the kinetic molecular theory.
3. Students showed poor analysis of concepts in the kinetic molecular theory.
4. Students were unable to synthesise scientific concepts in the kinetic molecular theory.
5. The entry behavior (pre-existing knowledge) of students in the kinetic molecular theory of matter with reference to the four levels of Bloom's taxonomy was generally poor.

The results of the study indicated that the students who participated in the study had limited knowledge on the various concepts under kinetic molecular theory. The study tested students on four cognitive dimensions of the Bloom's taxonomy, namely understanding, application, analysis and synthesis. The research revealed that the students exhibited more of partial understanding to lack of understanding on the concepts assessed under the understanding domain. The results were in line with the findings of Nurhuda, Rusdiana, and Setiawan (2017), who reported that a good majority of students have partial understanding of scientific concepts at certain levels.

Application of concepts is a key aspect in the study of chemistry. Learners of chemistry should be able to apply the chemical concepts learned to solve life problems. Results from the study showed that the students examined display partial application of concepts and most of them showed lack of concept application. On the domains of analysis and synthesis, the students equally showed low levels of knowledge. They rather displayed high levels of partial and complete lack of knowledge in these areas.

Tutors of chemistry at the Colleges of Education often assume that students who studied elective chemistry at the senior high school have in-depth knowledge in the basic concepts. Their instructional approaches are directed (most often) towards consolidating the concepts. However, this study revealed that this notion by the chemistry tutors is incorrect.

Most of the students have low understanding of some of the basic chemistry concept, like the kinetic molecular theory studied in this study. Thus the researcher reasoned that instruction in the traditional classroom do not place emphasis on reasoning at the higher cognitive levels, hence most graduates from senior high schools lack these cognitive abilities, as shown in the pretest.

4.3 What is the effect of the flipped classroom approach on students' performance in the study of kinetic molecular theory?

The answers provided by the students in the intervention exercises showed their zeal and understanding of the concepts treated due to the out-of-class and in-class activities enshrined in the flipped classroom approach adopted. Students worked in groups for minutes to provide answers for the question. Five minutes was given for presentation of answers in the exercise in lesson 1. Some of the answers provided by the groups is shown in Appendix G:

On lesson two exercises, students worked collaboratively in their groups to solve the problems. They used 15 minutes to solve the problems and used 5 minutes to present their answers. Questions were asked by members of other groups on procedures that were not clear. Clarifications were given supported by the researcher who acted as a guide on the side. Some of the good answers provided are shown in Appendix G.

Students read out their answers after a period of discussion in their various groups on lesson 3 exercise. The answers highlighted the importance and limitations of the law. Some answers provided were shown in Appendix G. The same approach was given to the exercise in lesson 4. A summary of their performance is shown in Table 12.

4.3.1 Effect on class interactions and exercises

Results in Table 12 shows the group scores of exercises conducted during the intervention. Due to the videos that gave the fundamental concepts at the students convenient time and the collaborative problem solving in the in class time, group performances were high. Almost all students scored the maximum marks during the class exercised. The class exercise results (Table 12) demonstrates that the flipped classroom teaching approach is effective. The study therefore found that the flipped classroom approach improved students' collaborative work, motivation, interest and performance in the concepts of kinetic molecular theory taught.

Table 12: Class Exercise Scores during the Intervention

Exercise	1		2		3		4	
Group	Total Score (40)	Mean (5)	Total Score(48)	Mean (6)	Total Score (48)	Mean (6)	Total score (40)	Mean (5)
1	38	**4.75**	42	**5.25**	48	**6.0**	40	**5.0**
2	36	**4.5**	46	**5.75**	48	**6.0**	38	**4.75**
3	38	**4.75**	46	**5.75**	46	**5.75**	40	**5.0**
4	40	**5.0**	48	**6.0**	40	**5.0**	38	**4.75**
5	40	**5.0**	46	**5.75**	40	**5.0**	38	**4.75**
6	40	**5.0**	45	**5.63**	42	**5.25**	40	**5.0**
7	36	**4.5**	40	**5.0**	38	**4.75**	40	**5.0**
8	34	**4.25**	44	**5.5**	40	**5.0**	36	**4.5**
9	38	**4.75**	44	**5.5**	42	**5.25**	40	**5.0**

4.3.2 T-test analysis

The post test questions were then set administered to measure their performance in kinetic molecular theory of matter studied. A one sample t-test analysis of the pre and post test results showed an improved performance of students in the post-test.

Students appeared to significantly perform better in the post-test than in the pre-test after the intervention. The students received lower score for the pretest (M = 19.01, SD = 5.466) than in the post test (M =31.07, SD = 6.483), t(71) = -11.950, p<.05), two-tailed [Table 13]. The size of the effect was large (effect size r = .85).

Table 13: The Paired Sample t-test Analysis of the Pretest and Posttest of the Sample

Test	Mean Score	Standard Deviation	Mode	t-value	p- value
Pretest	19.01	5. 466	24		
Posttest	31.07	6.483	32	-11.950	.000*

*** = significant, p< 0.05**

The calculated t-value was significant in favour of the posttest. This means that the performance of the students was greatly enhanced due to the implementation of the flipped classroom approach in the delivery of the concepts in kinetic molecular theory.

The researcher, therefore, concluded that there was a statistically significant difference in students' performance due to the use of the flipped classroom approach to teach the concepts. The null hypothesis was therefore rejected. The study therefore found that the flipped classroom strategy had a large effect on the students' performance in the study of kinetic molecular theory.

Findings:

1. The flipped classroom approach improved students' collaborative work, motivation, interest and performance in the concepts of kinetic molecular theory taught.
2. The flipped classroom strategy had a large effect on the students' performance in the study of kinetic molecular theory.

The introduction of the flipped classroom learning strategy in this study had shown improved performance of the students. As an emerging teaching and learning strategy, the flipped classroom technique is yielding improved performance as reported by researchers. The findings of this research was in line that of Sirakaya and Özdemir (2018) who found a significant difference between groups in terms of academic achievement, motivation and retention. Talan and Gulsecen (2019) also reported a statistically significant difference in performance an experimental and control groups with regard to academic achievement and engagement. Shao and Liu (2021) indicated that the flipped classroom can improve students' academic performance.

The study also agree with the research of Asad, Ali, Churi and Moreno-Guerrero (2022) who reported that the flipped classroom is a practical learning approach that enhances student performance, engagement, and learning in class. Jundt, Moormann, Voorhees and Ziemann (2015) showed that students enjoyed learning with the flipped classroom method, and completion rates were higher than previously observed, and students mastered classroom content successfully.

The results of this study have shown that the use of the flipped classroom method had a positive effect on students understanding and analysis of concepts. This finding is however contrary to the study of Sourg, Satti, Ahmed, *et al* (2023) who found no statistically significant difference in performance after comparing the pre and post-tests of students in experimental and control groups. However, van Alten et al. (2019) found a small positive effect on learning students' outcomes

Other research reports showed improvement in semester and exam grades. Thus generally, the flipped classroom teaching method has a significant positive effect on students' performance as is seen in the improvement on students concepts in kinetic molecular theory used in this research.

4.4 What is the level of engagement of students using the flipped classroom approach?

During the intervention lessons, some students were observed in the classroom (about 20 on one occasion and about 10 on three occasions) watching and discussing the videos sent to them to observe at home. This implies that these students were unable to watch the videos at home due to some constraints, and hence came to the class early to watch the videos from friends' gadgets, and engage in prior discussions so as to have the fundamental concepts before the class time. During the instructional time, all the students were present in class on all four occasions. It is therefore concluded that a few of the students have constraints that prevented them from watching the videos at home.

Table 14: Observed Behavior of Students before Instructional Time

	Whole Class	%	About half	%	About 20	%	About 10	%
Some students were present in class before instructional time	-		-		1	25	3	75
Some students seen watching videos individually or in groups	-		-		1	25	3	75
Some students were seen discussing the videos	-		-		1	25	3	75
Number of students present during the instructional time.	3	75	1	25	-		-	

Results in Table 15 shows the engagement of students during instruction. It was observed that students actively shared information they gained in watching the videos (75%), and were seen actively reading question they wrote down while watching the videos, and asked for explanations. During group tasks the students very actively (100%) participated in the group activities and their collaboration in solving group calculation problems was very high. It is therefore concluded that the flipped classroom strategy enhanced their engagement, collaboration and group work.

Table 15: Students' Instructional Engagement Actions

	Very Active	%	Active	%	Somehow Active	%	Not Active	%
Students willingly shared information gained from the videos observed.	1	25	3	75				
Students wrote down questions and asked for further clarification.	1	25	2	40	1	25		
Students worked on assigned group tasks.	4	100	-		-		-	
Students seen collaborating to solve problems based on the lesson.	-		4	100	-		-	

Results in Table 16 shows information on students' engagement in group presentations during the in-class activities. The students were observed to perform very well (75%) as each member of the group contributed effectively to questions asked by other group members. After the group works students were seen working independently on other problems based on the lesson (Table 16). The conclusion drawn was that the flipped classroom approach improved the students' self-confidence and collective knowledge generation.

Table16: Students' Participation in Group Presentations

	Very Well	%	Well	%	Somehow Well	%	Badly	%
Group tasks were solved.	3	75	1	25				
Individuals were able to work independently after group discussions.	1	25	3	75	-		-	

Throughout the intervention lessons, observers graded the learners' interest in the lessons as very high (75%) [Table 17]. Students' motivation in the lessons were very high (75%) and collaboration was very high (75%). Individual performance that demonstrated knowledge acquisition using the method was collectively high (Table 17). The observers' general impression of the in-class flipped classroom activities was graded as high.

Table 17: Grading of Interactions

	Very High	%	High	%	Low	%	Very Low	%
Interest	3	75	1	25	-		-	
Motivation	1	25	3	75	-		-	
Collaboration	1	25	3	75	-		-	
Individual performance	2	50	2	50	-		-	
General impression	2	50	2	50	-		-	

Findings:

1. A few of the students had constraints that prevented them from watching the videos at home.
2. The flipped classroom strategy enhanced their engagement, collaboration and group work.
3. The flipped classroom approach improved the students' self-confidence and collective knowledge generation.

On students' engagement in learning activities, the study found that the flipped classroom approach was more engaging, more motivating and students had enough time to practice science skills. This finding reflects the finding of Vergroesen, (2020) who found that student engagement increased in flipped classrooms for the reason that the strategy relegates lower-order learning activities to the student's own time, while making space for collaborative and higher-level learning during class time. Additionally, Bond (2020)'s researches review on flipped classroom found the approach to overwhelmingly support student engagement in at least one dimension.

The study also agreed with Asiksoy (2018) who reported a significant increase in motivation for the classroom and learning achievements, and concluded that the approach had positive effects on physics students' motivation. Furthermore, Campillo-Ferrer, and Miralles-Martínez, (2021) who studied student teachers' self-perceived motivation and learning reported students' positive evaluation of the teaching method in motivation and perception of learning. The participant agreed they felt motivated both intrinsically and extrinsically.

The finding on motivation also is in accord with the finding of Sookoo-Singh and Boisselle (2018) who indicated a positive and significant effect of the flipped classroom approach on students' motivation, and students' perception on the method was favorable. Sharma and Chowdhry (2021) saw an increase in the self-efficacy of students, and a promising increase in the self-confidence and positive attitude of the students. Murillo-Zamorano, Sánchez and Godoy-Caballero (2019) confirmed that the flipped classroom had positive effects on students' knowledge, skills, and engagement.

In order to maximize learning time, instructors can apply this valuable teaching strategy called the flipped classroom at any educational level. The study found that students using the flipped classroom approach had enough time to practice science skills. This finding corroborated the work of Talan and Gulsecen (2019) who found an increased class study time, together with other beneficial qualities such as student-centeredness, support of active learning, as well as the provision of a richer and more flexible learning environment.

The implication was that the use of flipped classroom approach in the study of chemistry is beneficial and enhances students' participation, motivation and collaboration.

4.5 What are the perceptions of students in the use of the flipped classroom?

Results from the analysis of the 20-item questionnaire that examined the perception of students on the flipped classroom were in three categories: perception about the video lessons, perception about their performance and their perception about collaborative learning. Table 18 presents results on the students' perception about the video lessons, whilst Tables 19 and 20 show respectively result on the average rate of how students watched the videos and percentage of the assigned videos for the term that they watched.

Results from Table 18 show that all the students agreed that taking note while watching the videos contributed positively to their learning. They tried the video problems before coming to class (90.6%), and this enabled them to ask and get answers to more difficult problems. This in effect enhanced their learning. They frequently repeated segments (94.3%) of the videos of interest to them, and this had increased understanding of the material or concept. The study therefore found that students used their leisure time (home environment of the flipped classroom) effectively to watch video materials posted to them.

Table 18: Students' Perception about the Video Lessons

Item	D	%	U	%	A	%
I feel that viewing the videos and taking notes while watching the videos contributed to my learning.	0	0.0	0	0.0	53	100
I feel that solving video problems contributed to my learning.	3	5.7	0	0.0	50	94.3
I tried to learn as much as possible while watching the videos.	1	1.9	2	3.8	50	94.3
I find it helpful to view videos and solve video problems before coming to class so that in class I can ask and get answers to more difficult problems.	3	5.7	2	3.8	48	90.6
I frequently pause or repeat segments of the videos in order to increase my understanding of the material.	1	1.9	2	3.8	50	94.3

Source: Field Data, 2022

A total of eight videos were provided for students to watch several times at their convenience in order for them to consolidate their understanding of the concepts.

Results from Table 19 shows that of the eight videos, only one student indicated watching less than 20% of it. As much as 62.2% of students watched between 20% to 80% of the videos, and 9.4% watched more that 80% of the videos (Table 19). Twenty six percent (26%) of the respondents did not answer this question, suggesting that they might not have had access to the videos and not watching them due to some constraints

(Table 19). The result implied that the majority of the students have watched the videos a good percentage of the videos. Also, a small percentage of the students did not watched the videos at home due to some of the constraints stated in the framework.

Table 19: Percentage of Videos Watched by Students

Percentage of Videos Watched	Number of Students	Percentage of Students
0-19	1	1.9
20-39	5	9.4
40-59	14	26.4
60-79	14	26.4
80-100	5	9.4
Missing	14	26.4

Source: Field Data, 2022

Teachers measure students' performance by their ability to solve problems in the content areas, as well as how they demonstrate the capacity and confidence to learn more. From Table 20, 98.1% of the students had positive perception that the flipped classroom approach contributed positively to their learning, and that solving problems in the class gave them a better focus on learning. A slight majority (60.4% believed that they will be able to learn elective chemistry using the flipped classroom strategy. However, when asked whether they preferred the flipped class format to the traditional lecture method, 37.7% agreed but 34.0% disagreed, that is, students were divided on their preference of the traditional and the flipped methods. However, it was observed that a good number of students (28.3%) did not respond to this item, suggesting that they were undecided.

Table 20: Students' Perception about the their Performance

Item	D	%	U	%	A	%
I feel that solving problems in the class contributed to my learning	0	0.0	1	1.9	52	98.1
Solving problems in class instead of outside class allows me to better focus on the assigned problem	13	24.5	7	13.2	33	62.3
I prefer the flipped classroom format to the traditional classroom format	18	34.0	15	28.3	20	37.7
I feel that I have sufficient knowledge of science at the beginning of the semester for taking this course	7	13.2	15	28.3	31	58.5
I believe that I am able to learn elective chemistry better with flipped classroom instruction than with traditional lecture instruction	13	24.5	3	5.7	32	60.4

Source: Field Data, 2022

Majority of the students (79.3%) perceived that they would get good results (grades A-B) in the end of semester examination (Table 21) The implication of this result students had positive perceptions about the flipped classroom approach to improve their exam scores.

Table 21: Students' Grade Expectations

Grade	Frequency	Percentage
A	31	58.5
B	11	20.8
C	3	5.7
D	3	5.7
E/F	1	1.9
Missing	4	7.5

Source: Field Data, 2022

The flipped classroom approach enhanced the students' collaborative learning. Results in Table 22 shows that students perceived that they received individualised attention from their instructor (88.7%), and wished their future chemistry tutors will use the flipped classroom approach (50.9%). Their perception was that the flipped classroom offered them greater opportunity for learning chemistry than the traditional classroom approach.

Almost all the students (94.3% perceived that they enjoyed working with other students, gave and received help from others and this increased their understanding of the concepts, so therefore the flipped classroom approach was especially appropriate for science learning. This implied that the students perceived positively that the flipped classroom learning approach enhanced their collaborative learning skills.

Table 22: Students' Perception about Collaborative Learning

Item	D	%	U	%	A	%
I liked being able to speak with my instructor during class and receive individual help when solving problems	2	3.8	4	7.5	47	88.7
I would like my future chemistry instructors to teach using a flipped classroom approach	9	17.0	17	32.1	27	50.9I
I have previously taken elective chemistry at Senior High School and had already been exposed to most of the chemistry taught in the course	9	17.0	6	11.3	38	71.7I
feel the flipped classroom offers me opportunity to learn elective chemistry than the traditional in-class lecture with out of class problem solving.	13	24.5	6	11.3	34	64.2
Giving and receiving help with other students in my group increased my learning	0	0.0	1	1.9	52	98.1
The flipped classroom is an instructional method especially appropriate to science	5	9.4	8	15.2	40	75.4
I enjoy being able to work with other students in the classroom	0	0.0	3	5.7	50	94.3

Source: Field Data, 2022

Findings:

- Students used their leisure time (home environment of the flipped classroom) effectively to watch video materials posted to them.
- Majority of the students have watched the videos a good number of times.
- A small percentage of the students did not watched the videos at home due to some of the constraints stated in the framework.
- The students had positive perception that the flipped classroom approach contributed positively to their learning.
- Students were divided on their preference of the traditional and the flipped methods.
- Students had positive perceptions about the flipped classroom approach to improve their exam scores.
- Students perceived that the flipped classroom offered them greater opportunity for learning chemistry than the traditional classroom approach.
- The students perceived positively that the flipped classroom learning approach enhanced their collaborative learning skills.

This current study again found out that the students had positive perceptions about the influence of the flipped classroom on their learning of chemistry. They believed that their experience of the flipped classroom would enhance the end of semester results. The flipped classroom gave them greater opportunities for learning and lessons became clearer. Their perception about collaboration was positive. This finding compared favourably with Aljaraideh's (2019) research that showed that students' perceptions of flipped classroom in Jordanian private universities were high and therefore recommended the use of flipped learning technique in high institutions.

The findings are in line with the findings of Cho, Zhao, Lee, Runche and Krousgrill (2021), that students' in the flipped classroom felt the method was useful. The students favoured the approach and performed better. Their research showed that students benefited from the flipped classroom learning method, and hence prepared themselves for the semester's course. These researches confirmed the speculations of Shin and Thai (2017) that the approach may enhance students' learning effectiveness, interest, motivation, and may encourage diverse development and teamwork as well.

The researcher, therefore, concluded that this emerging teaching and learning approach is perceived favourably by students in this study hence is appropriate for use as an effective teaching and learning strategy to enhance understanding of chemistry concepts such as kinetic molecular theory.

Flipped Classroom is an approach of learning that integrates technology with learning process and this integration facilitates concept acquisition at the various cognitive levels. This study found that social media is a potent factor in the learning of chemistry concepts. The students agreed that employment of technology that enabled them to access the online resources was very helpful. Technology makes pre-class materials usually available, such that students can make quick reviews of those resources to better prepare for tests, quizzes and exams. Schools that do capture lectures make those materials valuable study guides that students can rely on. Apart from the freedom to learn at the students' time of convenience, integrating technology into their classrooms also enhances the information technology skills of instructors and students (Aidoo, Macdonald, Vesterinen, Pétursdóttir & Gísladóttir, 2022).

Even though the flipped classroom projects many benefits to the learner, the study found that many of the students still prefer the teacher-facilitated approach to teaching. This might be due to the students' lack of confidence in themselves, lack of clarity in some of the video lessons or absence of internet facilities to access the online lessons.

The researcher concludes this section by stating that students who enrolled in colleges of education in the study area to do elective chemistry do not have complete understanding of some of the basic chemistry concepts, let alone reason at higher cognitive levels. However, the use of creative teaching approaches, such as the flipped classroom approach has the potential of enhancing students' performance in the concepts and improving their reasoning at higher cognitive levels.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

The study revealed that most students have partial or complete lack of understanding, application, synthesis and analysis of some basic concepts of the kinetic molecular theory of matter. Further analysis revealed that most of the difficulties of the students are at the higher cognitive levels of learning; that is, at the application, analysis and synthesis levels.

Some of the concepts that learners could not show complete understanding of in the pre-test included reasons why temperature remains constant during inter-convention of states of matter; the diffusion rates of liquids of different densities; the kinetic theory that explains boiling, as well as the concepts of melting and condensation. The others were interpretation of temperature versus time graph of the change of state of water, solvation of solid ionic compounds in water, and interpretation of the gas laws.

Some areas where the students showed partial understanding of concepts were:

i. identification of the forces of attraction between different states of matter
ii. the usefulness of knowing the boiling points and melting points of substances
iii. heats of fusion and vaporization, as well as
iv. rigidity, compressibility, fluidity, kinetic energy and density of solid, gas and liquid states of matter.

After implementing the flipped classroom intervention, it emerged that students' understanding, application of concepts, analysis of concepts and synthesis of concepts improved significantly. In addition, students' engagement in the flipped classroom activities improved. They also participated collaboratively in solving problems in the classroom. Furthermore, they shared positive perceptions about the flipped classroom teaching approach.

5.2 Summary of Findings

The following were key findings of the study.

1. Students demonstrated poor understanding of concepts in kinetic molecular theory when the concepts were operationalized.
2. Students demonstrated poor application of many concepts in the kinetic molecular theory.
3. Students showed poor analysis of concepts in the kinetic molecular theory.
4. Students were unable to synthesise scientific concepts in the kinetic molecular theory.
5. The entry behavior (pre-existing knowledge) of students in the kinetic molecular theory of matter with reference to the four levels of Bloom's taxonomy was generally poor.
6. The flipped classroom approach improved students' collaborative work, motivation, interest and performance in the concepts of kinetic molecular theory taught.
7. The flipped classroom strategy had a large effect on the students' performance in the study of kinetic molecular theory.
8. A few of the students had constraints that prevented them from watching the videos at home.
9. The flipped classroom strategy enhanced their engagement, collaboration and group work.
10. The flipped classroom approach improved the students' self-confidence and collective knowledge generation.

11. Students used their leisure time (home environment of the flipped classroom) effectively to watch video materials posted to them.
12. Majority of the students have watched the videos a good number of times.
13. The students had positive perception that the flipped classroom approach contributed positively to their learning.
14. Students were divided on their preference of the traditional and the flipped methods.
15. Students had positive perceptions about the flipped classroom approach to improve their exam scores.
16. Students perceived that the flipped classroom offered them greater opportunity for learning chemistry than the traditional classroom approach.
17. The students perceived positively that the flipped classroom learning approach enhanced their collaborative learning skills.

These findings proved that the flipped classroom teaching strategy adopted by the researcher had a large positive effect on students' engagement, performance and collaborative efforts in the study of kinetic molecular theory.

5.3 Conclusions

The present study examined the pre-existing knowledge of pre-service teachers in their first year teacher education programme on kinetic molecular theory of matter. The analysis of students' existing knowledge on the concept in terms of understanding, application of the concept, analysis of situations using the concept and synthesis in the concept showed low levels in the domains. The students however showed appreciable knowledge in the areas of temperature and reaction rates of matter related to kinetic molecular theory.

The study implemented flipped classroom learning approach as a teaching strategy to see if it would have a positive effect on the students' understanding, application and analysis of concepts and synthesis of concepts in kinetic molecular theory. The performance of the students after four weeks of intervention showed a significant improvement in their performance at all the four levels of the cognitive domain. There was a large positive effect on their performance, engagement and collaborative work. The results of the study lent credence to research that the emerging teaching approach improves the performance of students.

On student engagement and perception about the flipped classroom, the study found that the students were actively engaged in active learning, and studied collaboratively. They also had positive perceptions about the learning approach and hoped for improved performance at the end of semester exams in Chemistry.

The results indicated clearly that the flipped classroom approach influenced the students learning positively, and widened their scope of learning Chemistry. The strategy also provided an alternative approach to learner-led learning technique, creating a richer learning environment and empowering the learners to learn the fundamentals of the Chemistry concepts before class. The approach empowered the learners to become active learners and improved their information and communication technology skills.

The learning approach also made the researcher more prolific in using technology to plan and deliver lessons asynchronously. It made teaching flexible, so that the researcher acted as a co-learner, facilitator and a guide instead as a "sage on the stage".

5.4 Implication for Teaching and Learning of Chemistry

Flipped classroom is gaining ground as a useful teaching approach that can assist learners to understand abstract chemistry concepts. Application of the flipped classroom learning may not be too challenging to students in colleges of education since most of them have access to technological gadgets like android phones and laptops and freely use them to access information during and after instructional hours. With the introduction of this method into instruction in colleges of education, the teaching and learning of science, especially Chemistry, as well as other science related subjects will become meaningful and interesting, and students will be able to reason at higher cognitive levels and apply chemistry concepts in dealing with everyday life problems related to chemistry.

5.5 Contribution of the Study to Science Education

The inception of the internet and information and communication technologies in today's society have resulted in many changes in which the digital channel is one of the powerful information dissemination and consumption means for young students in tertiary institutions such as colleges of education. Reflecting on the challenges in the pre-existing knowledge of the students in this study in the concept of kinetic molecular theory, the use of creative teaching strategies and methods such as flipped classroom learning approach will bring a novel alternative for learners to receive instructional contents that are abstract in nature like the kinetic molecular theory.

Depending on the creativity of the teacher, the flipped classroom methodology can effectively promote instruction from different knowledge disciplines at the tertiary level, through various ways such as video-tutorials, animated videos and training modules in audio forms. The persistent traditional approach to teaching science (listening, looking, instructor fed, and difficult aspects as homework) which have contributed to students' dislike for Chemistry will be a thing of the past.

5.6 Recommendations

Based on the findings of this study, the researcher made the following recommendations to enhance the teaching and learning of Chemistry in Kibi College of Education:

In the first place, teachers should use the various forms of the flipped classroom teaching approach to enhance students' performance in Chemistry and their thinking abilities at higher cognitive levels.

Secondly, tutors at Kibi College of Education should plan and design flipped classroom activities to lessen their instructional burden and place the learner at the center of learning in order for them to generate knowledge on their own.

In the planning and implementation of the flipped classroom instructions tutors in Kibi College of Education must place more emphasis on students reasoning and performance at higher cognitive levels.

5.7 Suggestion for Further Research

The flipped classroom approach is a promising teaching and learning strategy. For further study on flipped classroom, the researcher recommends that studies should be made into how students can apply the flipped classroom approach in group presentations or individual presentations of assignments. Chemistry tutors can also research into how pre-service teachers can design and implement the flipped classroom teaching approach lessons at the lower level classes (basic school) where the use of mobile phones is not allowed.

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APPENDICES

APPENDIX A

Kinetic Molecular Theory Diagnostic Test (KMTDT)

Conceptual category 1: Understanding

1. With the aid of a table, state the differences between evaporation and boiling.

2. Which one of the following substances has the highest force of attraction?

(a) Water

(b) NaCl (solid)

(c) ice (solid)

(d) wax (solid)

The reason for my answer is

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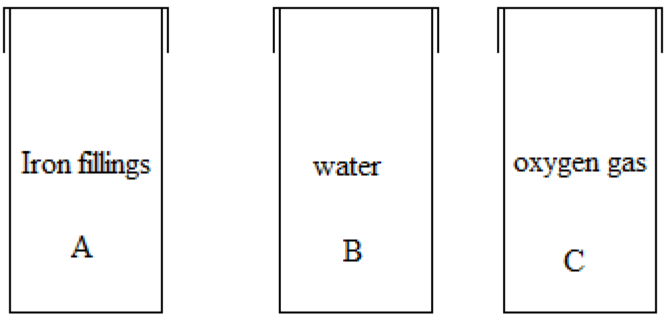
……………………………………………………………………………………………….

……………………………………………………………………………………………….

3. Which of the substances below will exert more pressure on the walls of the containing vessel?



A. A

B. B

C. C

The reason for my answer is

…………………………………………………………………………………………

……….. ……………………………………………………………………………

………………………………………………………………………………………

4. Explain why temperature remains constant during interconversion of states of matter.

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5. Which one of the following statements is **not consistent** with the kinetic-molecular theory of gases?

   A. Individual gas molecules are relatively far apart.

   B. The actual volume of the gas molecules themselves is very small compared to the volume occupied by the gas at ordinary temperatures and pressures.

   C. The average kinetic energies of different gases are different at the same temperature.

   D. There is no net gain or loss of the total kinetic (translational) energy in collisions between gas molecules.

   E. The theory explains most of the observed behaviour of gases at ordinary temperatures and pressures.

Give reason for your answer

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APPENDIX B

Kinetic Molecular Theory Diagnostic Test (KMTDT)

Conceptual category 2: Application

1. Two moles of nitrogen gas are kept in a glass container. The temperature of the gas is 400K.

   What is the kinetic energy of the gas? R=8.314J/mol∗K

   A. 4.99kJ,

   B. 16.4kJ,

   C. 49.2J,

   D. 98.4J,

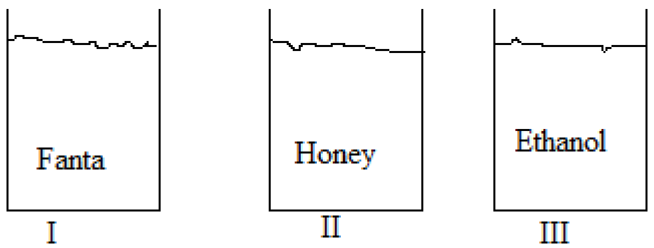
   E. 9.98kJ

2. Give two ways in which melting points and boiling points can be useful.

   (i)……………………………………………………………………………………

   (ii)……………………………………………………………………………………

3. Which of the substances below will have the lowest rate of diffusion in water?



   A. I

   B. II

   C. III

   D. I and III

The reason for my answer is ………………………………………………………….………………

4. Why does a higher temperature result in a faster reaction?

   A. It increases the pressure of the reactants

   B. It increases the surface area for reactions

   C. It lowers the activation energy for a reaction

   D. It increases the number of effective molecular collisions

   E. It helps orient reactants into the correct position to react

5. A sample of oxygen occupies 47.2 liters under a pressure of 1240 torr at 25°C. What volume would it occupy at 25°C if the pressure is decreased to 730 torr?

APPENDIX C

Kinetic Molecular Theory Diagnostic Test (KMTDT)

Conceptual category 3: Analysis

1. Explain the following terms as applied in the kinetic theory

   A. Boiling

   B. Melting

   C. Condensation

2. A student heated ice in a beaker with a thermometer suspended in it. Below is the record of her observations:

Time (mins)	0	1	2	3	4	5	6	7	8	10	15	20	25	30	35
Temp. °C	-3	-1	0	0	5	8	12	15	19	22	30	50	73	100	100

Based on the above observations, answer the following questions:

(a) What change(s) are observed between 2-3 min. and what is the process involved? …..………………………………………………………………………..…

(b) The temperature remains constant between 30-35 min. what reason accounts for this? ……………………………………………………………………………...

(c) Describe the heat involved in the process.

…………………………………………………………………………………

……………………………………………………………………….…...

3. When 50 g of sugar is dissolved in 100 mL of water, there is no increase in volume. What characteristic of matter is illustrated by this observation?

4. (a) Enumerate two conditions under which gases can be liquefied.

   (i)…………………………………………………………………….……..

   (ii)………………………………………….………………………………

   (b) In which form is LPG filled in gas cylinder?

   ……………………………………………………………………………….

   ………………………………………………………………………………..

APPENDIX D

Kinetic Molecular Theory Diagnostic Test (KMTDT)

Conceptual Category 4: Synthesis

1. Comment on the characteristics of the states of matter in the table below

	Gas	Liquid	Solid
Rigidity			
Compressibility			
Fluidity			
Kinetic energy			
Density			

2. The kinetic energy of particles of water in three containers labeled U, V and W are U_E, V_E and W_E respectively and $U_E > V_E > W_E$. Arrange the temperatures, U_T, V_T and W_T of water in the three containers in increasing order.

Explain your answer ……………………………………………………………………

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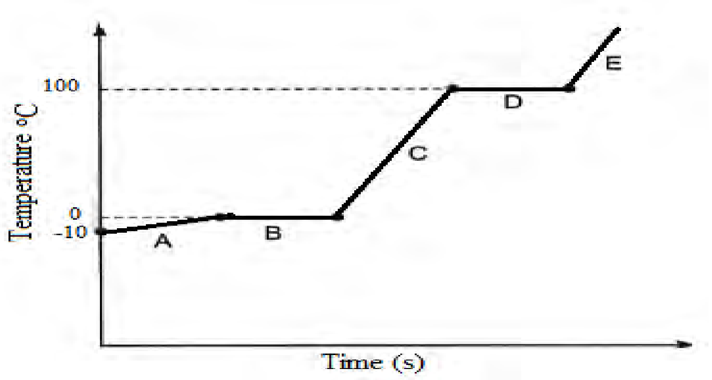
3. Study the temperature versus time graph of water given below.



(i) Fill the table by identifying the region of activity.

Activity	**Region**
Liquid only	
Mixture of ice and water	
Heat of vaporization present	
Mixture of vapour and liquid	
Ice only	

(ii) Why does the temperature of a substance remains constant during its melting point or boiling point?

4. On the basis of molecular kinetic theory explain why, ammonium chloride sublimes. ,……………………………………………………………………………………

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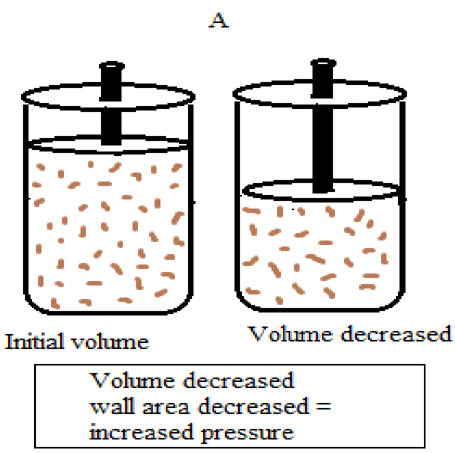
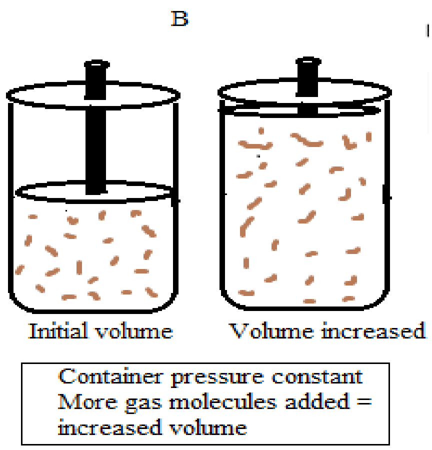
5. Explain the gas laws being shown in the diagrams A and B





A……………………………………………………………………………………………

B……………………………………………………………………………………………..

APPENDIX E

ANSWER TO TEST ITEMS

Kinetic Molecular Theory Diagnostic Test (KMTDT)

1. In a tabular form state how evaporation differ from boiling.

Boiling	Evaporation
1. Occurs rapidly	Occurs slowly
2. Occurs throughout the liquid	Occurs only on the surface of the liquid
3. Produces bubbles	Does not produce bubbles
4. Does not result in cooling	Leads to cooling
5. Occurs when the temperature is greater than the boiling point	Occurs at any temperature

Any 3 x 1 = **(3 marks)**

2. Which one of the following substances has the highest force of attraction?

(a) Water

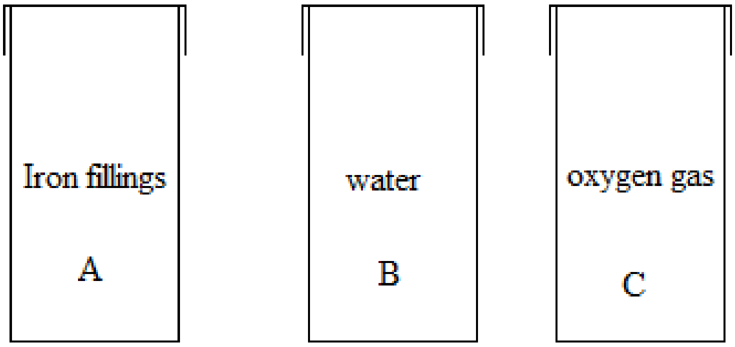
(b) NaCl (solid) **(1 mark)**

(c) ice (solid)

(d) wax (solid)

The reason for my answer is: **there is electrostatic force of attraction holding the atoms of NaCl. The others have covalent bond holding the atoms.** **(1 mark)**

3. Which of the substances below will exert more pressure on the walls of the container?



A. A

B. B

C. C **(1 mark)**

The reason for my answer is: **the gas molecules move freely, bouncing of the walls of the container hence exerting more pressure.** **(1 mark)**

4. Explain why temperature remains constant during inter-conversion of states of matter.

   Heat supplied to the substance helps in breaking the crystal lattice of solids or bonds in liquids. **(1 mark)**

5. Two moles of nitrogen gas are kept in a glass container. The temperature of the gas is 400K.

What is the kinetic energy of the gas? $R = 8.314 J/mol*K$

A. 4.99kJ,

B. 16.4kJ,

C. 98.4J,

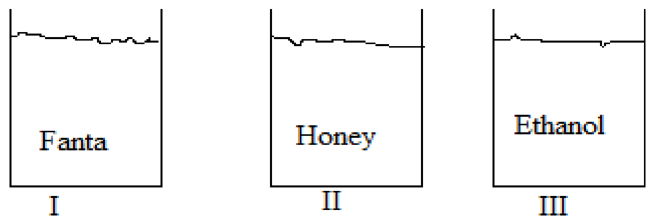
D. **9.98kJ** **(1 mark)**

6. Give two ways in which melting points and boiling points can be useful.

   (i) **For identification of the substance** **(1 mark)**

   (ii) **For checking the purity of the substance (1 mark)**

7. Which of the substances below will have the lowest rate of diffusion in water?



   A. I **(1 mark)**

   B. II

   C. III

8. The reason for my answer is: **rate of diffusion in water is dependent on the density of the substance. Honey is denser than the others.** **(1 mark)**

9. Why does a higher temperature result in a faster reaction?

   A. It increases the pressure of the reactants

   B. It lowers the activation energy for a reaction

   C. It increases the number of effective molecular collisions

   D. It helps orient reactants into the correct position to react **(1 mark)**

10. A sample of oxygen occupies 47.2 liters under a pressure of 1240 torr at 25°C.

What volume would it occupy at 25°C if the pressure is decreased to 730 torr?

$V_1P_1 = V_2P_2$

$V_2 = V_1P_1/P_2$

1240* 17.2 / 730

= 80.174 L **(3 marks)**

11. Explain the following terms on the basis of the kinetic theory

A. Boiling: **rapid vaporization of a liquid as a result of the vapour pressure of the liquid equaling atmospheric pressure.**

B. Melting: **phase transition of a substance from solid to liquid as a result of increase in the internal energy of the solid.**

C. Condensation: **change of state of mater from the gas phase to liquid phase as a result of decrease in temperature.** **(1 mark each)**

Conceptual category 3: Analysis

12. A student heated ice in a beaker with a thermometer suspended in it. Below is the record of her observations:

Time (mins)	0	1	2	3	4	5	6	7	8	10	15	20	25	30	35
Temp. °C	-3	-1	0	0	5	8	12	15	19	22	30	50	73	100	100

Based on the above observations, answer the following questions:

(a) What change(s) are observed between 2-3 min. and what is the process involved?

Between 2-3 minutes ice converts to water. The process is fusion. 2 marks

(b) The temperature remains constant between 30-35 min. what reason accounts for this?

The temperature remains the same because heat supplied is used to convert liquid to vapour. 2 marks

D. Name and define the heat involved in the process

Latent heat of vaporization: the heat required to change on mole of a liquid at its boiling point under standard atmospheric pressure. **2 marks**

13. When 50 g of sugar is dissolved in 100 mL of water, there is no increase in volume. What characteristic of matter is illustrated by this observation?

Water particles are loosely packed and the sugar molecules fit into the spaces between the water particles 2 marks

14. (a) Give two conditions under which gases can be liquefied.

(i) low temperature 1 mark

(ii) high pressure 1 mark

(b) In which form LPG is filled in gas cylinder?

Liquid form – (under pressure) 1 mark

15. Comment on the characteristics of the states of matter in the table below

	Gas	Liquid	Solid
Rigidity	**Rigidity absent**	**Flows; not rigid**	**rigid**
Compressibility	**Highly compressible**	**Less compressible**	**Highly incompressible**
Fluidity	**Highly fluid**	**Fluid**	**Not fluid**
Kinetic energy	**High**	**Moderate**	**Low**
Density	**Low**	**High**	**High**

½ mark each = 7½

Conceptual category 4: Synthesis

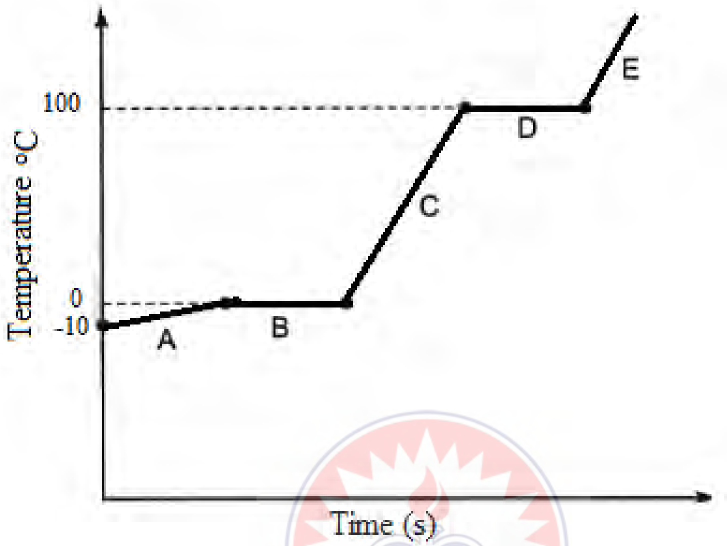
16. Kinetic energy of particles of water in three containers U, V and W are U_E, V_E and W_E respectively and $U_E > V_E > W_E$. Arrange the temperatures, U_T, V_T and W_T of water in the three vessels in increasing order.

$W_T < V_T < U_T$ 1 mark

Explain your answer

Kinetic energy is temperature dependent: the higher the temperature, the greater the kinetic energy **2 marks**

17. Study the temperature versus time graph of water given below.



½ mark each = 2½

(i) Fill the table by identifying the region of activity.

Activity	**Region**
Liquid only	**C**
Mixture of ice and water	**B**
Heat of vaporization present	**E**
Mixture of vapour and liquid	**D**
Ice only	**A**

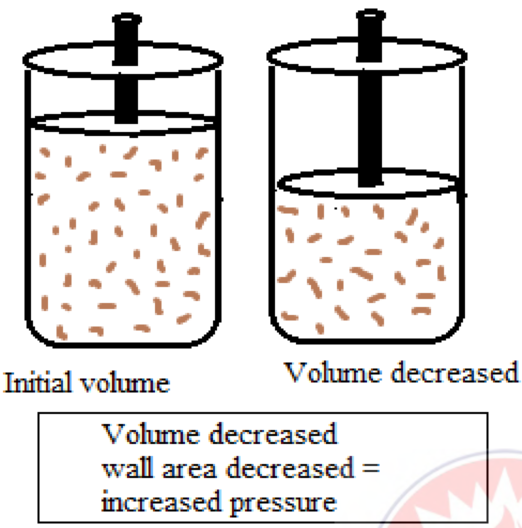
(ii) Why does the temperature of a substance remain constant during its melting point or boiling point?

1mark

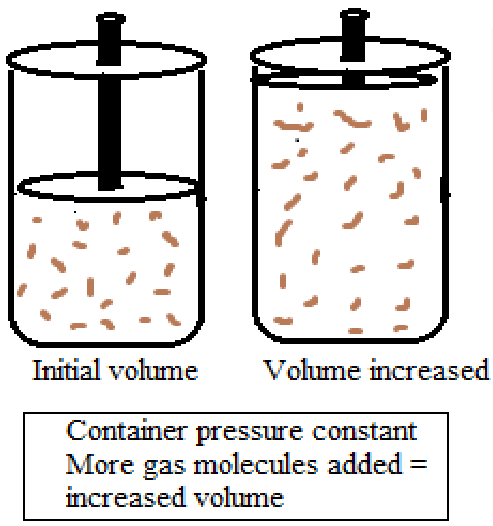
18. On the basis of kinetic theory explain why, ammonium chloride sublimes.

The forces holding the molecules are weak; the heat absorbed is enough to break the bonds into gaseous state **2 marks**

A



B



19. State the gas laws being shown in the diagrams A and B

A Boyle's Law **1 mark**

B Charles's Law **1 mark**

APPENDIX F

CLASSROOM OBSERVATION CHECKLIST

Instruction observed…………………………………………… Date …………………

Course Title ………………………………………………………………………………

Topic …………………………………………………………………………...………

Semester ………………… Credit Hr ………………. No. of Students ……..…………

Observer ………………………………………………………………………………..

Purpose: The purpose of this observation is to:

- Monitor the engagement of students in activities the flipped classroom during the lesson on changes of states of matter.
- Provide data for the improvement of teaching.

IN –CLASS ACTIVITIES				
	Whole Class	**40 – 59**	**21 – 39**	**1 – 19**
Some students present in class before instructional time				
Some students seen watching videos individually or in groups				
Some students seen discussing the video lessons				
Number of students present during instructional period				
INSTRUCTIONAL TIME ENGAGEMENT				
	Very Active	**Active**	**Somehow Active**	**Not Active**
Students willingly share information gained from the videos observed				
Students wrote down questions and asked for further explanation				
Students worked on assigned group tasks				

Students seen collaborating to solve problems based on the lesson				
STUDENTS' PARTICIPATION IN GROUP PRESENTATIONS				
	Very Well	**Well**	**Somehow Well**	**Not well**
Group tasks were solved				
Individuals were able to work independently after group discussion				
GRADING OF INTERACTION				
	Very High	**High**	**Low**	**Very low**
Level of interest				
Level of motivation				
Level of collaboration				
Level of individual performance				
Overall impression				
Reflection				

APPENDIX G

Assessment for Lesson 1

Question: *Write five things you have learnt today about kinetic molecular theory*.

Some answers provided:

- *Molecules of gases are very small and the distance between the molecules are large*
- *Molecules are moving continuously.*
- *Molecules collide with each other and the walls of the container.*
- *The motion of molecules depend on the temperature of the system.*
- *Matter is made up of small particles.*
- *Liquids and solids are formed when the temperature of the molecules drop.*
- *Pressure in gas depends on the rate of collision of the molecules.*

Assessment for Lesson 2

Solve the following problems on the gas laws:

1. The vapor pressure of water at 25 degrees Celsius is 22.8mmHg. If three moles of a nonvolatile solute adds to twelve moles of water, what is the new vapor pressure of the solution?
2. Calculate the vapor pressure of a mixture containing 252g of n-pentane (Mw = 72) and 1400 g of n-eptane (Mw = 100) at 20ºC. The vapor pressure of n-pentane and n-eptane are 420 mm Hg and 36 mm Hg respectively
3. What is the vapor pressure of an aqueous solution that has a solute mole fraction of 0.1000? The vapor pressure of water is 25.756 mmHg at 25 °C.

Solutions:

Question 1

Raoult's Law $P_{solution} = (\chi_{solvent})\ (P_{solvent})$

χ = the mole fraction of the water

P = is the original vapor pressure of the water.

By adding 3 moles of solute were added, value of solution is 15 moles.

$$P_{solution} = \left(\frac{12\text{moles water}}{15\text{moles of water}}\ x\ 22.8\right)$$

$P_{solution}$ =18.2mmHg

Explanation:

*The solute is not volatile, so will not have an additive vapour pressure, however, it will lower the vapour pressure because it takes up surface s*pace in the solution. We used Raoult's law to determine the new vapour pressure of the solution

Question 2

P = vapour pressure of component of mixture

P_1 = vapour pressure of the pure component

χ = mole fraction of components

Raoult''s law : $P = P_1\ \chi$

Mole of n-pentane = mass / molar mass

252g / 72 = 3.4 moles

Mole of n-eptane = mass / molar mass

1400g / 100 = 14 moles

Total no. of moles = 3.5 + 14 = 17.5 moles

Calculate mole fraction of components

$\chi_{\text{n-pentane}}$ = 3.5 / 17.5 = 0.2

$\chi_{\text{n-eptane}}$ = 14 / 17.5 = 0.8

Calculate partial pressures of components

$P_{\text{n-pentane}} = 0.2 \times 420 = 84$ mmHg

$P_{\text{n-eptane}} = 0.8 \times 36 = 28.8$ mmHg

Calculate total pressure

Total $P_{mixture} = 84 + 28.8 = 112.8$ mmHg

Therefore, the vapour pressure of mixture is 112.8 mm Hg.

Question 3

Mole fraction of solute = 0.1000

Mole fraction (χ) of solvent = 1.000 – 0.1000 = 0.9000

Pressure (P) of water = 25.756 mmHg

Raoult's Law $P_{solution} = (\chi_{solvent})(P_{solvent})$

Substitute $P_{solution} = (0.900)(25.756)$

$P_{solution} = 23.18$ mmHg

The answer is reasonable because since the solution contain solute, the solute lowered the vapour pressure.

Assessment for Lesson 3

Raoult's law: *Solvent's partial vapour pressure in a solution is equal or the same as the vapour pressure of the pure solvent multiplied by its mole fraction in the solution.*

To determine vapour pressure exhibited by all solids and liquids. This depends only on the sort of liquid and temperature.

- *To determine the fraction of molecules on the surface of a liquid having sufficient energy to escape to the vapour phase.*
- *To determine the partial vapour pressure of a mixture of liquids.*

- *The partial pressure of a mixture of liquids is given by Raoult's law and depends on the concentration of each component in the liquid phase.*

Some limitations of Raoult's law given by students were:

- *Raoult's law is only good at describing ideal solutions: solutions in which the gas phase exhibits thermodynamic properties similar to those of a mixture of ideal gases, and this is rare.*
- *A mixture of different gases do not have the same uniformity in terms of attractive forces, so their solutions tend to deviate away Raoult's law.*

Assessment for lesson 4

Difference between Crystalline and Amorphous

CRYSTALLINE SOLIDS	AMORPHOUS SOLIDS
Atoms are arranged in regular dimension	*They do not have regular arrangement*
Sharp melting point	*No particular melting point*
Anisotropic	*Isotropic*
True solid	*Pseudo solid*
Symmetrical	*Unsymmetrical*
More rigid	*Less rigid*
Long range order	*Short range order*
Example: Potassium nitrate, copper	*Example: Cellophane, polyvinyl chloride*

APPENDIX H

PERCEPTION QUESTIONNAIRE

Dear Student,

Thank you for being part of Kibi Presbyterian College of Education. I would like you to take this 10 minutes short survey on your opinion about the flipped classroom learning technique we used this semester. There are items on your perception about the method. I hope you will respond with honest feedback as the responses will lead to improvement on the strategy. I assure you that any information provided will be treated with outmost confidentiality.

PART 1: BIODATA

1. Programmememe [ ] Maths & ICT [ ] Maths & Science [ ] ICT & Science
2. Gender [ ] Female [ ] Male
3. Age: [ ] 16 – 19 [ ] 20 – 24 [ ] 25 – 29 [ ] 30 and above

PART 2: PERCEPTION

For each item, except items 9, 9, and 20, indicated your level of agreement with the statement by ticking one of the following responses **Strongly Disagree** (SD); **Disagree** (D); **Undecided** (U) **Agree** (A); **Strongly Agree** (SA)

For items 9, 19 and 20, tick the option that corresponds to your activity with the flipped classroom.

SN	ITEM	SD	D	N	A	SA
1	I feel that viewing videos, and taking notes while watching the videos contributes to my learning.					
2	I feel that solving video problems contributes to my learning					

3	I feel that solving problems in class contributes to my learning.					
4	I try to learn as much as possible while viewing the videos.					
5	. I find it helpful to view videos and solve video problems before coming to class, so that in class I can ask and get answers to more difficult questions.					
6	Solving problems in class instead of outside class allows me to better focus on the assigned problems.					
7	I prefer the flipped classroom format to the traditional lecture format.					
8	I feel that I had sufficient knowledge of science at the beginning of the semester for taking this course					
9	On average, I've watched about _____ of each assigned video at least once.	0%-19%	20%-39%	40%-59%	60%-79%	80%-100%
10	I believe that I am able to learn elective chemistry better with flipped classroom instruction than with traditional lecture-based instruction	SA	D	N	A	SA
11	I like being able to speak with my instructor during class and receive individual help when solving problems.					
12	I would like my future chemistry instructors to teach using a flipped classroom approach.					
13	I have previously taken Elective Chemistry at Senior High School and had already been exposed to most of the chemistry taught in the course prior to the first day of class.					
14	I frequently pause or repeat segments of the videos in order to increase my understanding					

	of the material.					
15	I feel the flipped classroom offers me greater opportunity to learn elective chemistry than the traditional in-class lecture with outside-class problem solving					
16	Giving and receiving help with other students in my group increased my learning.					
17	The flipped classroom is an instructional method especially appropriate for science.					
18	I enjoy being able to work with other students in the classroom					
19	I've watched approximately _____ of the videos that have been assigned this semester	0%-19%	20%-39%	40%-59%	60%-79%	80%-100%
20	At the end of the semester, I expect to receive a grade of _____.	A	B	C	D	F or E

APPENDIX I

T-TEST OUTPUT

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper			
Pair 1	pretest scores - post test scores	-11.986	8.511	1.003	-13.986	-9.986	-11.950	71	.000

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	pretest scores	19.01	72	5.466	.644
	post test scores	31.00	72	6.483	.764

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	pretest scores & post test scores	72	-.008	.950

Paired Samples Effect Sizes

			Standardizer[a]	Point Estimate	95% Confidence Interval Lower	95% Confidence Interval Upper
Pair 1	pretest scores - post test scores	Cohen's d	8.511	-1.408	-1.733	-1.079
		Hedges' correction	8.556	-1.401	-1.723	-1.073

a. The denominator used in estimating the effect sizes.
Cohen's d uses the sample standard deviation of the mean difference.
Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.