UNIVERSITY OF EDUCATION, WINNEBA

EFFECTS OF ICT-BASED INTERVENTION ON CONCEPTUAL UNDERSTANDING AND PERFORMANCE OF STUDENT-TEACHERS IN SELECTED CONCEPTS IN PHYSICS

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DECLARATION

Student's Declaration

I, COSMOS EMINAH, hereby declare that this dissertation, with the exception of quotations and references contained in published works have all, to the best of my knowledge, been identified and acknowledged, is entirely my own original work, and that it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: …………………………………

Date: ………………………………………..

Supervisors' Declaration

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

Name: Prof. Victor Antwi (Principal Supervisor)

Signature: …………………………………

Date: ………………………………………..

Name: Prof. Kodjo Donkor Taale (Co-Supervisor)

Signature: …………………………………

Date: ………………………………………..

DEDICATION

This work is dedicated to my father, Prof John Eminah, my wife Angela Eminah, and my children Davidson, Melissa and Michelle.

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TABLE OF CONTENTS

Content **Page**

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The study is an action research that focused on the application of the technology Acceptance Model to identify and improve student teachers' conceptual understanding in some selected concepts in physics (Matter, Forces and Energy) within the new four-year Basic Education Curriculum for Colleges of Education. Further, it sought to improve the performance of student teachers in the selected concepts and also to improve their attitude and intent to use ICT in science delivery in their future classrooms. The study was conducted in the Department of Basic Education, University of Education, Winneba. The sample consisted of 90 student teachers from one intact class. Tools used in data gathering consisted of a two-tier questionnaire (for determining conceptual understanding of student teachers). The main instruments for data gathering were tests (pre-test and post-test) on the three concepts of interest, a questionnaire for identifying student-teachers' level of conceptual understanding, another questionnaire on student teachers views, attitudes and intent on usage of ICT in science teaching as well as an interview guide . Five research questions were formulated for the study. Findings of the study reveal that student teachers held misconceptions in each of these science concepts in the four-year teacher education curriculum. After the intervention, the conceptual understanding of student teachers in each of the three concepts improved. It was also revealed that there were statistically significant differences ($P< 0.05$) in the performance of student teachers before and after the intervention. However, gender was not seen to be a contributing factor to student teachers' performance in the concepts. The key recommendation made was the integral use of ICT in the daily teaching and learning of science by science lecturers and tutors in the University of Education, Winneba and Colleges of Education. It was also suggested that Universities and Colleges of Education should equip science student-teachers with knowledge and skills on how to access and operate ICT resources and services such as computers, projectors and internet connectivity to promote the effective usage of these resources in science teaching and learning at the basic level of education.

CHAPTER ONE

INTRODUCTION

1.0 Overview

The introductory chapter of the study focuses on the role of ICT in science education, conceptual understanding of teachers in selected concepts in physics as well the trends in students' performance in science at different levels. Currently, ICT plays a key role in educational delivery. The above assertion and other related matters are discussed in the background of the study. The next sub-heading discussed is the statement of the problem which highlights the problem of low usage of ICT in science teaching and learning as well as students' consistent under-performance in science over the years. Further on, the chapter elaborates on the purpose of the study and goes on to state the objectives of the study and the research questions. The significance of the study to stakeholders in education such as the Ministry of Education (MoE), Ghana Education Service (GES), School-Management Teams, Directors of Education and Heads of Institutions, is also discussed under this chapter. The delimitations and limitations of the study are also outlined. Finally, the chapter ends with the definitions of terms and abbreviations.

1.1 Background to the Study

Scientific literacy is important for individuals to make informed decisions and rational judgments about issues of public interest, for example, environmental degradation, waste disposal, environment protection, energy conservation and food (Hoy, 2018). The application of scientific principles has resulted in technological advancements that have improved the living standards of people (Anaeto et al., 2016). Science, Mathematics and Technological literacy at all levels, probably hold the key and potential of Ghana being able to catch-up with the developed world in terms of technological advancement and also improvement in the overall standards of living of all Ghanaian citizens. For this reason, successive governments have put in place several measures aimed at boosting the teaching and learning of science and also the training of science teachers. Despite the various interventions put in place by government to promote Science education, Ghana as a nation continues to face challenges in its bid to embark on an industrialisation drive (Fenny, 2017).

Unfortunately, Science appears to be one of the academic subjects students dislike most (Anwer et al., 2012). Currently, the performance of most Ghanaian Junior High School (JHS) students in science is not encouraging as noted in the West African Examinations Council (WAEC) Chief Examiner's Report (2018). At the Senior High School (SHS) level, the situation is not better as a significant proportion of candidates continue to perform below expectations in the Integrated Science examination results (WAEC, 2020). This trend of poor performance continues at the tertiary level where student teachers pursuing further studies in Diploma or Bachelor of Education Studies in Science have been identified to be exhibiting low proficiency in fundamental science concepts (Dorsah et al., 2020).

At the international level, Ghana's performance in the 'Trends in International Mathematics and Science Study' (TIMSS)' has been abysmal. Ghana placed 45th out of 46 participating nations in the 2003 TIMSS. In 2007, the nation placed 46th out of 47 countries which took part in the TIMSS. In more recent times, Ghana placed last out of 76 countries that partook in the biggest ever global school ranking conducted by the Organisation for Economic Cooperation and Development (OECD) in Science and Mathematics (The Business Times, 2015). According to OECD if Ghana, which occupied the last position was to attain basic skills for all 15-year-olds in the nation, the country's GDP would increase by 38 times, over the lifetime of today's youngsters (The Business Times, 2015). This clearly reveals the crucial role that the provision of good Science education to basic school students can play in catapulting the economic growth of the country. In the aftermath of the COVID-19 Pandemic, there has been a global recognition of the crucial role of Information and Communication Technologies (ICTs) in addressing some of the constraints which education systems in countries such as Ghana is facing. Ponelis and Holmner (2015) stressed on the increasingly significant role of ICTs in the African context with respect to addressing issues such as growing demand for education, increasing shortage of teachers, limited access and escalating high education cost. The technology has proven to provide remote learning resources to previously underserved constituencies, and deprived population, people traditionally excluded from education as a result of cultural or social reasons and are unable to enrol on campus (Tinio, 2002; Toro & Joshi, 2012). For this reason, teachers must be adequately trained to make effective use of ICT resources as an effective pedagogical tool in their daily teaching.

The role of effective teachers in the academic attainment of learners is well acknowledged. While many people criticise teachers for the poor performance of Ghanaian students in Science, others are of the view that the problem of poorly-equipped laboratories, libraries and non-availability of textbooks and other resources are to blame for the inability of the Ghanaian Science teacher to teach effectively (Quaisie, 2016).

The standards-based curriculum for basic schools was implemented in the 2019/2020 academic year. A key feature of the curriculum is the integration of core competences such as critical thinking, communication, collaboration, creativity and digital literacy. Thus the preamble for the science curriculum stresses that among other expectations, teachers are required to be erudite, knowledgeable with a plethora of teaching strategies that meet the divergent needs of all learners (National Council for Curriculum and Assessment [NaCCA], 2019). It also calls for the active usage of ICT for teaching and assessment of learners (Ministry of Education [MoE], 2019). This calls for a commensurate enhancement in the training of teachers to handle this important subject.

At the teacher education level, the Ministry of Education (MoE) has over the years, made various attempts to reform teacher education to enhance the quality of teaching and learning of Science and Mathematics at the basic education level. This is evidenced in the 2004 Educational Reforms that led to the upgrade of 38 public Teacher Training Colleges to Diploma Awarding institutions. Fifteen (15) colleges out of the 38 Colleges of Education (CoE) were selected to train preservice teachers in Science (Hanson, Taale & Antwi, 2011).

More recently, the Transforming Teacher Education and Learning (T-TEL) initiative has been implemented leading to the upgrading of the 46 public Teacher Training Colleges to Degree Awarding institutions (MoE, 2017). This has been marked with corresponding review of the curriculum for various programmes at the CoE including Science. The revised Curriculum for Teacher Education is currently being implemented in all the forty-six (46) CoEs as well as in universities that offer degree programmes in Basic and Early Childhood Education.

With this development, students at the Basic Education and Early Childhood Education Departments in public universities across the country offer the same courses as student teachers pursuing a four-year Bachelor of Education Degree in Basic Education at the Colleges of Education. During their first two years as students, the student teachers who major in Science receive tuition in such courses as, Integrated Science, Chemistry, Biology, Physics, English, Basic Mathematics, Instructional Methods in Science, Research Methods and Assessments, Special Needs Education, HIV/AIDS, Trends in Education, Guidance and Counselling and Basic knowledge in ICT.

The overarching vision of the new Curriculum for Teacher Education is to “transform initial Teacher Education and train highly qualified motivated new teachers who are effective, engaging and fully prepared to teach the basic school curriculum and so improve the learning outcomes and life chances of all learners” (MoE, 2017). It is thus visible that the new curriculum emphasises on the acquisition of competences in delivery of content as well as the acquisition and exhibition of effective pedagogical skills by graduate student teachers.

Notably, the West African Examinations Council (WAEC) Chief Examiner’s Science Reports of 2017 and 2018 on student teachers’ work output point to the fact that student teachers’ performance in science is generally poor and is continually on the decline. This situation is very disturbing since the future of many young scientists rest in the hands of these prospective basic level Science teachers. A number of problems account for this observation including, poor entry behaviour of student teachers, inappropriate pedagogical approaches adopted by tutors/lecturers as well as the absence of science equipment in such tertiary institutions (Owusu-Ansah, 2012).

In many jurisdictions, ICT has been used effectively by educators to help students understand complex concepts in science and other subject areas (Bhattacharjee &

Deb, 2016; Poushter, 2016; Somashekhara & Dange, 2016). This serves as a good substitute to help educators adequately carry-out practical and activity-based lessons in the absence of realia or state of the art equipment. There is the need for a deliberate and concerted attempt to equip student teachers with appropriate skills in ICT usage during the period of their training. This is particularly important in the context of the Ghanaian educational system where the problem of the absence and inadequacy of teaching and learning resources is a mainstay (Yeboah, Abonyi, Luguterah & Chapman, 2019).

The acquisition of requisite skills in ICT by all teachers is a necessity for optimum performance in the classroom considering its role as an integral pedagogical tool, in the 21st century classroom. Many studies reveal the integral role of ICT in enhancing the academic performance of students (Attuquayefio & Addo, 2014; Merino & Serradell Lopez, 2014; Westera, 2015). Irrespective of its crucial role, most basic school teachers in Ghana including science teachers prefer traditional methods of teaching to ICT-based teaching (Buabeng-Andoh, Yaokumah & Tarhini, 2019; Enu, Nkum, Ninsin, Diabor & Korsah, 2018).

A key question to be asked is, to what extent do Ghanaian teacher educators make use of ICT in training of student teachers? Additionally, how are educators able to assist student teachers to make use of ICT to do independent studies or solve problems that they encounter whilst studying? In the current study, the primary aim is to make use of an intervention in the form of ICT-based training to enhance the conceptual understanding and academic performance (in some selected science topics) of a group of student teachers offering Basic Education at the University of Education Winneba (UEW).

Macanas and Rogayan (2019) explain conceptual understanding as the ability of students to transfer knowledge acquired in class to explain phenomena or concepts across different domains. Studies reveal a disturbing trend of lack of conceptual understanding in many science related concepts (Ganeb & Morales, 2018; Ruiz-Gallardo & Reavey, 2019). Research shows that students hold misconceptions about different science concepts (Treagust & Duit, 2009). Studies such as Kamariah (2009) and Marouchou (2012) identified a strong link between conceptual understanding and students' academic performance. Duit, Treagust and Widodo (2008) reveal that the teaching approaches used by teachers is a key source of students' misconceptions of students. Other sources of students' misconceptions include textbooks, (Awan, Khan, Mohsin & Doger, 2011), abstract nature of concepts (Ozmen & Kenan, 2007), wrong association of concepts by students (Adadan, Trundle & Irving, 2009) and cultural beliefs (Kirya, Seje & Yadav, 2022)

Kavak (2007) identified that students under performed in tests in the concept matter. Kapici and Akcay (2016) also identified a gap in teachers' conceptual understanding of the concept matter. Because student teachers are prospective teachers, there is the need for their misconceptions to be identified and addressed. This will result in improved conceptual understanding of key concepts which will ultimately translate into improved academic performance. In the long term, the intervention will result in mastery of subject knowledge and better classroom delivery by these teachers.

Energy is a concept that features prominently in the Ghanaian science curriculum at all levels of education. It appears both as a strand to be studied (NaCCA, 2019) as well as a cross-cutting global issue of interest (MoE, 2019). As pointed out by Wernecke, Schütte, Schwanewedel and Harms (2018), energy is an integral concept at all levels of education. They however point out that students' conceptual knowledge of energy is often low. This assertion is corroborated by other works such as Lancor (2014) and Opitz, Harms, Neumann, Kowalzik and Frank (2015). Wernecke et al. (2018) call for a clear instruction tool to assist in dealing with students' misconceptions in energy.

In other jurisdictions, ICT has been used to enhance students' conceptual understanding in science concepts such as reproduction, DNA replication and duplication, chemical reactions and various processes within living cells (Barak & Dori, 2009; Fetaji, Loskovska, Fetaji & Ebibi, 2007). Boahen and Atuahene (2021) identified teacher cognition as one of the key factors militating against the effective usage of ICT in lesson delivery in Ghanaian high schools. There is the need to address this unfortunate phenomenon, considering the increasingly crucial role of ICT across the globe in all sectors, particularly education. In seeking to address this unfortunate phenomenon, one main question that needs to be answered is, how does teachers' attitude towards the use of ICT influence their decisions to integrate ICT in teaching? Additionally, it is important to find out other factors that influence the inability of teachers to make use of ICT in teaching.

Although the teacher education curriculum emphasises strongly on the use of ICT as a key pedagogical tool, the review of the literature does not provide information on the intent of student teachers to use ICT in their future classrooms within the Ghanaian context. The present study seeks to identify the link between ICT-based teaching and the attitude and intent of student teachers to use ICT to teach science in their future classrooms. This can potentially assist stakeholders on the most effective pedagogical strategies to implement in ensuring the attainment of the intended curriculum.

Additionally, the current study is deemed crucial because the review of the literature reveals a dearth of research on student teachers' misconceptions in various subject areas since the roll-out of the new 4-year curriculum for teacher education in 2019/2020. Particularly the researcher did not find any previous studies that sought to investigate the misconceptions of Ghanaian CoE student teachers in science related concepts.

The study is also a pioneer study in terms of the usage of ICT-based intervention to improve conceptual understanding of student teachers in science concepts within the 4-year B.ED programme. It also seeks to employ the ICT-based intervention to improve the academic performance and thus the attitude of student teachers towards the study of science. In Ghanaian education circles, there is little research on the link between student teachers performance in science and their intent to teach the subject after receiving ICT-based instruction within the subject area thus the present study seeks to bridge the gap in that stead.

The technology acceptance model (TAM) has been used in various studies to predict the intent and attitude of pre-service teachers and classroom practitioners towards the usage of ICT-based learning strategies (Charness & Boot, 2016; Davis, 2011; Granić & Marangunić, 2019; Weerasinghe & Hindagolla, 2017). However to the best of the researcher's knowledge, the current study is setting the pace in terms of the use of the technology acceptance model to predict the intent of Ghanaian-student teachers to use ICT in their future classrooms. The study focuses on how the ICT-based intervention influences student teachers' views about perceived ease of use and usefulness of ICT in their future classrooms. This will help to validate the model for usage in investigating technology utilisation in different educational contexts within the Ghanaian educational system and other jurisdictions in sub-Saharan Africa.

According to Dibbon (2004), the failure to identify the needs of teachers in implementing an intervention has a negative impact on the success of the intervention. Although various policy documents on education advocate for the increased role of ICT in educational delivery (MoE, 2019; NaCCA, 2019; MoE; 2017), there is little information on the envisaged challenges to the successful utilisation of such ICT-based interventions. For this reason the study focuses on bringing to bear the challenges that will impede student teachers from employing ICT to teach science, through a first-hand interaction with these prospective classroom practitioners.

Ultimately the study provides information on how the intent of curriculum developers to leverage ICT for improving student teachers' academic performance and output as teachers can be realised within the classroom setting. This thus positions the study as a precursor for the future review of the science curriculum for teacher education in terms of content and the role of ICT in successful curriculum implementation.

1.2 Statement of the Problem

Research into students' understanding of science-related topics indicates that ineffective methods of teaching promote misconceptions leading to poor performance as well as loss of interest in science (Adegbola & Depar, 2019; Akarsu & Kariper, 2013; Azure, 2015).

Despite the growing importance of Science in our today's world, many students are losing interest in the study of this vital subject area due to several reasons including poor teaching methods (Veselinovska, 2011). As suggested Ali, Iqbal and Akhtar

(2013), most of the students have developed ambivalent attitudes and perception towards Science and Technology.

Teaching at the various Colleges of Education and the universities that offer education-related courses in Ghana is mostly done through the traditional lecture method (Boahen & Atuahene, 2021). Research indicates that this method dominates most of the tertiary institutions (Deslauriers, Schelew & Wieman, 2011). Arguably, one of the reasons behind this phenomenon is the absence of requisite teaching resources that could have been used to enhance conceptual understanding. Some of the concepts that students usually complain about and perform abysmally in include States of Matter, Light, Measurement, Compounds and Mixtures. ICT could be leveraged to relay better conceptual understanding and improve students' performance (Ghavifekr & Mohammed, 2015). This makes the research very pertinent to find the effect of ICT-based training on the performance of student teachers in integrated science.

Various studies (Kapici & Akcay, 2016; Özalp & Kahveci, 2011; Driver, Squires, Rushworth & Wood-Robinson, 2014; Rosenblatt, Sayre & Heckler, 2014) in different settings also found out that student teachers held misconceptions in the three concepts (Matter, Forces and Energy) under consideration.

After teaching science-related courses in the Department of Basic Education and the College of Distance and E-Learning (CoDeL) of the UEW for four years, the researcher discovered a trend of student teachers' poor performance in these three integral concepts in the science curriculum for teacher education. Particularly it was observed that the research subjects attained low scores in various assessment tasks in these three concepts. The average score of student teachers in various quizzes conducted in these concepts ranged from 7.2 to 8.5 out of a total score of 20. Similarly, they failed to demonstrate conceptual understanding in these concepts during group or individual tasks on either Matter, Forces or Energy. Notably, the answers posed by student teachers to questions during lessons provided further evidence that generally, they lacked conceptual understanding in these science concepts, which ultimately translated into poor performance in various assessment tasks in these science topics. Studies such as Chabalengula, Sanders and Mumba (2012), Rittle-Johnson, Siegler and Alibali (2001) and Vosniadou, (2001) also show that students' poor conceptual understanding results in poor academic performance.

The observed trend of student teachers' (in the Department of Basic Education, UEW) poor conceptual understanding in some integral science concepts is worrying, considering the fact these student-teachers are potential teachers at the basic level of schooling in Ghana. Thus if these shortfalls in their conceptual understanding in key concepts in science (Matter, Energy, Forces) are not addressed, it will lead to these misconceptions being passed on to learners, leading to poor learning outcomes and ambivalent attitudes of learners towards the study of science. Therefore measures must be put in place to address the subject matter knowledge difficulties of student teachers before they complete their programmes. The researcher is of the view that the over reliance on the traditional method of teaching science as well as the absence of requisite resources over the years are key contributory factors to the low conceptual understanding and resulting poor academic performance of student-teachers in science within the Department of Basic Education, UEW. As observed by Westera (2015) the use of various ICT-based resources such as videos, virtual laboratories, images and PowerPoint presentations promotes conceptual understanding and academic performance. To the best of the researcher's knowledge, not much research work has been done on the role of ICT in promoting student teachers' conceptual understanding and academic performance in science, in the Department of Basic Education and also in the 46 Colleges of Education, since the introduction of the 4-year teacher education programme. Yeboah et al. (2019) emphasised the over reliance on traditional methods of teaching in the typical Ghanaian setting. For this reason, the researcher intends to design ICT-based modules to teach level 200 upper primary student teachers in the Department of Basic Education of UEW to determine its effect on their conceptual understanding as well as their performance in science and their attitude and intent to teach the subject after completing their studies. Additionally, the research will be used to help enhance the pedagogical skills of student teachers in ICT.

1.3 Purpose of the Study

The study sought to determine the effect of ICT-based teaching on student teachers' conceptual understanding in some selected concepts in physics.

1.4 Objectives of Study

The objectives of the study were to:

1. assess the misconceptions held by student teachers on some key concepts in physics.
2. assess the effect of ICT supported teaching on student teachers' conceptual understanding in some concepts in physics.
3. examine the influence of ICT-based instruction on student teachers' performance in some concepts in physics.
4. determine the difference in the performance of respondents in the physics concepts in terms of males amd females.

5. evaluate the impact of ICT-based instruction on student teachers' attitudes, and self-efficacy about teaching of some concepts in physics using ICT.

1.5 Research Questions

The study sought to find answers to the following research questions:

1. What are the misconceptions held by student teachers about some selected concepts in physics?
2. To what extent will the use of ICT-based teaching strategies improve the conceptual understanding of student teachers in some concepts in physics?
3. What will the use of ICT–based teaching strategies have on the performance of student teachers in selected concepts in physics?
4. What are the differences in performance of the male and female student teachers in the selected concepts in physics?
5. What is the effect of ICT-based instruction on student teachers' attitudes, views and intent about teaching of Science using ICT resources?

1.6 Hypothesis

The following null hypotheses were formulated for the study:

H_{01}: There is no statistically significant difference between the pre-test scores and post test scores of student teachers in the concept, matter.

H_{02}: There is no statistically significant difference between the pre-test scores and post test scores of student teachers in the concept forces.

H_{03}: There is no statistically significant difference between the pre-test scores and post test scores of student teachers in the concept, energy.

H_{04}: There is no statistically significant difference between the overall pre-test scores and overall post-test scores of student teachers in the concepts under study.

H_{05}: There is no statistically significant difference in the post-test performance of student teachers in Matter, Forces and Energy.

H_{06}: There is no statistically significant difference in the performance of student teachers with respect to gender

1.7 Significance of the Study

The present study focuses on enhancing student teachers' conceptual understanding in the selected concepts in physics and also improving their performance in the concepts Matter, Energy and Forces. The findings of the study shed light on the misconceptions held by student teachers in key concepts in physics (Matter, Energy and Forces). It also would bring to light the relevance of using modern technology, especially ICT in teaching science at the Basic Department of the University of Education Winneba and all levels of education, in Ghana. In addition, the study would contribute immensely to improve the attitude of teachers towards the teaching of science. It would also go a long way to encourage the student teachers to use innovative methods in the classroom after they have been taught the concepts of Matter, Energy and Forces using ICT. Furthermore, it would seek to educate science teachers on how they could make use of online resources as substitutes to solve the problem of unavailability of resources and equipment for science lessons. This venture would contribute greatly to provide a suitable substitute that caters for the absence of modern equipment and logistics which has characterised the study of science across the length and breadth of Ghana and other Sub-Saharan African countries. This would contribute a lot to make the study of science motivating for students, thus improving their attitude and perceptions about science. It would also go a long way to inform stakeholders on the need to purchase relevant teaching and learning equipment to boost the teaching and learning of science in Ghanaian schools, especially when they chance on reading this thesis. Finally, it would serve as a source of reference for other researchers who would like to undertake research in other science topics in general, by applying the same method.

1.8 Limitations

According to Theofanidis and Fountouki (2019) limitations in the context of a research study bother on potential weaknesses that are most often beyond the researcher's control, and may be linked with one aspect of the research or the other such as the chosen research design. For this reason, they stress on the need to report on limitations of the study since they may affect the study design, results and conclusions.

Particularly there are several limitations that characterise action research as a research design for effecting desirable changes within a given environment irrespective of its advantages (Edwards, 2010). A key limitation associated with action research is that since the researcher is evaluating his/her own performance, an element of bias might be exercised in several ways during selection of respondents, data gathering or writing of the final report.

In trying to overcome this limitation, Norasmah and Chia (2015) advocate for teachers to involve their colleagues more actively in data gathering and in the implementation of the intervention. In order to eliminate researcher bias, the researcher employed the services of a colleague science lecturer to administer the intervention and also to gather data through the use of tests, questionnaires and interview guide. Nevertheless, the researcher might have unconsciously exhibited a little bias in the write-up of this thesis.

Additionally, 3 out of the 93 student teachers in the class were not involved in the study, due to lack of punctuality and this might have had a slight effect on the data gathered.

Iliev (2010) identified possible methodological limitations in action research with regard to data gathering. Even though the research subjects were at liberty to opt out of the study at any stage, the fact that the researcher was their science teacher might have compelled some of them who would have liked to opt out to refrain from doing so, for fear of victimization.

Some of the respondents might have hesitated in providing responses to some questions for fear of revealing their weaknesses to the researcher even though he was not directly involved in the administering of the intervention or the conduct of interviews. In order to address this limitation, the researcher assured them (respondents) of anonymity and confidentiality of their responses.

Throughout the study, the respondent student teachers had access to their mobile phones and thus had access to the internet and various sources of information on the concepts being learnt in class. This might have had an impact on their performance in the post-tests. As with most studies carried out through the action research design, the sample may not be representative of the entire population, thus creating a limitation in terms of the generalisability of the research findings and recommendations.

1.9 Delimitations of the Study

The entire study was conducted in the Central Region of Ghana. Within the region, the study was restricted to second-year science students in the Department of Basic Education of UEW. The main tools for data gathering were a two-tier questionnaire on conceptual understanding, tests (pre-test and post-test) and a questionnaire for gathering data on respondents' views, attitude and intent to use ICT resources in science lesson delivery. These instruments were augmented with the use of an interview protocol. The intervention was in the form of ICT-based teaching involving the use of computers, projector screens, as well as video and PowerPoint resources. In terms of content coverage, the intervention in the form of ICT-based lessons focused on three concepts within the science curriculum for teacher education, which are Matter, Energy and Forces. According to Krathwohl (2002), knowledge can be categorised into four types: (1) factual knowledge, (2) conceptual knowledge, (3) procedural knowledge, and (4) metacognitive knowledge. The study focused on the conceptual knowledge of student teachers.

1.9 Organisation of the Study

The entire study is organised under five (5) chapters. Chapter 1 provides an introduction into the background of the study, the statement of the problem, the research questions to be answered as well as the significance of the study. Chapter 2 is devoted mainly to the review of relevant literature. The chapter focuses on the theoretical and conceptual underpinnings of the study. It also discusses previous studies on students' conceptual understanding as well as the role of ICT in science education. Chapter 3 focuses on the methodology of the study, instrumentation, validity and reliability as well as data gathering and analysis. The chapter also discusses the ethical considerations followed throughout the entire research. Chapter 4 details the analysis of data and results providing descriptive statistics, model representations, and results. Chapter 5 presents a summary of the study; discussion; interpretation and evaluation of the findings; conclusions; recommendations and suggestions for practitioners, administrators, curriculum designers, programme evaluators, policy makers, and accreditation bodies, and recommendations for further research.

1.10 Definitions of Terms and Abbreviations

CoE: The Colleges of Education (CoE) are responsible for training basic school teachers in Ghana.

Conceptual Understanding/Knowledge: Conceptual knowledge is explained as knowing the interrelationships and/or functions among the details and elements that make up a larger structure. In this study, it is used interchangeably with conceptual understanding. This definition includes (1) knowing information classification and categorisation, (2) knowing principles and generalisations, and (3) knowing theories, models, and structures.

GES: Ghana Education Service

GTEC: Ghana Tertiary Education Commission (GTEC) is the regulatory body in charge of Tertiary education in Ghana in terms of supervision and accreditation.

ICT: Information and Communications technology in this study encapsulates the use of computers and other technologies such as projectors and internet resources in classroom instruction.

JHS: Junior High School

MoE: Ministry of Education

NaCCA: National Council for Curriculum and Assessment

NPECF: National Pre-Tertiary Education Curriculum Framework

NPLAF: National Pre-Tertiary Learning Assessment Framework

NTECF: National Teacher Education Curriculum Framework

SHS: Senior High School

Student teachers: This term is synonymous with pre-service teachers and teacher trainees. Under the new Teacher Education reforms preservice teachers are referred to as student teachers.

TTEL: Transforming Teacher Education and Learning

UEW: University of Education, Winneba

WAEC: West African Examinations Council

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

Literature was reviewed under the following headings: Theoretical Framework, Conceptual Framework, Concept of ICT, Concept of Teaching and Learning, Teaching and Learning Technologies, Integration of ICT into Teaching and Learning, ICT Integration in Teacher Education, Approaches to Evaluating Teacher Effectiveness, Concept of Misconceptions, Misconceptions in Science, Effects of ICT-based Instruction on Students' Performance, Effects of Technology Integration on Teachers' Attitudes and self-Efficacy.

Just like any other academic study, this study is premised on theoretical foundation. This chapter focuses on a review of theories relevant to understanding how ICT based training can improve the performance of student teachers in Integrated Science. These theories serve as the foundation for making and supporting key arguments within the context of this study. Inferring on these theories, a conceptual framework is developed for the study to enhance the analysis in the study.

2.1 Theoretical Framework underpinning the study

This study infers on theories; key amongst the theories to be considered in this study are; the Technological, Pedagogic, Content Knowledge Theory (TPCKT), Technology Acceptance Model (TAM), and the Activity Theory.

2.1.1 The technological, pedagogic, content knowledge theory

The Technological, Pedagogic Content Knowledge theory (TPCK) by Mishra and Koehler (2006) was built on Shulman's (1986) idea of Pedagogic Content Knowledge

(PCK). According to Shulman (1986), in order for a teacher to ensure effective teaching in the classroom, the teacher is mandated to have in-depth knowledge of the content of his/her domain (content knowledge) and in-depth knowledge of the various approaches he/she will be using to deliver his/her lessons (pedagogic knowledge). This notion of Shulman (1986) was developed by Mishra and Koehler (2006) who added that, knowledge and use of ICT can be used to support the content and pedagogic knowledge of the teacher for an effective teaching and learning outcome. The essence of the TPCK model is to equip the 21st century teacher and student with all the skills needed to use ICT to function in the classroom for the best teaching and learning outcome.

The theory is relevant to this study as it points to the inherent importance of teachers to be knowledgeable in the area of their specialisation and also acknowledges the role of ICT integration into teaching and learning which has a potential to improve the performance of teachers in contemporary times. Thus, when ICTs are integrated into the training programmes of these potential integrated science teachers as well as current teachers, they will have improved skills, attitudes and knowledge which will translate into improved competence and consequently higher performance in both content and pedagogy.

The TPCK theory acknowledges the complex interrelationship of diverse elements, which are contextually bound in a fruitful integration of ICT in teaching and learning. These core elements constitute the different components of the theory and they are; technological knowledge, pedagogical knowledge and content knowledge (Mishra & Koehler, 2006). These elements interact for an effective integration of ICT in teaching and learning (Mishra & Koehler, 2006).

Content Knowledge - deals with individual's knowledge about the contents of the subject area they are reading or teaching (Ofori, 2019). This element of knowledge underlines disciplinary differentials, which results in the application of different methodologies in teaching and learning (Koehler & Mishra, 2008). As per the TPCK, every subject or discipline have unique nature and characteristics and these informs how the content of these subjects can be disseminated from one person to the other for teaching and learning goals to be attained (Ofori, 2019). Knowing what entails in a subject or discipline is key to knowing the right approaches to knowledge dissemination in that discipline or subject area and this is what Shulman (1986) as well as Harris et al (2019) described as Content Knowledge. Inferring on this component of the TPCK, the study argues that, trainees' misconceptions about key concepts of the integrated science subject has significant impacts on their competences. As such, the integration of ICT in their training may help alleviate these misconceptions and enhance performance.

Pedagogical Knowledge – As per the TPCK theory, this represents the methods and processes of teaching and learning purposes, values and aims (Mishra & Koehler, 2006). This component deals with the planning and implementation techniques of teaching and learning. An enriched pedagogical knowledge of students enables them to know and understand how to construct knowledge and build skills from what they are taught and from what they learn. Thus, inferring from this component of the TPCK theory, when effective approaches are integrated in the training of trainees, this may have significant effects on their skills and competence and ultimately, their performance. Similarly, an enriched pedagogical knowledge of teachers enable them to effectively transmit acquired knowledge and skills to students for a better educational outcome. This talks about the manner in which knowledge is transmitted to a recipient and the manner the recipient also receives and process that knowledge in a way that the objectives of that transmission is obtained.

Technology Knowledge – this concerns knowledge of the potentials of basic teaching and learning technologies such as books and chalkboard as well as modern and advanced teaching and learning technologies such as computers, projectors, and internet (Ofori, 2019). As per the TPCK theory, both teachers and students are required to possess the skills needed to apply these technologies productively in their teaching and learning activities (Mishra & Koehler, 2006). It is about incorporating technology into content and pedagogic knowledge. That is technology becomes the platform for the application of the CK and the PK.

However, before technology can serve as the platform for the effective application of CK and PK, teachers and students need to know the potentials and functions of the technology as well as how to apply them in specific approaches for the delivery of specific contents in a particular discipline or subject area.

In view of what CK, PK and TK are all about, Mishra and Koehler (2006) stated that, these three are interrelated and are represented with three overlapping circles to aid understanding as shown in Figure 1. Each circle represents Content, Pedagogy and Technological knowledge. Content and pedagogy overlap to create Pedagogical Content Knowledge (PCK), technology and content overlap to create Technological Content Knowledge (TCK) and technology and pedagogy overlap to create Technological Pedagogical Knowledge (TPK).

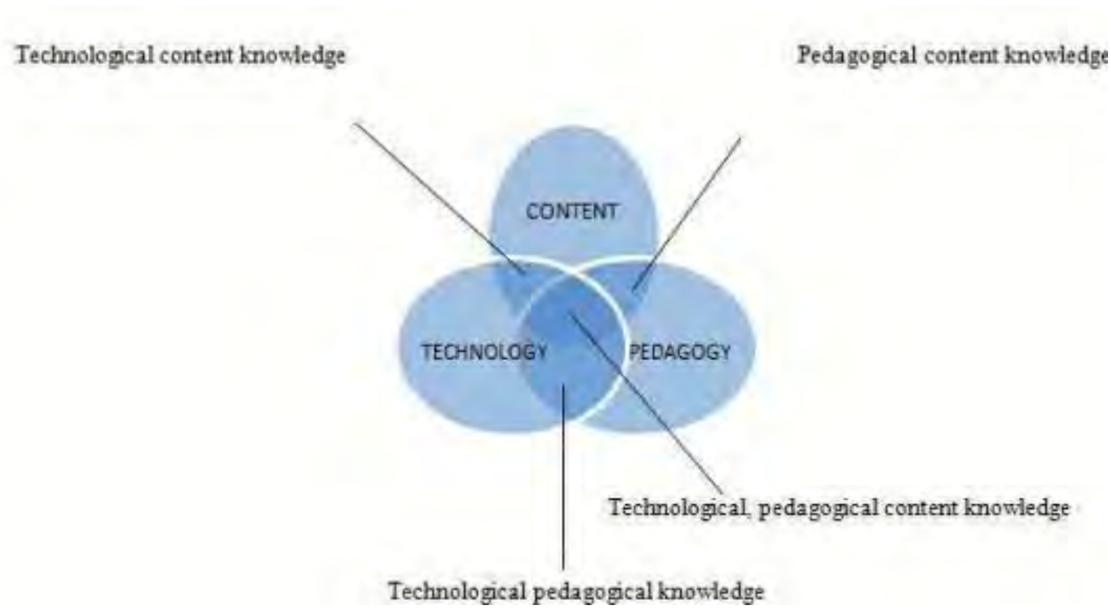

Figure 1: Diagrammatic presentation of the TCKP theory
Source: Koehler and Mishra (2008)

These three components overlap each other thereby creating three different intersections as can be seen in Figure 1. In this study, it is argued in line with the proponent of the theory that, it is the interactions, between and among these elements, playing out differently across several contexts that account for the wide variations realised in educational technology integration and the benefits that trainees may reap from them. The first intersection forms Pedagogical Content Knowledge (PCK) and it shows the strong relationship between content and pedagogy. It indicates that each subject area (discipline) is different and should be taught and presented with different instructional approaches or strategies for utmost outcome. The second intersection is Technological Content Knowledge (TCK), which comes from the overlap of technology and content. This demonstrates the importance of understanding the impact of technology on specific content or subject, and vice versa.

In essence, certain contents can limit or enhance the type of technology to use, and some technologies can limit or enhance the content and subject for easy understanding

(Harris et al, 2019). The third intersection from the overlap of Technology and Pedagogy forms Technological Pedagogical Knowledge (TPK). This intersection depicts how teaching and learning can change when certain technologies are used (Koehler & Mishra, 2008). Different forms of technologies can enable the application and development of different forms of pedagogy. On the other hand, different pedagogical methods will require different forms of technology. The simultaneous integration of content, pedagogy and technology makes a vast difference in realizing the goals of investment in educational technology.

2.1.2 The Technology Acceptance Model (TAM)

The Technology Acceptance Model has been a theory that is most widely used to explain an individual's acceptance of an information system (Davis, 1989). The technology acceptance model proposes that perceived ease of use and usefulness of a technological tool determines the extent of consumer acceptance (Charness & Boot, 2016). In this study, this theory is inferred upon as it explains trainees' desire to accept the integration of ICT in their curriculum which may have significant consequences on building their skills for their career.

In the TAM model, there are two factors, perceived usefulness and perceived ease of use are relevant in computer use behaviours. Davis (1989) defines perceived usefulness as the prospective user's subjective probability that using a specific application system will enhance his or her job or life performance.

Perceived ease of use (EOU) can be defined as the degree to which the prospective user expects the target system to be free of effort. According to TAM, ease of use and perceived usefulness are the most important determinants of actual system use. These two factors are influenced by external variables. The main external factors that are usually manifested are social factors, cultural factors and political factors (Mafang'Ha, 2016). Social factors include language, skills and facilitating conditions. Political factors are mainly the impact of using technology in politics and political crisis. The attitude to use is concerned with the user's evaluation of the desirability of employing a particular information system application. Behavioural intention is the measure of the likelihood of a person employing the application.

Therefore, it is crucial for lecturers and prospective teachers to have basic ICT competencies and skills that is applicable in their teaching and learning activities. The interest and frequency of use of ICT facilities and acceptance by these of lecturers and students is therefore crucial to attain competence post successful integration into training programmes. The more a particular skill is frequently practiced, the more the competence gained in using that skill and more areas to apply the skill is discovered.

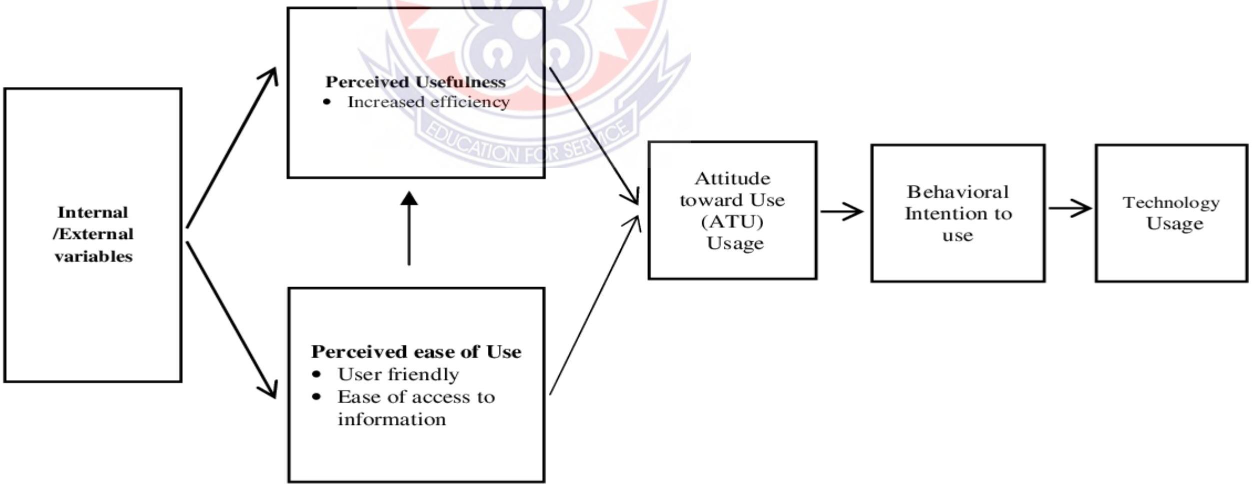

Figure 2: Diagrammatic presentation of the technology acceptance model

Source: Venkatesh and Davis (1996)

Fathima (2013) explained that good teaching is not simply adding technology to the existing approach and content domain. Rather it should cause the demonstration of new concepts and developing of sensitivity to the dynamic nature, and the transactional relationship between the content, the approach and the technology to use. It is therefore important for teachers and students to know the content of their field of study, the appropriate approaches to use in teaching or learning the content of that field of study and the acceptance and application of the right technology in their teaching and learning activities for the utmost outcome. This study through the application of this theory was able to determine the availability of teaching and learning technologies in the study area to examine the acceptance and use by trainees in teaching and learning.

2.1.3 The activity theory

Russell's (1997) Activity Theory seeks to create an account of human cognition in which people, their intentions, tools, culture, and encompassing social structures are all considered as inherently inseparable components of human activity which constitute thought (Wardle, 2015). Within educational technology, Activity theory is concerned with how people work together, using tools, toward outcomes (Devane & Squire, 2012). For instance, at the various training institutions, teachers, students, researchers, administrators, and staff interact with each other and with tools to achieve the outcomes of learning. Activity systems are also constrained by divisions of labour and by rules (Wardle, 2015). Within the context of this study, this theory is relevant in that it explains how tools and resources such as videos, animations and e-charts influence the thought process of individuals. As a result, at the background of the integration of ICTs into teacher training programmes, these may have significant effects on the thought process of these prospective teachers which may lead to the improvement of their competencies

The most basic activity theory lens, or unit of analysis, is the activity system, defined as a group of people (in this context teachers) who share a common object (integrated science) and motive (teaching) over time, as well as the wide range of tools (ICTs) they use together to act on that object and realise that motive (Mafang'Ha, 2016). As such, this study proposes that, studying teachers in the context of the level of ICT integration in their education will have significant effects on their competence levels, thereby increasing their performance in the classroom.

Russell (1997) describes an activity system as "any ongoing, object-directed, historically conditioned, dialectically structured, tool-mediated human interaction" (p. 510). This definition is broken down as;

Ongoing – concerned with looking at how systems functions over time. For instance, the teacher training colleges are an activity system of long duration that began in the past and will continue into the future (Mafang'Ha, 2016). We can trace the various training institutions' activity over time and consider how it might evolve in the future. Thus, in the context of this study, the training institutions were hitherto averse to the integration of ICTs in the training modules. As such, this element of the theory explains that, it is possible to study these teachers in the context of integrating ICTs, which hitherto was not part of their curriculum, into their education and observe the results it might have on their teaching competence.

Object-directed – The types of activities that activity theory is concerned with are directed towards specific goals (in this context, enhancing teaching and learning of integrated science). Continuing with the example of the Colleges of Education in Ghana, the object of its activity is learning, which is accomplished through instruction and research. As such, inferring on this theory, it is evident that, teacher training institutions have a core mandate of improving the competence of its products in the teaching of various subjects such as science. In view of that, the integration of ICTs in the training will be significant towards enhancing the teachers' performance.

Historically conditioned – Activity systems come into being because of practices that have a history. At any point of a study on how a system works, there is the need to consider how it came to function in a particular way. For instance, ways that the training institutions carry out their training activities developed over time. Many things being done in the contemporary classroom can be explained by the history of the training institutions' mission as well as the history of western educational institutions (Devane & Squire, 2012). As such, inferring on this component of the theory, this study argues that, teachers' competence can be influenced by the quality of training they receive from their training institution. Hence, a deep integration of ICT into the science curriculum for the teacher education programme, may help reduce some core misconceptions that teachers may have about the subject.

Dialectically-structured – The term "dialectic" describes a type of relationship in which aspects of a process, transaction, or system are mutually dependent (Devane & Squire, 2012). When one aspect changes, other aspects change in response. Some of these changes we can anticipate; others we cannot. Thus, inferring on this aspect of the AT, the study argues that, the skills, attitudes and competence of teachers of science can be influenced by the integration of IT in their training. That is to say, teachers' attitudes, skills and competence has a significant relationship with how well ICT is integrated into their training. For example, when these training institutions begin to use computers as a tool in education, the ways that teachers, researchers, and students accomplish tasks related to the activity of learning will begin to change in response.

Tool-mediated – People use many types of tools to accomplish activities. These may be physical objects, such as computers, or systems of symbols, such as mathematics. At the various training institutions, we use textbooks, syllabi, laboratory equipment, computers, and many other tools to accomplish our goal of learning. The types of tools we use mediate, or shape, the ways we engage in activity and the ways we think about activity. For example, if we think about the course syllabus as a tool, we might say that it organises the work in the classroom for both the instructor and the students, which affects how we participate in learning activities.

Human interaction – Studies of activity systems are concerned with more than the separate actions of individuals (Devane & Squire, 2012). Activity theory is concerned with how people work together, using tools, toward outcomes. In the various training institutions, teachers, students, researchers, administrators, and staff interact with each other and with tools to achieve the outcomes of learning. As such, inferring on this component, it is argued that, the integration of ICT into the various training programmes of teachers will have significant positive effects on training outcomes.

2.2 Conceptual Framework

Basing on the theoretical foundations of this study as well as the objectives of this study, a conceptual framework is proposed as displayed in Figure 3. According to the Activity theory, learning is directed towards specific goals (in this context, enhancing teaching and learning of integrated science). Inferring from this perspective, Colleges of Education in Ghana's object of activity is learning, which is accomplished through instruction and research. As such, inferring on this theory, it is evident that, teacher training institutions have a core mandate of improving the competence of its products in the teaching of various subjects with the use of improved technologies. Thus, the integration of ICTs in the training will be significant towards enhancing these teachers' performance, their attitudes and also remediating key misconceptions which these trainees may bring to the classroom (Ajzen, 1985).

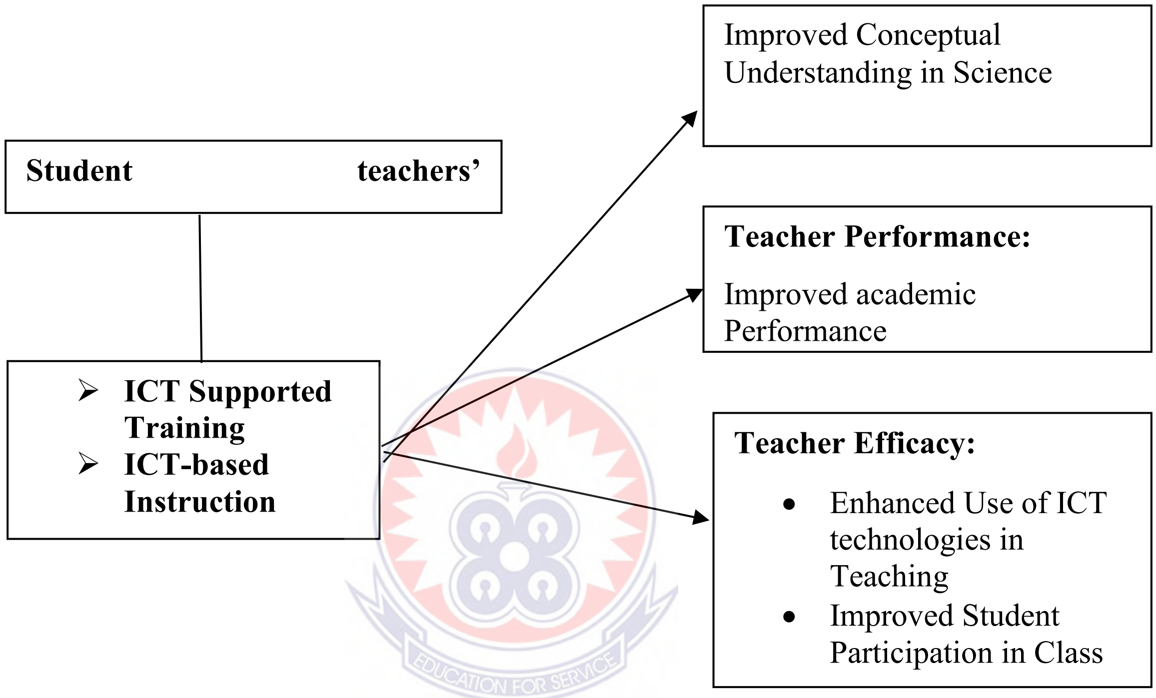

Figure 3: Conceptual framework
Source: Researcher's Diary (2022)

Support is provided by the Technology Acceptance model which explains that, good teaching is not simply adding technology to the existing approach and content domain rather it should cause the demonstration of new concepts and developing of sensitivity to the dynamic nature, and the transactional relationship between the content, the approach and the technology to use (Mishra & Kohler, 2006). As such, the integration of technologies in the training programmes of student teachers will help remove some misconceptions and enhance conceptual understanding of core concepts in science, thereby also improving performance and their attitudes towards technology use.

2.3 Conceptual Review

This section of the review of literature concerns itself with an understanding of the key concepts relevant to this study, notable of these concepts includes, the concept of ICT,

2.3.1 Concept of ICT

Information communication technology (ICT) encompasses computer and telecommunication. It is concerned with the technology used in handling acquiring processing, storing and dissemination of information (Kenny, 2012). Thus, information communication technology is any technology used in producing, organising and passing information for various purposes (Mirzajani, Mahmud, Ahmad & Wong, 2016). ICT refers to a series of services and devices that can carry out such functions as relieving, storing, computing, analysing, transmitting and retrieving information presented to them and allowing for one to one or group communication among humans (Ghavifekr et al., 2014). ICT infrastructure include multimedia, CD ROMS, MP3 players, websites, discussion boards emails, computer aided assessments, learning management software, blogs and so on (Khan, Khan, U-Din & Muhammad, 2015).

ICT is an interdisciplinary science mainly concerned with the collection, manipulation, classification, storage, retrieval and dissemination of information (Kazan, 2015). ICT is a means of receiving or accessing, transforming, processing, storing and sending ideas, perception or information through computer and their telecommunication facilities (Khan et al., 2015). ICT is a concept, method, function, process or system of collecting, analysing, processing and sharing of information using electronic equipment. ICT includes all that is involved in modern communication satellites, television, radio, video, tape recorders, floppy diskettes, compact discs, personal computers and other related equipment so that, the output generated can get to the user in good time and at reasonable cost to the overall benefit of mankind (Amer & Jaber, 2012).

Developments in ICT such as the World Wide Web, electronic mail and Electronic data interchange can be seen as facilitators to cross organisational boundaries when dealing with information intensive processes (Mirzajani et al., 2016). Some of the uses of ICT in teaching and learning include; ICT as objects, ICT as an assisting tool, ICT as a medium of teaching and learning, and ICT as a tool for organisation and management in schools (Ahmadi, Keshavarzi& Foroutan, 2011). ICTs allow learners to explore and discover rather than just listen and remember (Ghavifekr et al., 2014). Several reports and studies in recent years have placed emphasis on the potentials and opportunities of ICT for improving the quality of education. ICT is perceived as a major tool for the construction of knowledge and serves as an instrument at the educational level that can offer a way to restructure the educational systems and processes, resulting in quality education for all.

Additionally, in Europe, appropriate use of ICT is seen as a main factor in attaining quality education. In view of this, the European Commission is encouraging the use of ICT in learning through its e-Learning Action Plan (Khan et al., 2015). One of the specific objectives of the action plan is "to improve the quality of learning by facilitating access to services and resources as well as remote collaboration and exchange (Mirzajani et al., 2016). ICTs could be used to motivate students in their teaching and learning activities (Ahmadi et al., 2011). To prepare the students for the challenges of the 21st century workplace and community leadership, the integration of information communication technology into teaching and learning process has become inevitable (Kazan, 2015). Also, lecturers must be supported in the preparation of students' classroom use of technological tools and applications so that they can create learning environments that enable students to become responsible for their own learning and also focus on process and outcomes specifically for their individual learning states and needs.

Students' ability to speak, write and analyse information can be enhanced as part of their individual and personal growth through ICT (Ahmadi et al., 2011). Furthermore, teachers should emphasise the many benefits they derive from the use of ICT as productive tool in developing their own instructional materials and managing classroom and student information, in order to motivate their colleague teachers and students as well (Ansong, Lovia Boateng, & Boateng, 2017; Padayachee, 2017). The application of ICT in teaching and learning makes learning more productive and efficient as it facilitates pedagogical activities of teachers and academic performance of students. For instance, e-learning has become one of the most common means of using ICT to offer learning opportunities to students, both on campus and off campus through online teaching via web-based system (Ghavifekr et al., 2014). Also, ICT allows teachers and students to contribute, control and manipulate information in teaching and learning environments with the use of interactive books, journals among other resources that are usually available on the Internet (Mirzajani et al., 2016).

Researchers are also able to lay their hands on varied and counter opinion information of other researchers in other parts of the world to aid their work through the use of

ICT (Ahmadi et al., 2011). No field of research will be left untouched by the current explosion of information and communication technologies (Khan et al., 2015). Science for instance, used to consist of theory and experiment, but today it has computer simulation as a third element which links the other two (Adeyemi, 2011). ICT can lead lecturers into new frontiers in basic and fundamental research. ICT is relevant to lecturers and students in many areas of research. ICT facilitates dissemination of information and communication from one person to another through e-mail, mail lists, newsgroups and chat rooms (Padayachee, 2017). These ICT resources facilitates communication between scholars as they can post research, books, journals, assignments, lists of references to on-line materials among others. Problems and solutions can be discussed among researchers, and scholars can respond to the work of others in an electronic manuscript through the use of ICT.

ICT offers greater chances for research collaboration and networking among scholars across the globe, thus national and international aspect of research issues can be studied since they can allow for communication with experts and peers around the world (Kenny, 2012). Through collaborative knowledge building, studies can highlight transnational trend analysis through human and instrumentation collaboration (Rehmat & Bailey, 2014). ICTs can support research in any discipline as they offer faster and easier access to extensive and up-to-date information through digital libraries that provide digitised full-text resources to learners and researchers (Adeyemi, 2011). Others are the electronic list, thus a directory of professional and scholarly e-conferences containing topics and articles relevant to researchers, and virtual libraries or electronic reference desks (Kazan, 2015). Others include electronic books, journals, catalogues and image database. Other Internet resources, like CD-ROM and gopher can provide a researcher with current and in-depth information.

ICT can be used for data manipulation and analysis and can also be used to do complex statistical and mathematical calculations which are important in research (Ministry of Education and Higher Education [MEHE], 2012). ICT enhance the completion of data on time and enhance the swift performance of statistical analysis. In fact, complex statistical analyses are not only performed instantaneously but also more accurately than possible manually (Padayachee, 2017). ICT offer researchers ready means for the dissemination of research findings and reports. ICT also offer a ready avenue for the production of research reports (Adeyemi, 2011). Publication outlets include e- journals, e-books or through personal web-sites. Furthermore, digital video, audio, interactive software, asynchronous and synchronous chats, software simulation, social media among others, bring dynamism in describing a method or reporting result (Khan et al, 2015).

2.3.2 Concept of Teaching and Learning

Teaching is to cause people to learn and acquire the desired skills, knowledge and also required ways of living in a society (Padayachee, 2017). It is the process in which the learner, the teacher, the curriculum and other variables are systematically and psychologically organised in a way so as to achieve some pre-determined goals (Niederhauser & Stoddart, 2011). Teaching is the set of activities involved in educating and instructing in order to impart knowledge or skill (Cox & Marshall, 2017). Learning on the other hand is the acquisition of knowledge or skills through study, experience, or being taught (Saad, 2013). Learning is mostly interpreted as the process of acquiring knowledge, theories and values that relate to sustainable development but it also prioritises the changing of minds and active engagement of the learner in matters relating to more sustainable future (Ministry of Education and Higher Education [MEHE], 2012).

Learning is the cognitive process of acquiring knowledge or skills (Kreijns, Vermeulen, Kirschner, Van Buuren & Van Acker, 2013). Teaching and learning is a process that consist of many variables and these variables interact as learners pursue their goals and incorporate new skills, knowledge and behaviour that add to their learning experiences (Kazan, 2015). Despite the variance between the two concepts in terms of meaning, they are interrelated in practice. Even though there can be learning without the practical art of teaching, teaching on the other hand can hardly take place without a learner (Kenny, 2012). In view of this, the two concepts have been treated concurrently to aid discussion. Before beginning any lesson or activity, the teacher should ensure that students know what they will be learning and why it is important for them to learn it (Saad, 2013). The teacher is mandated to give students a general knowledge or an overview of the content of the activity, and a structure or method within which they can understand and connect the details of what will be presented by the teacher (Ahmadi et al., 2011).

Such knowledge of the nature of the activity and the structure of its content helps students to focus on the main ideas and order their thoughts effectively (Kreijns et al., 2013). Knowing the general content of the activity is termed Content Knowledge and the structure or method within which the student can understand the activity is also known as pedagogic knowledge (MEHE, 2012). A teacher needs to be abreast with the nature and content of what he/she is to deliver, and the structure or method within which he/she will deliver, in order to be able to present it well to the understanding of the students (Amer & Jaber, 2012). Meaning, for a complete cycle of teaching and learning to take place, theory must be accompanied by practice. Therefore, the provision of teaching and learning materials and other resources to aid both theory and practice must be given utmost attention.

In teaching and learning, the learner discovers, draws in from the outside, and make that which is drawn a real part of them (Kazan, 2015). While trying to pass on knowledge to the learner, it is necessary to make sure the leaner is able to understand what is being taught in its practical sense, thus making what is learnt a real part of the learner, as it reflects in the daily life and activities of the learner (Niederhauser & Stoddart, 2011). In this context, it is necessary that, lecturers integrate ICTs in learning such that, these trainees will inextricably embed IT technologies in their teaching philosophy in order to enhance performance. This is because, skills practiced extensively tend to be retained indefinitely, whereas skills that are mastered only partially tend to deteriorate (Saad, 2013). Most skills included in school curricula are learned best when practice is dispersed across time and rooted within variety of tasks (Cox & Marshall, 2017). Thus, it is important to follow up through initial teaching with occasional review activities and with opportunities for students to use what they are learning in a variety of application contexts (Saad, 2013).

It is important for the development goals of any country to direct its education towards skill acquisition than just the theoretical orientation of concepts. For teachers to be able to bring all students to the level of understanding and skill acquisition, they will need a new generation of books and other instructional tools (IT inclusive). In other words, reaching demanding goals in education requires having access to appropriate technologies that can help in reaching those goals (Rehmat & Bailey, 2014).

Tutoring has been an effective means of teaching and learning in most Ghanaian learning institutions and across the world (Cox & Marshall, 2017). It is therefore in the right direction that Universities in Ghana have made it a policy to reduce the large class sizes into smaller ones in order to balance the lecturer/student ratio (Bingimlas, 2013). Also, the use of teaching assistants to support teaching and learning has greatly been encouraged. Tutoring directs learning to student's needs, hence teaching one student or a small number with the same abilities and instructional needs can be very effective and yields great teaching and learning outcome (Rehmat & Bailey, 2014). Lecturers are therefore admonished to help students to learn by seeking the active participation of students. The background of the student must also be considered throughout the learning process. This is because students' background turn to shape the understanding and truth the student creates, and the knowledge and skills the student acquires through the learning process (Bingimlas, 2013).

Assessment is one of the means by which learning is established, and it gives the teacher opportunity to measure the absorption rate or otherwise of the learner. Besides tests and quizzes, students' assessment should address the full range of objectives or intended outcomes of not only their knowledge but also the thinking and practical skills of students, content-related values and dispositions (Rehmat & Bailey, 2014); this is an opportunity which IT provides in the contemporary world. It should also be directed towards planning curriculum improvement. The learner develops their conceptual understanding through repeated attempts to achieve a particular goal, and then reflecting on how well they succeeded in achieving that goal (Youssef, 2010). By so doing, they gain more insight and understanding of a particular knowledge or skill acquired, making the application of acquired knowledge or skill easier for them. In this way, it becomes easier to also develop appropriate structure or method to transmit these acquired knowledge to another person.

2.3.3 Teaching and Learning Technologies

Talking in a positive sense, the impact of technology on education has been phenomenal. Using Internet and computers as an effective medium to establish communication between schools, teachers, students and parents; educational institutes have been able to handle many issues that were previously not handled with ease due to geographical limitations or lack of adequate training technologies (Boote, 2014). The effective use of technology must be supported by significant investments in hardware, software, infrastructure, professional development, and support services (Kreijns et al., 2013). While complex factors have influenced the decisions for where, what, and how technology is introduced into educational institutions (Amer & Jaber, 2012) ultimately, the schools will be held accountable for these investments. While many different terms have been used to describe what students need, such as digital literacy, technological literacy, and 21st century skills, education leaders, nationally and internationally, are beginning to come together around a new common definition of what students need to know, Information and Communication Technology (ICT) Literacy.

Various technologies deliver different kinds of content and serve different purposes in the classroom. For example, word processing and e-mail promote communication skills; database and spreadsheet programmes promote organisational skills; and modelling software promotes the understanding of science and mathematics concepts (Alotaibi, 2011). It is important to consider how these electronic devices differ and what characteristics make them important as vehicles for education (Alkanani, 2012). Technologies available in classrooms today range from simple tool-based applications (such as word processors) to online repositories of scientific data and primary historical documents, to handheld computers, closed-circuit television channels, and two-way distance learning classrooms (Ahmadi et al., 2011). Even the cell phones that many students now carry with them can be used to learn (Niederhauser & Stoddart, 2011). Each technology is likely to play a different role in students' learning. Rather than trying to describe the impact of all technologies as if they were the same, researchers need to think about what kind of technologies are being used in the classroom and for what purposes.

Two general distinctions can be made. According to Bingimlas (2013), students can learn "from" computers (where technology is used essentially as tutors and serves to increase students' basic skills and knowledge) and can learn "with" computers (here technology is used a tool that can be applied to a variety of goals in the learning process and can serve as a resource to help develop higher order thinking, creativity and research skills). Technological aids not only break the monotony to grab students' attention, foster inquiry and increase interest but also improve comprehension and stimulate retention (Boote, 2014). Classes become more interactive, engaging and collaborative as students move from passive reception to active discovery and learning (Shúilleabháin, 2013). Effective teaching is strongly influenced by the manner in which teachers use ICT tools or technologies in the teaching and learning process and not only how the various ICT tools function (Kreijns et al., 2013).

By implication, the teachers' knowledge in the functions of the various ICT tools is not enough for the effective teaching and learning outcome, but the ability of the teacher to practically use the ICT tools is very crucial for effective teaching (Alotaibi, 2011). As such, in the context of science teachers, when these ICTs are integrated into their learning programmes, these teachers will be better able to use these technologies with ease in the classroom which will have a consequential impact on their skills, competencies and overall performance. Mention must be made that technology is the application of human or scientific knowledge to practical problems (Webb & Cox, 2014). In the context of this work, teaching and learning technologies refer to all ICT hardware and software tools that can be used to enhance teaching and learning (Niederhauser & Stoddart, 2011).

ICT consists of the software, hardware, media and networks for the collection, processing, transmission, storage and presentation of information (data, voice, text, and image) and its related services (Shúilleabháin, 2013). They include the use of computers, DVD/CD-ROM, projectors, web-based multimedia training, interactive media, modems, satellites, teleconferencing, webcast (live video streamed over the web), interactive whiteboards and other technological means (Rehmat & Bailey, 2014). DVD/CD-ROM technology enhances learning mobility. A computer and a source of electricity allow learners to carry volume of information on DVD/CD-ROM with them (Baek, Jong & Kim, 2018). It gives the learner, access to quality information at locations where they may not gain access to the library and the internet. The use of interactive whiteboard and software plays a potential role in conjoining the teacher's "personal curriculum" to the knowledge of students in the classroom settings (Bingimlas, 2013).

The use of some music software package (for example, fruity Loops, Acids Xpress and Dance eject) enables students to compose within various contemporary styles of music that are clearly important in young peoples' social and cultural lives (Webb & Cox, 2014). The results of the music design initiatives indicate that this can lead to increase motivation and engagement in school activities. The internet also as an IT tool in education provides the platform for teaching to take place across boundaries

(Rehmat & Bailey, 2014). Using such resources as teleconferencing, webcasting, and web-based multimedia has aid teachers to provide teaching to learners from a distance (Alotaibi, 2011). Some universities around the world run online programmes for distance students. The system offers both in-campus and off-campus access to students and gives them opportunity to interact with each other and with their lecturers through webcasting (Boote, 2014).

Videoconferencing systems use a regulated band of frequencies and allows remote participants to be connected live by telephone lines (Baek et al., 2018). Video conferencing systems can support distant collaborative learning. Students can have group discussions and tutorial sections through video conferencing (El-Daou, 2015). Skype is another internet facility that can be utilised by educators to enhance teaching and learning activities. Skype is a software application that also allow students to make voice and video calls and chats over the internet (El-Daou, 2015). Currently, Zoom, WhatsApp and Facebook live video calls are also available to support online interaction between lecturers and students and amongst students thereby bridging the limitations of time and space on teaching and learning. Even though digital tools are rarely developed with the needs of formal teaching and learning in mind (Baek et al., 2018), with the internet now available in most University Campuses in Ghana, educators can take advantage of the vast resources and potentials of the internet to support teaching and learning in so many ways. This will make the training of prospective teachers more real and modern.

Aside discussion groups, lecturers can conduct assessments and evaluations via the internet. Students watch videos of what they have learnt on YouTube thereby enhancing their understanding of what they have been taught (Ahmad, Kumar, Nehra

& Kumar, 2012). The continual use of these tools in a trainee's student years, will enhance the possibility that, these trainees would use them during their career in the classroom, thereby enhancing performance. It is common knowledge that, computers have changed the traditional classroom experience from perceptive learning to a visual, web-based and virtual learning experience (El-Daou, 2015). Moreover, different visual formats facilitate ease of learning and an enhanced retention period for the learners (Ahmad et al., 2012). The different pedagogies available for teachers enable them to improve not only teaching but also create personalised learning plans since all students do not learn the same way (Baylor & Ritchie, 2012).

There is a wide variety of audio/visual/technological tools that can be utilised in different ways to help teachers teach and students learn (Baek et al., 2018). The simplest visual representation is with an overhead projector and transparencies to present text, graphs illustrations, photographs, and cartoons (Ahmad et al., 2012). Video documentaries and audio- tapes are used so that students can actually view and better understand theoretical concepts like human anatomy or the eclipse phenomena (Webb & Cox, 2014). Teachers can effectively use ICT tools such as the computer, internet and mobile phones, the array of teaching aids and online services including email, online chats, Facebook, twitter, forums, blogs, slideshows, search engines, interactive whiteboards, videoconferencing, and so on, to communicate with students, ask questions, solve doubts, answer queries, give assignments, send reminders, coordinate group activities or even have a group discussion out of the class (Ahmad et al., 2012). Such virtual interactions encourage a running dialogue of thoughts, comments, reflection and feedback overcoming limitations of time, distance and even students' shyness (Baylor & Ritchie, 2012).

Teachers can post course material, a lesson presentation or other important information on the internet, enabling students to quickly access them anytime they want (Wong & Li, 2018). This can be replete with links to relevant definitions, background information, audio, images, animation, and so on (something that is missing in traditional books/lectures). This will help arouse students' curiosity and invite them to explore (Abbit, 2011). Teachers can go a step ahead and use an e-group to organise interactive quizzes or even conduct polls that help students understand how their opinions relate to the lessons (Alotaibi, 2011). Different computer programmes like word processors, PowerPoint, databases and spreadsheets help teachers organise, evaluate and present information in a quick and interesting way (Webb & Cox, 2014). Another use of these computer s is keeping track of students' grades/progress. Teachers can use software products and multimedia components to design and deliver rich, engaging and visually stunning presentations (Abbit, 2011).

Students can even view real phenomena and processes with simulations that help them to easily relate to the principles and concepts (Boote, 2014). Educators can also run websites with Learning Management Software (like Moodle, Edmodo, and Canvas) to not only deliver content but also build collaborative communities of learning (Baylor & Ritchie, 2012). These sophisticated tools also support self-paced learning. Options like CDROMs, e-books, podcasts, smart boards, Skype, YouTube videos are also open. The web offers a variety of options for students. They can easily conduct research with Google or Wikipedia, use Microsoft Office for creating a project, air different perspectives for solving a problem on Blogger and share ideas with other students through MSN Messenger/Facebook/Twitter, sometimes even to the extent of collaborating in real-time with another class across the globe (Thomas & Palmer, 2014). This enhances their thinking, problem-solving and creative skills.

2.3.4 Integration of ICT into Teaching and Learning

Technology is a means for improving education and not an end in itself (Bhasin, 2012). Integrating ICT into teaching and learning is not a new concept; computer integration in the classroom is the application of technology to assist, enhance, and extend student knowledge (Shúilleabháin, 2013). However, ICT in education means more than just teaching students (in this context, student teachers) how to use computers. Thus, ICT should also be used to promote information literacy, with the capacity to access, use and appraise material from various sources in order to enhance learning events to solve difficulties and to craft awareness (Adarkwah, 2021; Abbit, 2011). Technology literacy is totally different from being able to integrate technology into teaching to enhance learning. In other words, doing "digitally fluent", means, not only know how to use the technological tools, but how to construct things of significance with those technological tools.

Teachers do not only need to learn about technology, but they need to learn how to use technology to enhance their learners' understanding and critical thinking skills (Baylor & Ritchie, 2012). Enhancing basic information and communication skills like speaking, reading and writing, should rather be the focus of using ICT in education, but not simply being ICT literate (Thomas & Palmer, 2014). A wide range of learning technologies should be selected and incorporated into educational programmes and that technology integration should consider learning pedagogy, the pattern of student teachers ' use of ICT, and the extent of use in teaching and learning programmes (Abbit, 2011). E-learning is an example of the use of these ICT supported teaching and learning methods whose use in educational institutions is gaining momentum with the passage of time (Bosse & Törner, 2015). Teachers acknowledge ICTs as tools for building knowledge mediated by collaborative activities that are relevant for participation in future society and guide towards an authentic problem (Antwi-Boambong, 2020; Granić & Marangunić, 2019). However Amedeker (2020) revealed that despite the various policies and professional developmement sessions organised for teachers towards the effective usage of ICTs, its actual implementation has remained at the policy level and has had little impact on the actual teaching of science at the classroom level.

Teachers collaborating among themselves are important as it provides the platform to contribute to the pedagogical uses of ICTs in the classroom (Bhasin, 2012). Basically, when we talk about technology integration in education in this study, it literally and usually mean computer technology (Granić & Marangunić, 2019). However, mention must be made that the blackboard and chalk are also technologies, as much as charts models and animations; simulations and videos are all technologies that can be used to enhance teaching (Wong & Li, 2018). Mention must also be made that technology is merely a method of doing something. Teacher education is neither mere pedagogy nor acquisition of training qualification (Youssef, 2010). Globalisation and shift to a knowledge-based economy require that educational institutions develop in the individual the ability to transfer information into knowledge and to apply the knowledge in dynamic cross-cultural contexts (Granić & Marangunić, 2019).

Generally, teachers accept being trained on using technologies through courses, seminars and workshops. Most nations have limited resources for teacher training; as such, they must adopt cost-effective strategies by making judicious use of resources (Jung, 2015). The author further says that a well-designed teacher training programme is essential to meet the demand of today's teachers who want to learn how to use ICT effectively for their teaching (Baylor & Ritchie, 2012). This study is to investigate how technology integration in pedagogical training of teachers will affect trainees' performance in the field. It must be made clear that, merely learning ICT skills is not enough but using the ICT skills to improve the teaching and learning is the key for pedagogy-technology integration (Wong & Li, 2018). But the question is how we can combine these two. As it is, now the situation seems to be left to the discretion of the trainer concerned. Thus, an innovative trainer will use images, play video of real time situation or even animate objects to explain critical concepts (Bhasin, 2012). Practicing teachers must then use whatever knowledge they gained from ICT integration courses. This can be attained by incorporating these practices within the classroom and avoid the risk of losing the acquired knowledge (Thomas & Palmer, 2014).

Within the Ghanaian Educational Setting, the curriculum has made provisions for the effective integration of ICT by teachers (Agyei & Voogt, 2011). NaCCA (2019) stressed that under the current dispensation, ICT is expected to serve as a key pedagogical tool in the basic school. Thus Adarkwah (2021) recommended the identification and elimination of barriers to effective e-learning in jurisdictions such as Ghana, particularly in rural areas where ICT resources are either unavailable or inadequate.

2.3.5 ICT Integration in Teacher Education

Continuing training and development is necessary to maintain teachers' competencies: for pedagogical and professional portfolio reform, and to learn new skills and approaches (Youssef, 2010). Teachers' ICT training can be of a higher priority than hardware and software availability. Planning for integration of ICT in the curriculum has to include teachers' professional development and ICT infrastructure (Granić & Marangunić, 2019). Agyei and Voogt (2011) stressed on the key emphasis placed on the use of ICT for supporting effective teaching and learning by teachers. However the training of teachers does not adequately prepare them to use ICT in their classrooms (Agyei & Voogt, 2011). The quality of the school's ICT equipment is immaterial if teachers do not have the required competencies, and authorities should recognise the value of attaining and retaining appropriate skills. As a result of pedagogical and technical advances, teachers require access to continuous skill and knowledge opportunities to maintain their positions in the evolving standards in these fields, and this factor is recognised by all capable educational authorities (Youssef, 2010).

Professional development of teachers sits at the heart of any successful technology and education programme. Teachers' professional development is a key factor to successful integration of computers into classroom teaching (Alkanani, 2012). Adarkwah and Huang (2023), stressed that although young adults' attachment to ICT is expected to boost the usage of this technology in educational delivery, there are various bottle necks that prevent this expectation from being achieved so far as higher education is concerned. Amedeker (2020) observed that ICTs integration in science teaching at the senior high school level is inhibited by lack of effective coordination as well as a flurry of policy implementation procedures.

Many school leaders perceive the lack of ICT related knowledge of teachers as one of the main impediments to the realisation of their ICT related goals (Thomas & Palmer, 2014). One of the pertinent factors contributing to the usage of computer is that teachers need to be computer literate and thus be given appropriate training in computer usage (Wong & Li, 2018). Different people hold different views about computer literacy. They are those who take a literal interpretation of computer literacy. They regard writing and reading computer programmes as the basic skill of a computer-literate person (El-Daou, 2015). Training too plays an important role in a teacher's readiness to use computers (Jung, 2015). With regards to the issue of having attended formal computer courses, it was identified through numerous studies that there is a significant relationship between usage of computers and computer training (Hussain, 2018).

Professional development is one of the most important support in most schools for ICT integration into teaching as it has the greatest impact on the beliefs and practice of teachers and yet professional development time was not budgeted for in many schools (Jung, 2015). Professional development has a significant influence on how well ICT is embraced in the classroom (El-Daou, 2015). As compared to mathematics teachers, science teachers' perceived professional development needs of ICT use in context to teaching and learning is significantly higher (Hussain, 2018). But both mathematics and science teachers rank as professional development needs at the second place (Bosse & Törner, 2015). Teachers; technology skills are thus strong determinant of ICT integration, but they are not conditions for effective use of technology in the classroom (Wong & Li, 2018). For instance Agyei (2015) revealed that even though teachers received professional training on how to integrate ICT in lessons, their usage of ICT was limited to their own professional development at the expense of actual classroom implementation.

This supports the argument that, training programmes that concentrate on ICT pedagogical training instead of technical issues and effective technical support, help teachers apply technologies in teaching and learning which enhances performance. When technology is introduced into teacher education programmes, the emphasis is often on teaching about technology instead of teaching with technology (Alkanani, 2012). Hence, inadequate preparation to use technology is one of the reasons that teachers do not systematically use computers in their classes; Teachers need to be given opportunities to practice using technology during their teacher training programmes so that they can see ways in which technology can be used to augment their classroom activities (Bosse & Törner, 2015). Teachers' understanding of content knowledge and how to apply technology to support students' learning and attainment are joined to their increase in knowledge level, confidence and attitudes towards technology (El-Daou, 2015). As such, professional training courses must be designed to identify beliefs about successful teaching, policies for enhanced teaching and learning and syllabus design for teaching purposes (Hussain, 2018).

Clearly, it is imperative to allow student teachers to apply ICT in their programmes when in school in order to be able to use the technology to supplement their teaching activities (Fortunasari, 2016). Teachers when given time to practice with the technology, learn, share and collaborate with peer, it is likely that they will integrate the technology into their teaching (Goos, 2014; Buabeng-Andoh, 2017). Training programmes for teachers that embrace educational practices and strategies to address beliefs, skills and knowledge improve teachers' awareness and insights in advance, in relation to transformations in classroom activities should be encouraged (Fortunasari, 2016). Training thus makes a positive difference to those who receive it. Teachers who receive eleven or more hours of curriculum-integration training are five times more likely to say they believe they are much better prepared to integrate technology into their classroom lessons than teachers who received no such training (Kenny, 2012). Teachers receiving more training of either type, but especially of integration training, are more likely to use software to enhance instruction in their classrooms (Isisag, 2012).

Several empirical findings provided an insight that the variable, training in computer usage has a positive impact on Actual Usage of Computer (AUC) and hence increasing performance of teachers (Jung, 2015). The number of computer skills acquired by teachers, its currency, and the number of hours of formal training play an important role in positioning the AUC of teachers in a higher level (Isisag, 2012). When teachers are being trained the expertise expected increases in competence. Professional development and the continuing support of good practice are among the greatest determinants of successful ICT integration (Bosse & Törner, 2015). This thus presupposes that, training programmes that concentrate on ICT pedagogical training instead of technical issues and effective technical support, help teachers apply technologies in teaching and learning. If training programme is of high quality, the period for training lasts longer, new technologies for teaching and learning are offered, educators are eagerly involved unimportant context activities, teamwork among colleagues is improved and has clear vision for student's attainment (Hussain, 2018).

Teachers may adopt and integrate ICT into their teaching when training programmes concentrate on subject matter, values and the technology (Goos, 2014). Similarly, teachers require expertise in technology to show them the way to integrate ICT to facilitate students' learning (Fortunasari, 2016). Teachers' understanding of content knowledge and how to apply technology to support students' learning and attainment are joined to their increase in knowledge level, confidence and attitudes towards technology (Giordano, 2017). Educators who integrate technology with new teaching practices gained through professional training can transform the performance of the students (Hussain, 2018). The issue of training is certainly complex because it is important to consider several components to ensure the effectiveness of the training (Jung, 2015). These are time for training, pedagogical training, skills training, and an ICT use in initial teacher training (Alkanani, 2012). Similarity, teachers want to learn how to use new technologies in their classrooms but the lack of opportunities for professional development obstructed them from integrating technology in certain subjects such as science or maths (Fortunasari, 2016).

However, some problematic issues related to professional development in ICT are that training courses are not always differentiated to meet the specific learning needs of teachers and the sessions are not regularly updated (Isisag, 2012). Pre-service teacher education now becomes crucial in its role in providing opportunities for experimentation with ICT before using it in classroom teaching (Giordano, 2017). Lack of an ICT focus in initial teacher education is a barrier to teachers' use of what is available in the classroom during teaching practice (Goos, 2014). Again, teachers have a strong desire for the integration of ICT into education but that they encountered many barriers to it (Bingimlas, 2013). The major barriers are mostly lack of confidence, lack of competence, and lack of access to resources (Giordano, 2017). Since confidence, competence and accessibility have been found to be critical components for technology integration in schools, ICT resources including software and hardware, effective professional development, sufficient time, and technical support need to be provided for teachers (Clark-Wilson et al., 2014).

No one component in itself is sufficient to produce good teaching. However, the presence of all components increases the likelihood of excellent integration of ICT in learning and teaching opportunities (Goos, 2014). Teachers' professional development is a key factor to successful integration of computers into classroom teaching as aforementioned. ICT related training programmes develop teachers' competences in computer use (Clark-Wilson et al., 2014). Teachers have to integrate information and communication technologies with teaching and learning processes (Raman & Mohamed, 2013). However, integrating technology into teaching cannot be achieved overnight. Integration of ICT in teacher education will have to follow some stages, with the first stage being that, these teachers will tend to use the technology almost not at all, however later on; they consider the technology as an instrument which necessities to be taught. As the use of technology increases, they tend to perceive it as an instrument to aid the instruction, rather than being a core educational topic (Isisag, 2012).

Professional Development (PD) programmes induce a positive impact not only on developing the information technology skills of teachers, but also on their familiarity with ICT as a curricular tool to some degree while, it had a very limited impact on the classroom practice (Clark-Wilson et al., 2014). While most of the teachers, who enter PD programme, expanded their knowledge, skills, ideas, and their lesson plan repertoire through these learning experiences; only a one-third of them are considered as proficient apprentices at the end of the programme (Bosse & Törner, 2015). Notwithstanding this, PD programme are capable of increasing the technology usage skills, whereas it failed to induce substantial change for the technology integration in the classroom (Kopinska, 2013).

2.3.6 Concept of Misconceptions

A misconception is well-known as a barrier to students in learning science. Some topics in science learning are always giving misconception to novice students, and there have been various kinds of diagnostic assessment used by researchers to identify student misconceptions in science (Soeharto, Csapó, Sarimanah, Dewi & Sabri, 2019). Misconceptions impede the students' conceptual understanding of science learning. Misconceptions are considered to have occurred if the students' understanding of a concept differs from what is understood by the scientific community (Widiyatmoko & Shimizu, 2018). Before being involved in formal learning, students bring certain concepts that they have acquired through interaction with the environment related to scientific phenomena. With that experience, they develop alternative concepts about the science phenomena in their mind, which are not always correct. The concept that is irrelevant with scientific concepts is called a misconception (Kopinska, 2013). The importance of prior knowledge and the struggle to replace that knowledge with or help that knowledge evolve into scientifically-sound knowledge has spurred a large tradition of research in developmental and instructional psychology and science education (Raman & Mohamed, 2013).

The prefix to the most common term - misconception - emphasises the mistaken quality of students' ideas (Raman & Mohamed, 2013). Terms that include the qualifier – alternative - indicate a more relativist epistemological perspective. Students' prior ideas are not always criticised as mistaken notions that need repair or replacement but are understood as understandings that are simply different from the views of experts (Kopinska, 2013). Students' alternative conceptions are incommensurable with expert concepts in a manner parallel to scientific theories from different historical periods (Shafwatul et al., 2019). Preconceptions and naïve beliefs emphasise the existence of student ideas prior to instruction without any clear indication of their validity or usefulness in learning expert concepts (Raval, 2014). However, researchers who have used them have tended to emphasise their negative aspects. This epistemological dimension emphasises differences in content. The content of student conceptions (whether mistaken, preexisting, or alternative) is judged in contrast to the content of expert concepts (Suprapto, 2020).

2.3.7 Types of Misconceptions

Preconceived notions: These are popular conceptions based on incomplete observations or previous experiences [example, ground water exist as underground rivers] (Mokos & Čižmek, 2020).

Nonscientific beliefs: These include conception learned by students from non-scientific sources, such as religious or mythical teachings (Mokos & Čižmek, 2020). For instance, reason for the extinction of species by predicted flood (Shafwatul et al., 2019).

Conceptual misunderstandings: These are based on misapplying a general principle or example. For instance, blood flows like ocean tides, or tornadoes are attracted to mobile home parks (Suprapto, 2020).

Vernacular misconceptions: These are based on misunderstanding about the meaning of the words, notably Sun "rises" and "sets" (Mokos & Čižmek, 2020).

Factual misconceptions: These are falsities, often learned at an early age and retained unchallenged into adulthood (Mubarokah, Mulyani & Indriyanti, 2018).

2.3.8 Sources of Misconceptions

After the comprehension of the concept misconception, the sources of misconceptions have been conceptualised by the researcher.

Book/ Reference Material: The book may not have adequate references or evidences. It may have ambiguous content presented in skeptical language. The books and references may not have comprehensive and sufficient examples to help users understand specific concepts (Shafwatul, Widodo, Sopandi & Wu, 2018).

Teachers' Language: The language is a powerful tool to communicate. The teachers' communicative language may affect the learning of the students and misconceptions in the concepts of science may emerge (Suprapto, 2020). The teachers' language in vernacular medium may also create misconceptions (Shafwatul et al., 2019). Science learning is enacted in classrooms mainly through the interactions between teachers-students, students-students, students-materials, and teachers-materials (Kaniawati et al., 2019). In the science classroom, the teacher is perceived to be the dominant figure to provide the direction for learning. Thus, the roles played by science teachers are necessary for shaping students' experiences of science learning and sometimes teachers are propagating misconceptions to students (Mokos & Čižmek, 2020).

Family Members/ Parents: The scientific temper of the family members especially elders, also influences on the students' understanding with reference to scientific concept (Kaniawati et al., 2019). The role allocated to the family members may hamper scientific thinking and concept formation.

Students Peer groups: The peer group is more influential in the form of informal learning of the students, especially for school going children as the abstract thinking along with rules, values, commitments are determined with consensus of peer group students (Kaniawati et al., 2019).

Cultural beliefs: The beliefs of an individual and family background along with religion, community, rituals, traditions, society where she or he stays also matters misconceptions (Kaniawati et al., 2019).

Media: The media is the most powerful tool as it forms or develops the thinking approach of individuals (Mubarokah et al., 2018). The TV channels propagating false beliefs without any scientific base in their serial content. The advertisement with fallacies and irrationality led misconceptions among students (Suprapto, 2020).

Students' Personal beliefs: Students personal beliefs influenced by the school, media, society, parents, peer group discussion, previous experiences and so on (Soeharto et al., 2019). This is one of the sources of students' misconceptions.

2.3.9 Teacher Performance

The way teacher effectiveness is defined influences how educational policy must be. In its narrowest form, teacher's effectiveness is often measured by their ability to improve student's standardised achievement test scores in core academic subjects, such as mathematics and reading (Little, Goe & Bell, 2009). Although this is one important aspect of teaching ability, it is not a comprehensive and robust view of teacher effectiveness.

There are several problems with defining teacher effectiveness solely in this way:

Firstly, Teachers are not exclusively responsible for students' learning – An individual teacher can make a huge impact; however, student learning cannot reasonably be attributed to the activities of just one teacher—it is influenced by a host of different factors. Other teachers, peers, family, home environment, school resources, community support, leadership, and school climate all play a role in how students learn.

Secondly, Consensus should drive research, not measurement innovations – Trends in measurement can be influenced by the development of new instruments and technologies. This is referred to as "the rule of the tool": if a person only has a hammer, suddenly every problem looks like a nail (Toh, Toh, Teo & Zhu, 2021). It is possible that the increase in data linking student achievement to individual teachers and new statistical techniques to analyse these data are contributing to an emphasis on measuring teacher effectiveness using student achievement gains (Toh et al., 2021). This, in turn, may result in a narrowed definition of teacher effectiveness. Instead, important aspects and outcomes of teaching should be defined first; then, methods should be used or created to measure what has been identified. In other words, define the problem; then choose the tools.

Thirdly, Test scores are limited in the information they can provide – Information is not available for some non-tested subjects and certain student populations. Furthermore, basing teacher effectiveness on student achievement fails to account for other important student outcomes. Student achievement gains do not indicate how successful a teacher is at keeping at-risk students in school or providing a caring environment where diversity is valued (Toh et al., 2021). This method does not provide any additional information on student learning growth beyond the data gleaned through standardised testing. Standardised testing cannot provide information about those who teach early elementary school, special education, or untested subjects (e.g., art and music). It cannot evaluate the effectiveness of teachers who co-teach and does not capture teachers' out-of-classroom contributions to making the school or district more effective as a whole.

Learning is more than average achievement gains – Prominent researchers have promoted the idea that definitions of teacher effectiveness should encompass student social development in addition to formal academic goals (Bafadal, Nurabadi, Soepriyanto & Gunawan, 2020). Improving student attitudes, motivation, and confidence also contributes to learning. If the concept of effective teaching is limited to student achievement gains, differentiating between these factors becomes impossible. Was a teacher deemed effective because they focused class time narrowly on test-taking skills and test preparation activities? Or did the student achievement growth result from inspired, competent teaching of a broad, rich curriculum that engaged students, motivated their learning, and prepared them for continued success? Teacher evaluations should be able to distinguish the former approach from the latter. Given these critiques, a broader and more comprehensive definition of teacher effectiveness is necessary.

The following five-point definition from Goe, Bell and Little (2008) is intended to focus measurement efforts on multiple components of teacher effectiveness. It is not proposed as a criticism of other useful definitions but as a means of clarifying priorities for measuring teaching effectiveness.

A Research Synthesis presents a five-point definition of teacher effectiveness developed through an analysis of research, policy, and standards that addressed teacher effectiveness (Kusumaningrum, Sumarsono & Gunawan, 2019). After the definition had been developed, the authors consulted a number of experts and strengthened the definition based on their feedback. "The five-point definition of teacher effectiveness (Goe et al., 2008) consists of the following:

1. Effective teachers contribute to positive academic, attitudinal, and social outcomes for students such as regular attendance, on-time promotion to the next grade, on-time graduation, self-efficacy, and cooperative behaviour (Kusumaningrum et al., 2019).
2. Effective teachers use diverse resources to plan and structure engaging learning opportunities; monitor student progress formatively, adapting instruction as needed; and evaluate learning using multiple sources of evidence.
3. Effective teachers contribute to the development of classrooms and schools that value diversity and civic-mindedness.
4. Effective teachers collaborate with other teachers, administrators, parents, and education professionals to ensure student success, particularly the success of students with special needs and those at high risk for failure" (Goe et al., 2008, p. 8).
5. Effective teachers have high expectations for all students and help students learn, as measured by value-added or other test-based growth measures, or by alternative measures.

For the purpose of this study teacher effectiveness will be measured by the Value-Added Approach.

Value-added models provide a summary score of the contribution of various factors toward growth in student achievement (Milanowski, 2011). The statistical models are complex, but the underlying assumptions are straightforward: students' prior achievement on standardised tests can be used to predict their achievement in a specific subject the next year (Kusumaningrum et al., 2019). When most students in a particular classroom perform better than predicted on standardised achievement tests, the teacher is credited with being effective, but when most of his or her students perform worse than predicted, the teacher may be deemed less effective (Little et al., 2009). Some models take into account only students' prior achievement scores; others include student characteristics (e.g., gender, race, and socioeconomic background); and still others include information about teachers' experience (Gewirtz, Maguire, Neumann, & Towers, 2021).

Value-added models are relatively new measures of teacher effectiveness, and supporters of their use (Gewirtz et al., 2021) argue that they provide an objective means of determining which teachers are successful at improving student learning. It is possible for teachers who are evaluated using classroom observations or other teaching measures to receive a high score but still have students with average or below-average achievement growth; however, value-added models directly assess how well teachers promote student achievement as measured by gains in standardised tests (Milanowski, 2011). This is particularly important as this study uses a pre-test-post-test approach to measure teacher performance after these teachers have undergone ICT-based training. Other researchers argue that these models are not yet fully understood and are theoretically and statistically problematic (Gewirtz et al., 2021).

Value-added models have several advantages. They directly examine how a teacher contributes to student learning and are considered highly objective by some because they do not involve raters making subjective judgments. They are generally cost-efficient and nonintrusive; they require no classroom visits, and test score data are already collected for measurement purposes (Little et al., 2009). They can reveal variation among teachers in their contributions to student learning and may be particularly useful in identifying teachers who fall at the top and bottom of that continuum. This makes this model more important in this research. New or struggling teachers could benefit by observing teachers who are consistently deemed highly effective (Milanowski, 2011). Establishing these teachers' classrooms as "learning labs" for colleagues and researchers may provide valuable information about what practices and processes contribute to student achievement gains. Teachers consistently deemed less effective could be provided with help and support. However, value-added scores must be interpreted with caution (Little et al., 2009).

Teachers vary greatly in their value-added scores, even within schools, but that variation has not been consistently and strongly linked to what teachers do in their classrooms (Milanowski, 2011). It may be that the classroom observation instruments typically used are not sensitive enough to capture the differences that influence student achievement, or it may be that value-added scores are measuring other elements of teaching that have not yet been conceptualised (Bafadal et al, 2020).

2.4 Misconceptions in Science

Soeharto et al. (2019) provided information about an overview of the common science topics that students usually have misconceptions in, and diagnostic assessment used to identify students' misconceptions in science. They provided a comparison of every instrument with the weaknesses and the strengths reviewed from a total 111 articles that had published from the year 2015 to 2019 in the leading journal having the topic of students' misconceptions in science. The study revealed that 33 physics, 12 chemistry, and 15 biology concepts in science that mainly caused misconceptions to students. Furthermore, it found that interview (10.74%), simple multiple-choice tests (32.23%) and multiple tier tests (33.06%), and open-ended tests (23.97%) are commonly used as diagnostic tests. However, every kind of test has benefits and drawbacks over the other when it is used in assessing student conception.

Mubarokah et al. (2018) in a research, used a descriptive exploratory research design to diagnose students' misconceptions of acid-base concepts. A Three-Tier Diagnostic Test (TTDT) with 20 items was administered to 72 Thai and 64 Indonesian grade 12 students in the science programme. The semi-structured interview was used to probe their responses to the interview questions. The result indicated that most of the students had misconceptions of such concepts as acid-base theories, the strength of acids and bases, pH concept in electrolyte and non-electrolyte characteristics of acids and bases. The results shed more light on students' conceptual understanding.

2.5 Effects of ICT-based Instruction on Students' Performance

Khan et al. (2015) sought to investigate the impact of Information and Communication Technology (ICT) on students and their access to information in the Gomal University. They used a sample of 50 students and analysed results descriptively. The study showed that, many students consider ICT tools very helpful to do their assignments. Teachers observed that ICT enables students with special needs or difficulties to perform better. It also helps to reduce the social disparities among students, since they work in teams in order to achieve a given task. Students also assume responsibilities when they use ICT to organise their work through digital portfolios or projects. In addition, the study showed that ICT has significant impact on students and learning processes. Therefore, students plan their lessons more efficiently. ICT also help students to work in teams and share ideas related to the curriculum. There is also evidence that broadband and interactive whiteboards play a central role in fostering students' communication and increasing collaboration between educators.

The above study points to the fact that, ICT-based instruction has significant positive impacts on students' performance. However insightful, the study of Khan et al. (2015) was limited in terms of both contextual and geographical scope, for instance, the study focused on students in a single tertiary institution. As such, the outcomes of the findings may not be applicable to all students even in the country of conduct. Also, the study was not specific to students in teacher training courses and as such did little to speak to the potential impacts the use of ICT-based instructions may have on these students' performance. Finally, the use of means for the analysis implied that, the study failed to establish a robust statistical relationship between integration of ICT and performance of students although it pointed to some significant perspectives from the students.

Hussain, (2018) in his study, aimed to examine the effects of ICT-based learning using wiki on learning of students' vocabulary mastery at the junior high school. Although insightful, just like the study of Khan et al. (2015) the focus of the study of Hussain was not on student teachers. Hussain's focus on language acquisition however demonstrates the inherent importance of ICT based instruction on performance of learners (in the context of this study, trainees). As such, this study may serve only as inference purposes but not for making conclusive arguments on the effects of ICT based training on trainees' performance. Again, a focus on junior high school students implies that, the outcomes of the study of Hussain may not be applicable for adults and for that matter student teachers.

Coates and Humphrey (2014) surveyed three matched pairs of face-to-face and online principles of economics courses taught at three different institutions. The students' score in the Test of Understanding College Level Economics (TUCE) administered at the end of the semester is used as the measure of learning outcomes. After controlling for selection bias and differences in student characteristics, they report that the average TUCE scores is almost 15 percent higher for the face-to-face format than for the online format. These statistics implies that, ICT-based learning has no significant effects on students' performance. These findings come as a contradiction to the findings of Khan et al. and that of Hussain who found significant positive impacts. These contradictions further justify the need for a study of this nature. As the study of Coates and Humphrey (2014) and that of Khan et al. (2015) were conducted in two separate geographical regions, an argument can be made for country specific considerations such as robustness of educational system and the skill of trainers.

In a similar study, Skidmore and Anstine (2005) surveyed two matched pairs of on-campus and online courses, one in statistics, and the other in managerial economics. They reported that after controlling for student characteristics and selection bias, students in the online format of the statistics class exam scored 14.1% less than in the traditional format, whereas, for the managerial economics class the test scores within both formats were not significantly different. These statistics confirm the earlier findings of Coates and Humphrey (2014), but also contradict the findings of Hussain (2018) and Khan et al. (2015).

Sosin, Blecha, Agawal, Bartlett and Daniel (2014) constructed a database of 67 sections of introductory economics, enrolling 3,986 students, taught by 30 instructors across 15 institutions in the United States of America during the spring and fall semesters of 2012. The authors found significant but small positive impact on students' performance due to ICT use. But the authors show that some ICT seem to be positively correlated to the performance while the others are not. The smallness of the positive relationship between ICT use and students' performance again supports the issues of geographical disparities earlier raised. This further strengthens the need for this research in the Ghanaian context. However, one core limitation of all prior studies has been the absence of focus on teachers' competence and the use of basic statistical techniques. This serves as a significant gap to be addressed. Also, majority of studies in this respect have been conducted outside Ghana which makes the conduct of this study crucial.

Fuchs and Woessman (2014), used international data from the Programme for International Student Assessment (PISA). They showed that while the bivariate correlation between the availability of ICTs and students' performance is strongly and significantly positive, the correlation becomes small and insignificant when other student environment characteristics are taken into consideration. Fuchs and Woessman (2014) reported two hypotheses explaining the mixed results shown in the literature. The first one run down to the point that everything else equal, ICT constitute an input in students' learning process that should help produce better learning output. ICT use can enhance learning by making education less dependent on differing teacher quality and by making education available at home throughout the day. Authors argue that the use of ICTs can positively infer knowledge to students. Furthermore, ICT use can help students exploit enormous information possibilities for schooling purposes and can increase learning through communication. This further entrenches the conduct of this study.

ICT based instruction induces reallocations, substituting alternative, possibly more effective forms of instruction. Given a constant overall instruction time, this may decrease student performance. Also, given that budgets are not perfectly elastic, the introduction of ICT based instruction can result in a reallocation of funds in favour of ICTs, possibly substituting more effective instructional materials. ICTs can distract learning. This may be particularly salient at home, where computers may be used mainly to play computer games and Internet access could be source of distraction because of chat rooms or online games, reducing the time spent in doing homework or learning. Thus, the impact of the availability of ICTs on student learning will strongly depend on their specific uses. ICT-based instruction could restrict the creativity of learner. ICT tend to allow acting only in a predefined way with limited interactive possibilities. This might reduce students' abilities in terms of problem solving and creativity thinking in predetermined schemes but not coming up with independent creative solutions by their own.

The analysis of the effects of these methodological and technological innovations on students' attitude towards the learning process and on students' performance seems to be evolving towards a consensus according to which an appropriate use of digital technologies in higher education can have significant positive effects both on students' attitude and achievement. However, due to some key digressions in the outcome of some empirical literature, it is necessary to conduct further investigation in this nexus to address the issue of geographical gap that exist in literature.

2.6 Effects of Technology Integration on Teachers Attitudes and Self-Efficacy

El-Daou (2015) explored the relationship of perceived teacher's self-efficacy to ICT usefulness and attitudes after training and the students' performance in science education; the impact of using technology on the science learning process, the students' interaction with their teacher and colleagues, their concentration, and participation in the class. The study was conducted with 11 teachers through questionnaires and interviews. Findings of this study revealed that teachers' self-efficacy in the level of technology use, and attitudes have significant effects on the grades and interaction of students with special needs. The results indicated that participants of group one, who were trained, were able to better define and apply technology in the science classroom than group two which was not being trained. Moreover, results indicated a significant positive Pearson correlation (r=.6) between teachers' self-efficacy, knowledge, attitudes, and special education students' science results. Although insightful, the use of correlation with a sample size as small as eleven teachers, was insufficient as the methodology in the quantitative elements were not robust enough. This as such endears the study for further investigation as to the actual effects of ICT-integration on teachers' self-efficacy and attitudes.

Uslu and Nilay (2012) observed that after professional development (PD) programmes, the teachers' technology usage for instruction were increased, both in classroom and out of classroom settings. This result is parallel with the studies revealing that the in-service training programmes increase the teachers' technology usage for preparation of education and instruction both in-classroom and out-classroom environments (Russell, O'Dwyer, Bebell & Tao, 2007; Van Braak, Tondeur & Valcke, 2004). The teachers who attended the assessed PD programme, inclined to motivate their students for using information technologies in a greater degree. The authors further found that, the teachers who attended the PD programmes encouraged their students in technology usage. This result is parallel to that of

Brinkerhoff (2006) who found that, technology usage was increased and that was sustained after a six weeks period.

Lavonen, Juuti, Aksela and Meisalo, (2018) indicated that the teachers did not stop using ICT when they started to use it for instruction. Many factors may contribute to these effects as per the authors. First of all, the long duration of PD programme may have contributed to this increase in Technology Integration. This indicates that, one-shot Professional Development programmes are ineffective. As per the study, the PD programme was scheduled as 30 hours for Web 2.0 course and 60 hours for ITP, a total of 90 hours timetable for five weeks. Thus, PD programmes aimed only to increase the technology usage skills are ineffective for integrating with the technology. At this PD programme it was aimed to increase both technology usage skills and also pedagogical skills for TI. During the first week for 30 hours, the teachers were instructed to learn the basic Web 2.0.v. technologies, which they would be able to use with their students. These activities contributed to enhance the teachers' skills and their confidence for using the ICT. Thereafter, the teachers discussed how to use these technologies for instructional purposes during the last 60 hours in the ITP. Glazer, Mahoney & Randall (2019) examined which kind of interactions influenced the peer-teacher efforts for integrating the technology in their classrooms and they found; "sharing ideas", "giving and seeking advice", "posing and responding to task-based questions" were the most used ones. Correspondingly, during the ITP, the teachers were required to communicate, share documents, and to collaborate via internet with the other teachers and instructor of the course. These interactions contributed to TI level of teachers. Besides, the inscription of lesson plans by the participant teachers on a collaborative, team-work manner, explaining how the teachers would implement these technologies in their classes had positively affected the TI too. Karagiorgi and Charalambous (2006) indicated that the social and collaborative dimension of PD increased the effectiveness of programme. Retention tests were conducted six weeks later after completing the PD programme. The findings of these tests demonstrated that, the teachers' increased level of integration with the technology as a consequence of the PD programme was retained after six weeks. This result is consistent with the studies in the literature (Harris, Mishra & Koehler, 2019; Kenny, 2012) indicating that increment at the level of TI is sustainable. The results obtained above showed that there were mixed results on the relationship between teachers training and ICT implementation. Majority of the studies showed that there was significant difference between ICT implementation and teachers training while few studies showed the opposite. For this reason, the researcher wants to conduct a further research on the same nexus to amalgamate the findings in the Ghanaian context.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter discusses the research methodology employed, research design, the population, sample and sampling technique, research instruments, validity and reliability of instruments, data collection procedure and the method of data analysis.

3.1 Research Paradigm

The philosophical assumption underpinning the study is the pragmatic paradigm. Pragmatism as a research paradigm finds its philosophical foundation in the historical contributions of the philosophy of pragmatism (Maxcy, 2003). As a research paradigm, pragmatism is based on the proposition that researchers should use the philosophical and or methodological approach that works best for the particular research problem that is being investigated (Tashakkori & Teddlie, 2003). It is often associated with mixed-methods or multiple-methods (Creswell & Clark, 2011), where the focus is on the consequences of research and on the research questions rather than on the methods.

Pragmatists believe in what works best in any given situation. A major underpinning of pragmatist epistemology is that knowledge is always based on experience. That is to say one's perceptions of the world are influenced by their unique experiences.

Since this study seeks to find out what works in relation to identifying and addressing issues regarding the conceptual understanding and academic performance of student teachers in science, it aligns clearly with the focus of the pragmatist viewpoint.

3.2 Research Approach

Creswell (2014) explains that research approaches are the plans and procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation. The factors that inform the decision to use a given research approach include the philosophical underpinning of the research, procedures of inquiry and specific methods of data collection, analysis, and interpretation. The selection of a research approach is also based on the nature of the research problem or issue being addressed, the researchers' personal experiences, and the audience for the study.

In line with the pragmatist paradigm, the study employed the mixed methods exploratory sequential research design which is a combination of both the quantitative and qualitative research approaches. Burke-Johnson et al. (2007) define mixed methods as the type of research in which a researcher or team of researchers combine elements of qualitative and quantitative research approaches to ensure in-depth understanding.

Mixed method involves the researcher collecting and analysing data based on both qualitative and quantitative approaches and integrating the findings in order to draw conclusions and make valid recommendations (Creswell & Tashakkori, 2007). According to Burke-Johnson et al. (2007) the researcher has to decide whether the approach will be purely mixed which gives equal status to both quantitative and qualitative information or whether it will be dominated by one approach or the other. In the present study, the quantitative approach was used more predominantly.

The researcher used this approach because the questionnaires and tests were deemed crucial for identifying the levels of conceptual understanding and academic performance of the student teachers, whilst the interview guides were relevant for obtaining in-depth understanding of student-teachers views and also seeking clarification on some of their responses to the questionnaire items. The use of this approach offered the researcher "the opportunity to compensate for inherent individual approach weaknesses, on inherent approach strengths, and offset inevitable approach biases as pointed out by Creswell (2014).

3.3 Research Design

The research design is intended to provide an appropriate framework for a study (Sileyew, 2019). Johnson (2008) describes action research as a systematic inquiry into one's own practices as a teacher. An action research design was used for this study. This research design was preferred because the researcher sought to find a workable solution by gathering data and taking necessary action to address an identified challenge within his working environment. Johnson (2012) asserts that action research bridges the gap between research and practice.

In the words of Stringer (2008), action research involves a systematic inquiry to improve social issues affecting the lives of people. In the field of education, it is a preferred method of data gathering and interventions by academic counsellors, educators, administrators and other key stakeholders for improvement in day-to-day school management and attainment of better learning outcomes among learners.

As noted by Mills (2011), action research has gained more prominence in recent times within educational circles. This may be partly due to the fact that researchers are usually active participants in the action and researchers of the action (Burns, 2015). Mertler (2014) further corroborates that action research is research that is conducted by educators for their own benefit.

Action research was the preferred research design because, the researcher was keen to make a change in the conceptual understanding and pedagogical approach of student teachers in his class. This is in line with Atiti's (2008) finding that, action researchers are change agents interested in resolving, dilemmas, predicaments or puzzles and making a change for a preferred future through systematic planning, data-gathering, reflection and further informed action.

Even though the findings of action research are not typically generalisable to other populations, it is possible that the evidence and recommendations can be implemented by instructors who practice in similar situations (Linder et al., 2014).

In undertaking the study, five key phases were followed.

These phases of action research as applied to this study are illustrated in Figure 4.

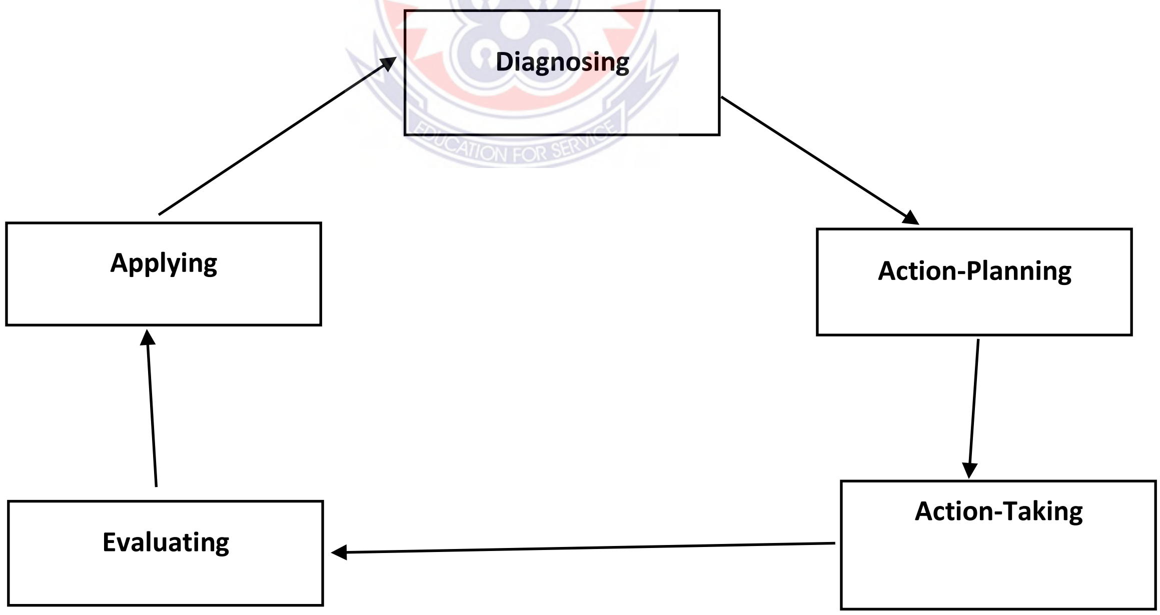

Figure 4: Phases of the action research

Source: Baskerville (1999)

The diagnosing phase identifies the problem to be addressed. It is also the stage where the possible solutions to the identified challenges are organised. The Action-Planning Stage is a key stage in the research which was used to plan the strategies for data gathering and implementation of the intervention to attain the desired outcome. In the action-taking phase, the various tools are administered and the intervention is introduced to the research subjects, namely the second-year science group. The evaluating phase was used to undertake an appraisal of the intervention in order to determine the impact of the intervention in the form of ICT-based training on the performance of the student teachers. In the learning phase, the results of the appraisal are put forward as recommendations to ensure the desired change in conceptual understanding and hence academic performance of student teachers.

In conducting the study, the researcher was mindful of some key limitations that impede the success of an action research as identified by Avgerinou (2014**).** These include: Observer bias (invalid information resulting from the perspective of the teacher researcher, influence of a researcher's background, personal experiences, preferences, attitudes), response set (tendency to see similar things), halo effect (how initial impressions and observer's knowledge of the participants affect subsequent observations).

Coghlan and Brannik (2014) assert that one main disadvantage of action research is that the practitioner evaluates himself or herself. This reduces the ability of action research to meet the required needs as there may not be presented the true picture of the situation because of personal evaluation by the teacher.

Further honesty in the responses given by the participants is also in doubt, this is due to the presence of fear of repercussions that may arise after the research.

To address the challenges highlighted above, the assistance of a colleague lecturer was solicited to assist in the task of administering the intervention (in the form of ICT-based instruction sessions) to check the researcher from exhibiting any form of bias. The colleague also assisted in the administering of the various research instruments. Additionally, student teachers were given the option to be part of the study on their own volition and informed that they could opt out of the study at any stage.

3.3.1 Action plan

The entire study itself is organised into three main stages namely: pre-intervention, intervention and post-intervention stages.

3.3.2 Pre-intervention phase

The pre-intervention activities involved the administration of the questionnaire and pre-test to find-out student teachers conceptual understanding and performance in three key concepts in physics within the curriculum for teacher education. Both the questionnaire and pre-test were administered to all the respondents.

3.3.3 Intervention Phase

The intervention phase involved the use of ICT-based approaches to provide instruction in three concepts namely; Forces, Matter and Energy. In teaching each of the concepts, various ICT based resources such as simulation videos, laptop computers, projectors and audio players were used in an interactive manner. Additionally, internet resources such as educational websites and links were also used to provide instruction as well as assessment tasks to the student-teachers.

The entire intervention was done within a period of 8 weeks. An average of two weeks was used to cover the content in each of the three concepts. Within each week, three hours were devoted to the lessons in the selected topics.

The final week was used to undertake a review of the entire content, address any outstanding challenges of the research subjects and finally administer the post test.

Table 1 shows the various ICT-based resources used in teaching each of the three concepts within the eight weeks. It also provides a breakdown of the content covered for each week.

Table 1: ICT resources used for the intervention

Week	Concept	Area of Focus	ICT Resources Used
1	Pre-test	Matter, forces and energy	
2	Matter	States of Matter	Video, Web-linked Materials
3	Matter	Properties of States of Matter	Power Point Presentation
4	Forces	Types and Effects of Forces	E-Platform and LMS
5	Forces	Laws of Motion	Animation, Web-linked Materials
6	Energy	Types of Energy	E-Platform (Padlet) and LMS
7	Energy	Energy Transformation and conservation	Animation, Web-linked Materials
8	Post-test	Matter, forces and energy	

3.3.4 Post-intervention

The procedure for the conduct of the post-intervention activities was similar to the steps followed during the pre-intervention phase. The questionnaire on conceptual understanding was administered to the respondents. Afterwards the post-test was given to the research subjects. Finally, 8 student teachers representing 20% of the total number of respondents were involved in interview sessions based on the interview protocol. The purpose of the interview guide was mainly to find-out their views on the use of ICT resources in science teaching and its impact on their conceptual understanding and academic performance. Figure 5 shows the diagrammatic presentation of how the entire study was carried out.

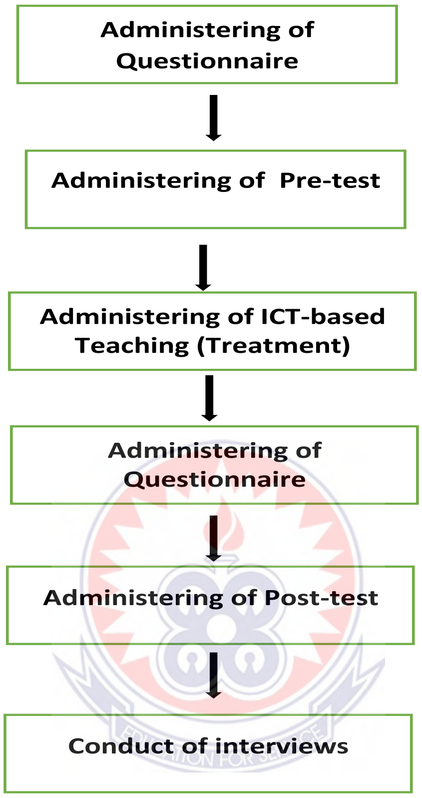

Figure 5: Diagrammatic representation of the research approach/research procedure

Source: Researcher's Diary (2021)

3.4 Area of the Study

The study was conducted in the Central Region of Ghana, specifically in the University of Education, Winneba.

3.5 Population

The population of a study is the group that conforms to specific criteria and to which the researcher would like to generalise the results of the study (Fraenkel & Wallen, 2003). There were a total of One thousand seven hundred and twenty (1,720) student-teachers in the Department of Basic Education.

The target population for the study was the student teachers who were undergoing training based on the new Pre-tertiary Teacher Education Curriculum. Out of the total of 1,720 student teachers in the Department of Basic Education, 329 were in Level 200 (both JHS and Upper primary options). However, the research subjects were selected from one intact class at the Department, specifically Level 200 student-teachers in the upper primary class. The total number of student-teachers in the class is ninety-three (93)

3.6 Sample and Sampling Procedure

Since the study was an action research, the entirety of students in one class served as the research subjects. Sampling basically refers to the way a sample is selected from a larger population to be part of a study (Etikan, Musa & Alkassim, 2016). Purposive and Convenience sampling were the main methods used in selecting the research subjects. Purposive sampling technique, is used when there is the need to select particular participants or groups of participants for a study based on some unique characteristics they possess (Etikan et al., 2016), which in this case refers to second year students offering basic education at UEW. In purposive sampling a group of research subjects are selected based on their proficiency in the phenomenon of interest (Creswell, & Plano Clark, 2011). Convenience sampling was based on proximity to the Department in which the study was conducted.

Homogenous sampling was also applied. Homogeneous sampling is a form of purposive sampling technique used to select respondents that have common characteristics such as age, occupation or gender (Elmusharaf et al., 2016). The sample size was 93, consisting of all the student-teachers within the Level 200 Upper Primary class. The sample selected for the study had common characteristics in terms of the fact that they were offering the same programme and were students of the same class, being taught by the same instructor.

Though the sampling method helps to select research subjects that can provide the needed information, an element of bias could be introduced since the selection of the sample is dependent on the researcher (Oliver, 2006). However, the effect of bias was minimised by ensuring an internal consistency between the goals of the study, and the sample selection criteria (Oliver, 2006). For this reason, a different lecturer was assigned a role to assist in the administering of the intervention as well as the gathering of data using the various tools following the recommendations by Stahl and King (2020).

3.7 Instrumentation

Research instruments are the fact-finding strategies and the tools for collecting data (Munir & Ilyas, 2017). The main instruments used in the study were tests, questionnaires and an interview guide. These were employed for collecting data on the research subjects before and after the intervention.

In designing the tools for measuring conceptual understanding and academic performance, the following steps were followed:

1. Analysis of the science curriculum to identify objectives of the three key concepts, Matter, Forces and Energy.
2. Identification and analysis of key content knowledge expected to be acquired by student-teacher
3. Identification and diagnosis of sources of misconceptions

4. Creation, design and standardisation of the conceptual understanding tool (multiple-choice and two-three tier diagnostic tests)
5. Development of pre-test based on the three key Concepts (Matter, Forces and Energy)
6. Design of the post-test after the intervention
7. Development of questionnaire and interview guide after the intervention

Table 2: Tools used for data gathering

S/N	Instrument	No. of Items	Stage of Administering	Target Respondents
1	Questionnaire	30	Before and after the intervention	All the respondents
2	Pre-Test	30	Before the intervention	All the respondents
3	Post- test	30	After the intervention	All respondents
4	Questionnaire	15	After the Intervention	All respondents
5	Interview Guide	5	After the Intervention	Till saturation was met

3.7.1 Questionnaire

Abawi (2013) described a questionnaire as a tool which consists of prompts and questions purposely for gathering data from respondents. The use of questionnaires comes with advantages such as relative ease of administering and its ability to cover a large group of respondents at the same time (Young, 2015). The questionnaire was the main tool for measuring the conceptual understanding of the student teachers involved in the study. It was used to undertake quantitative analysis of the data gathered from the respondents. This is because questionnaires enable researchers to obtain detailed information from a population in order to arrive at results that are of statistical significance (Mathers et al., 2009).

In the current study the use of a questionnaire was deemed appropriate because the study is primarily a quantitative study. The format of the conceptual understanding questionnaire was a Two-Tier Diagnostic Test.The two-tier test is described as diagnostic instrument wherein the first tier includes multiple choice content questions and second tier consists of multiple choice set of reasons for the answers to the first tier (Hrepic, 2004). Students were required to justify their answer to the multiple-choice items by selecting the correct reason behind their chosen answer.

There is the need to place particular emphasis on the design of the questionnaire so that accurate and valid data can be obtained (Roopa & Menta, 2012). Ten Items were set under each of the three concepts (Matter, Forces and Energy).

Conceptual Understanding is commonly defined as deep knowledge of the underlying concepts of a given subject and how they relate to one another (Crooks & Alibali, 2014). To develop the questionnaire, the key themes under each concept as captured in the curriculum were comprehensively studied and their inter-relatedness with other concepts identified. A sample item for measuring student teachers' conceptual understanding of the concept of matter is provided.

1. Fundamentally, all atoms are the same

   A. Yes

   B. No

   I chose my answer because:

   i. All atoms contain protons, neutrons and electrons
   ii. Atoms are different in terms of the number of electrons and protons
   iii. Atoms are the basic unit of an element that can take part in a chemical reaction
   iv. All atoms have the same number of protons and electrons

The next question shows an item on the conceptual understanding tool to be used for measuring student teachers' conceptual knowledge under the concept "force'.

16. Weight unlike mass, is classified as a force

A. Yes

B. No

I chose my answer because

I. The weight of an object is the product of its mass and acceleration due to gravity acting on the object

II. Mass and weight are all density related

III. The Weight and mass of a body are directly proportional

IV. The weight and mass of a body are inversely proportional

In the last example, an item under the concept of Energy is presented.

26. All forms of energy can be classified under potential and kinetic energy.

A. Yes

B. No

The reason for my choice of answer is:

I. there are other forms of energy such as electrical energy, solar energy, sound energy and heat energy

II. potential and kinetic energy are components of mechanical energy

III. all forms of energy are either in motion or are in stored form (position)

IV. potential and kinetic energy are associated with movement.

According to Crooks and Alibali (2014), the difficulty of measuring conceptual understanding presents a barrier to progress in the development of educational interventions. It was for this reason that ten items were formulated under each item, by strictly adhering to one of the main formats for developing conceptual understanding tools (Hrepic, 2004) as recommended in the literature.

The second questionnaire was a 15-item Likert-Scale instrument developed to find out the impact of the intervention on the respondents' attitude towards science teaching and learning, perceived challenges to the use of ICT in teaching as well as their intent to use ICT in their future classrooms. Joshi, Kale, Chandel & Pal (2015) stress that Likert Scales are one of the most fundamentally used instruments in educational research. Wolfe and Smith (2007) recommend that in developing questionnaires based on the Likert Scale format, each item should be well developed to be ambiguous and independent. Additionally, it is expedient to avoid the use of both positively and negatively worded items in measuring the same construct or idea (Quilty, Oakman & Risko, 2006). For this reason, the questionnaire was carefully designed to cover different items on scales such as attitude towards science teaching and learning, student teachers' views on impact of ICT-based teaching, intent to use ICT in future classrooms as well as challenges associated with ICT use in teaching.

No matter how well a questionnaire is developed, Young (2015) points out that their usage comes with some limitations. Additionally, questionnaires have been criticised for not providing detailed explanation of the concept being studied (Dornyei, 2007). It was for this reason that the use of the questionnaire was augmented with the tests and interview guide.

3.7.1.1 Scoring the Questionnaire

As indicated earlier, the format of the questionnaire was a Two-Tier Diagnostic Test. Student-teachers were required to justify their answer to the multiple-choice items by selecting the correct reason behind their chosen answer (Hrepic, 2004).

The Certainty of Response Index (CRI) method was used to classify respondents' answers to each questionnaire item (Putri, Hofifah, Girsang & Nandiyanto, 2021; Safriana & Fatmi, 2018; Utami & Wulandari, 2016).

Their responses were categorised as:

- Understand the concept (correct initial answer and correct reason)
- Do not understand the concept (correct initial answer but wrong explanation)
- Misconception (wrong initial answer)

3.7.2 Tests

Two main tests were used in the study namely; Pre-intervention test (pre-test) and post-intervention test (post-test).

3.7.2.1 Pre-test

Collins (2006) has stressed that test questions which are well-developed help to gather useful information on students' achievement. The pre-test was used to augment data gathered with the aid of the questionnaire on student teachers' conceptual understanding. It was basically used to measure the performance of the research subjects in three key concepts in physics (Matter, Forces and Energy) in the new 4-year curriculum for Teacher Education. The Pre-test contained 30 items. The items were mainly close-ended questions, with options provided, whilst a few questions required respondents to write down short answers. These consisted of questions designed under the knowledge, Application and Reasoning domains of learning in a ratio of 4:3:3.

Knowledge – 40% (12 items)

Reasoning – 30% (9 items)

Application – 30% (9 items)

Tarrant et al. (2006) recommend that in developing test items, overly general or ambiguous questions, leading or biased questions must be avoided. A sample item in the pre-test is presented in the following example:

1. Adzovi wants to fill a vessel with a substance that is light in weight and can easily be compressed. Which one of the following is most suitable for her to use?
   A. A substance in the gaseous state
   B. A substance in the liquid state
   C. A substance in the aqueous state
   D. A substance in the solid state

According to Allen and Nimon (2007), the main weakness of pre- and post-test design is that it cannot detect other possible causes of positive or negative results among the participants. They further state that in cases where a new pre- and post-test is being written, or an existing test adapted, pilot testing is strongly recommended. The pre-test was pilot tested with second-year students of the Komenda College of Education, who were offering the same course.

In conducting a pilot test, common signals of needs for improvement include; Many blank answers to specific questions, Inconsistent answers to related questions, Responses to open-ended questions that reflect lack of understanding and failures to respond to the questions towards the end of the test (Empower, n.d). Based on the pilot test, several changes were made to the test in the form of deletion of incorrect items as well as modification of others.

3.7.2.2 The post-test

The post-test was purposely developed to determine the effect of the intervention on the conceptual understanding and performance of student teachers in the selected science concepts. As in the case of the pre-test, it consisted of 30 items designed based on the Knowledge, Application and Reasoning domains of learning. In terms of design, the post-test was similar to the pre-test with modifications to 50% of the items. In developing post test questions, there is the need to ensure all learning objectives are covered.

However, the percentage distribution of test items based on the three key learning domains was same for the post test and pre-test.

Knowledge – 40% (12 items)

Reasoning – 30% (9 items)

Application – 30% (9 items)

A sample item in the post test is presented in the following example:

2. Kofi applied the brakes on his bicycle and it came to a halt. What is the name of the force between the ground and bicycle tyres that caused the bicycle to stop moving?
    A. electrostatic force
    B. frictional force
    C. magnetic force
    D. Molecular force

3.7.3 The interview guide

As noted by Schostak (2006), interviews are extended conversations that help to provide detailed information and help to ensure in-depth understanding of a phenomenon. Interviews are helpful because they offer researchers the opportunity to uncover information that is "probably not accessible using techniques such as questionnaires and observations (Blaxter, Hughes & Tight, 2006)

The interview guide was used to gather more detailed information on the sources of student teachers' misconceptions. It also sought to gather information on the views of student teachers about the use of ICT resources in science teaching as well as in boosting their conceptual understanding in the selected concepts. The interview schedule also enabled the researcher to gather more information on the impact of the intervention on the academic performance of student teachers.

A semi-structured interview was used. According to Rubin and Rubin (2005) the semi-structured interview, allows detailed information to be gathered by allowing the interviewer to probe further into the interviewee's responses. The interview schedule consisted of five (5) questions. The researcher adopted the use of both open and closed-ended questions in order to enhance the reliability of the interview schedule. Close-ended questions are more specific, thus more likely to communicate similar meanings.

According to Silverman (1993) as cited in Eminah (2014), one way of controlling reliability is to have a highly structured interview with the same format and sequence of words and questions for each respondent. He stated further that reliability can be enhanced by careful piloting of interview schedules and the extended use of closed questions. However closed questions do not give the respondents the chance to state whether they understand the question or not. So the essence of using open-ended questions in addition to the closed questions was to enable this researcher gain a holistic understanding of the conceptual understanding of student teachers and the impact of the intervention on their conceptual understanding and academic performance.

Triangulation of data is deemed necessary to ensuring the credibility of the entire study. Data triangulation is the use of a variety of data sources, including time, space and persons, in a study (Ponce & Pagán-Maldonado, 2015). In triangulation, findings can be corroborated and any weaknesses in the data can be compensated for by the strengths of other data, thereby increasing the validity and reliability of the results (McKim, 2017). The approach has been used in many sectors to strengthen conclusions about findings and to reduce the risk of false interpretations. Triangulation assists in overcoming the methodological deficits of partial research approaches (Gorard & Taylor, 2004).

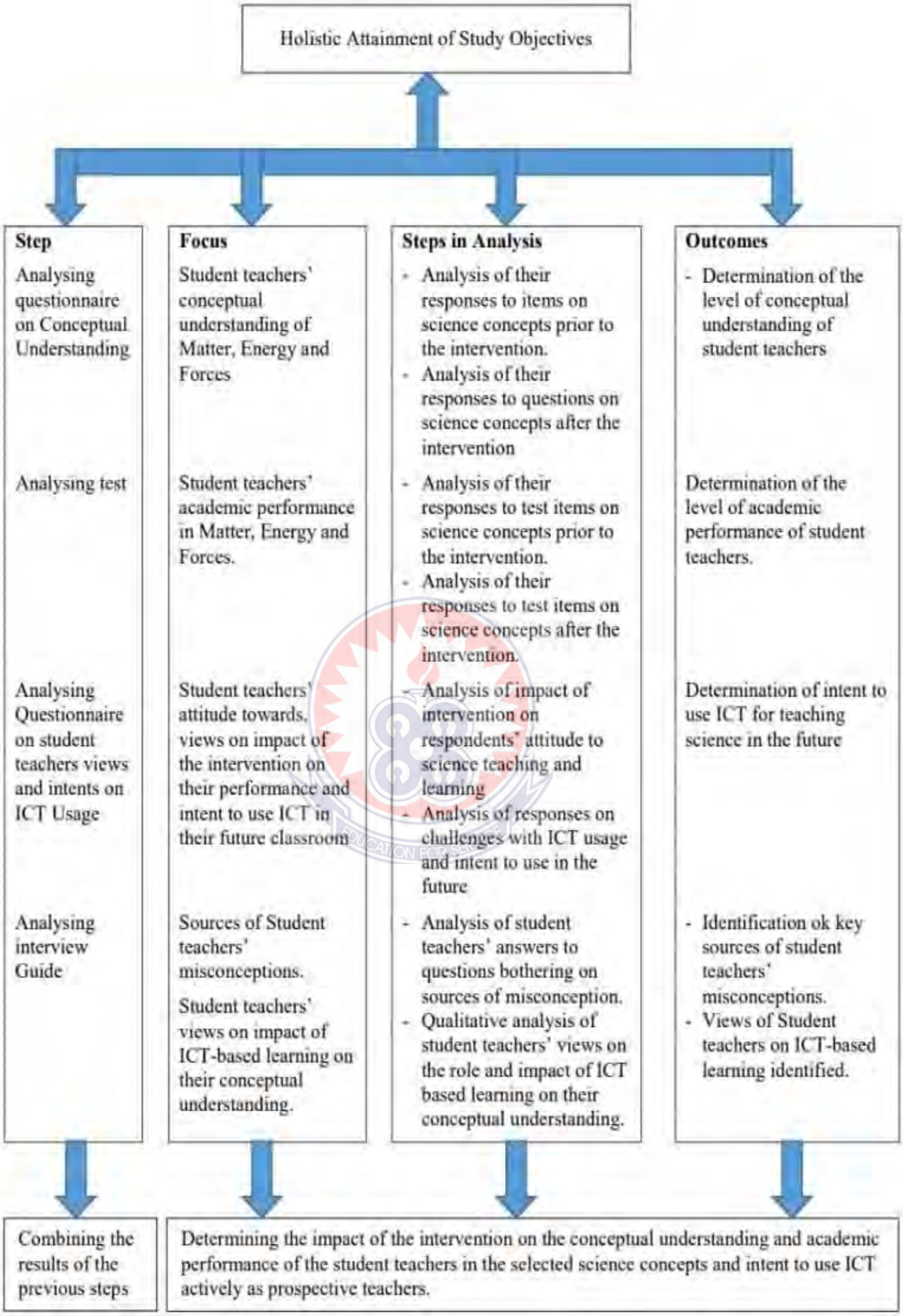

Figure 6: Steps involved in triangulation of data for the study

Source: Researcher's Diary (2021)

3.8 Validity of the Research Instruments

The validity of a research tool is integral to the success of the entire study. As Field (2005) explains, fundamentally the validity of a tool refers to the ability of the instrument to be used for gathering the correct data. Even though there are different forms of validity the two main types are content validity and construct validity (Sürücü & Maslakçı, 2020).

According to Yaghmal (2003), content validity focuses on the extent to which the instrument makes provisions for capturing information on the phenomenon it is expected to measure. The items in the questionnaire and tests were developed based on the science curriculum for the 4-year teacher education. Specifically, they cover concepts in the second-year course content for teacher education. Yaghmal (2003) went on further to talk about two key requirements for ensuring content validity which are that (1) each item must measure the trait to some extent and (2) all the items combined must measure all aspects of the given trait.

Yaghmal (2003) explained that the matching of learning objective expectations with certain item types provides a high degree of test validity, testing what is supposed to be tested. In designing the conceptual tool as well as the pre-test and post-test, the items were matched to the expected learning outcomes for student teachers so far as the learning of the concepts of interest is concerned.

For instance, a key learning outcome under the concept of matter is for student teachers to "Communicate the basic ideas about the nature and diversity of matter (Particulate nature of matter, Classification of matter) and map out the interactions between matters as well as discuss their interconnectivity, and their effects on the environment". Based on this outcome several items were designed to cover the particulate nature of matter, states of matter as well as the interaction between the states.

The items were developed to cover the Reasoning, Knowledge and Application domains of Learning. According to Ayre and Scally (2014), validation and scrutiny by qualified experts are essential for ensuring the content validity of an instrument. All the instruments were assigned to the supervisors of the thesis who were expert science educationists for editing and subsequent validation.

A key way of ensuring content validity is to ensure that experts evaluate each item on the tool in terms of the scale and give a holistic appraisal (Rubio, Berg-Weger, Tebb, Lee & Rauch, 2003). In this stead the questionnaire contained an equal number of items (10 items) under each of the three science concepts after which the tools were submitted to experts for scrutiny and appraisal.

Construct validity bothers on how well a pre-existing concept or theory is translated into reality on the given instrument (Taherdoost, 2016). In this context, it refers to the extent to which the instrument aligns to the provisions for designing tools for measuring conceptual understanding of students. The items in the test were also developed to reflect the different dimensions of learning and assessment captured in the curriculum for teacher education as well as the science curriculum for basic schools. With regards to the questionnaire on student teachers views and intent to use ICT in their future classroom, it was subjected to scrutiny by comparing it to the recommendations provided by Menold and Bogner (2016) for developing Likert scale instruments. Thus each item was carefully designed to be independent and devoid of ambiguity. The introduction of a 5-point Likert Scale also served the purpose of helping to eliminate researcher bias and providing independence to the respondents (Preston & Colman, 2000).

Face validity refers to ensuring the elimination of elements of ambiguity on the tool and also enhancing the tool to provide better clarity (Oluwatayo, 2012). The face validity of the questionnaire, tests and interview guide were ensured with the assistance of the research supervisors, science lecturers at the Department of Basic Education as well as colleague doctoral students.

As pointed out by Young (2015), even though optimum validity of the tool may be impossible, it can be improved by ensuring the questionnaire contains provisions that ensure the anonymity and confidentiality of respondents and clearly state the expectations placed on them. These guidelines were followed in the design of all the research tools in order to enhance validity.

3.9 Reliability of the Research Instruments

Jackson (2003) explained that the reliability of an instrument is a measure of the internal consistency of the instrument in measuring a given idea or phenomenon. Just like validity, reliability is key in appraising the quality of a given research instrument (Kimberlin & Winterstein, 2008). It helps to increase transparency and remove elements of bias (Singh, 2014).

In order to ascertain the reliability of the instruments, a pilot testing of instruments was conducted in the Komenda College of Education, also in the Central Region of Ghana. The college was chosen because it shares similar demographic characteristics as the University of Education, Winneba. The students in these two institutions offer the same 4-year programme and had both offered the course introduction to integrated Science.

In terms of instruments which contain the Likert Scale, the most ideal measure of reliability is the Cronbach Alpha (Robinson, 2009). The Cronbach Alpha reliability of the questionnaire and two tests were determined through the Pilot Study. According to Gall, Gall and Borg (2007), coefficient of reliability values above 0.75 are considered reliable. There was the measurement of inter-item correlation in order to promote homogeneity and ensure all the items on a given variable within each of the quantitative instruments measure the same construct (Heale & Twycross, 2015).

Table 3: Reliability values for the questionnaire, pre-test and post-test

Tool	**Cronbach Alpha Reliability Value**
Questionnaire on Conceptual Understanding	0.78
Pre-test	0.85
Post Test	0.80
Questionnaire on Student teachers' intent	0.84

Table 3 gives a breakdown of the Cronbach Alpha values recorded for each of the instruments.

3.10 Reliability and Validity of the Interview Guide

In gathering qualitative data, Lincoln and Guba, (1985) stress on attaining quality data through credibility, confirmability, consistency and applicability of the data gathered. According to Stahl and King (2020), credibility focuses on the consistency of the findings with the reality on the ground and this can be attained through triangulation.

Patton (2001) stated that qualitative researchers need to pay optimum attention to validity and reliability in design of the study, collection and analysis of data. In order to enhance the validity of the interview guide, it was aligned and triangulated with the questionnaire for soliciting the responses of student teachers on their attitude, views and intent to use ICT in science teaching.

Validity of qualitative data does not have a single agreed on format, but rather determined by various factors, depending on the context of the study (Hafeez-Baig, Gururajan, & Chakraborty, 2016). Creswell and Miller (2000) suggest that in this case the validity is dependent on the discretion of the researcher. Thakur and Chetty (2022) stress that the validity of qualitative data can be enhanced through employing of a moderator, triangulation and respondent validation. In this regard, a moderator in the form of another lecturer was employed to conduct the interviews. In terms of triangulation of the data gathered, three different researchers were employed to analyse the audio recordings in order to ascertain the consistency in the transcribed data. Finally, the interviewees were given their transcribed interview responses in order to ensure respondent validation. This helped to ensure confirmability as suggested by Healy and Perry (2000).

In the current study 10 of the 90 student teachers were interviewed, but saturation was reached by the time the eight (8) interview session was held. This thus indicates that the reliability of the interview Guide was high (Hafeez-Baig et al., 2016). According to Castillo-Montoya (2016) the reliability of the interview guide can also be enhanced through receiving feedback on interview protocols and piloting the interview protocol.

The interview guide was piloted with the same sample used in piloting the questionnaires and tests. The reliability of the interview protocol was also enhanced by the fact that the interviewer held one-to-one interview sessions with the various respondents using almost the same questions. Dikko (2016) notes that one-to-one sessions enhances the reliability of the data gathered in an interview session. Aligning the interview guide with the questionnaire also helped to enhance the reliability of the interview guide.

3.11 Data Analysis

In undertaking data analysis based on Action Research, Edwards and Burns (2018) suggest that the following steps should be followed; Assembling the data, Coding, Comparing the data, building meanings and interpretations and reporting the outcomes (and applying).

All statistical analyses were performed using the Statistical Software package from IBM/SPSS (IBM Corp., 2019).

In the first phase, the mean, frequencies and percentages (descriptive statistics) of the responses provided to various items on the questionnaire were computed. Additionally, the mean and standard deviations of the pre-test and post-test scores of student teachers were calculated.

The mean scores and responses of student teachers in the two tests (pre-test and post-test) were analysed using t-test with equal variances (for both the pre-test and the post-test scores). This was done to assist in determining the statistical difference between the test scores of the study respondents before and after the intervention. Additionally the effect size was computed to determine the magnitude and significance of differences (Ellis, 2010; Morris, 2008) between the pre-test and post-test performance of the student teachers in the various science concepts and also in terms of gender (male and female student teachers).

Further, the data was analysed based on the scaled instrument items using the responses on the items for each concept (Matter, Forces, and Energy). This was done to determine the differences in academic performance of respondents in relation with the three science concepts under study.

The frequencies and percentages of responses to the questionnaire on student teachers views and intent on ICT were computed. The data gathered using the interview protocol was also analysed qualitatively. The responses of the interviewees to each question were transcribed, analysed and summarised based on the common themes. Using the constant comparative method of analysis, the researcher read through the transcript for each interview to get a sense of the uniqueness of that story (Eminah, 2014). Each transcript was carefully reviewed, sentence by sentence, in order to identify words and phrases that were descriptive and represented a particular concept. Central themes were extracted as each transcript was read several times.

3.10 Data Gathering Procedure

Proper protocol was followed at all stages of the data gathering process. An introductory Letter from the Faculty of Science Education, UEW was used to gain access to conduct the study at the Faculty of Educational studies. With the aid of the introductory letter, permission was sought and granted by the Dean of the Faculty of Education as well as the Head of the Basic Education to involve students in the department for the study. The letter was also used to inform the concerned authorities within the faculty of educational studies about the study and to seek their cooperation to ensure successful data gathering. With the consent and assistance of the head of the Basic Education Department, the researcher formerly introduced the study and its purpose to the respondents. He officially solicited for their participation and cooperation in the study. Sufficient time was spent to explain the various ICT-based interventions to be implemented and the various instruments which the research subjects would be completing. At the onset of the intervention, the questionnaire and pre-test were administered. After six weeks of instruction, the student teachers were taken through a recap of the entire content. The post-test and questionnaires (on conceptual understanding and student teachers' intent to use ICT in their future classrooms) were administered in the eighth week. Afterwards, the interview sessions were held. The interviewees were selected based on their responses to the questionnaire items as well as their performance in the two tests.

3.11 Ethical Considerations

Akaranga and Makau (2016) emphasise that because researchers are professionals, each research team or institution must have a code of ethics for guiding their research activities. There was strict adherence to the rules and regulations on research integrity in order to avoid research Plagiarism, Fabrication, Misappropriation and Falsification.

Research ethics is important in our daily life research and must be followed to protect the dignity of research subjects and also to ensure accurate presentation of facts (Fouka & Mantzorou, 2011). Based on the scope of the study and target respondents, the likely areas where ethical issues could prop up include sex of respondents and also the willingness of respondents to participate in the entire study. Other areas of ethical consideration included the analysis and presentation of respondents' test scores and responses as well as referencing of all cited materials.

The researcher sought a written permission from the Faculty of Education and the Department of Basic Education to conduct the study within the department. The student teachers were also informed about the study and their expected roles in its success.

The study involved gathering of data at different stages mainly through tests (pre-test and post-test) as well as questionnaires. Denzin and Lincoln (2011) state that 'informed consent' is the bedrock of ethical research. Thus, they suggest that participants must provide signed consent to taking part within the research and agreeing to their data being used for the intended purposes. The consent of all respondents was sought and they were also informed that they could withdraw from the study at any time. In addition, anonymity and confidentiality of research subjects was maintained during the administering of all research tools.

The research instruments, were subjected to rigorous validation to avoid any biases as well as the use of offensive, discriminatory, or other unacceptable language. The gender, religion and ethnicity of respondents were kept anonymous to prevent unfairness and partiality during the administration of the questionnaire and tests.

Fabrication and misreporting of research results is another key ethical issue that must be well addressed during a study (Kour, 2014). Adequate and proper analysis, presentation and storage of the collected research data was done to prevent biases. This is very needful, because the purpose of the study is to determine the effect of the intervention on the student teachers rather than compare the performance of respondents based on different variables. In this stead, maintenance of the highest level of objectivity in discussions and analysis was observed throughout the study and subsequent write-up.

Saunders et al. (2011) emphasise on the fact that in the current era of increased ICT usage, plagiarism is on the increase. In order to address this issue, all cited and consulted were appropriately acknowledged and referenced, the contributions of all other parties in the study were appropriately acknowledged during the final write-up of the thesis.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Overview

This chapter presents the results of the study obtained through the analysis of data. Results from the analysis of the questionnaire on conceptual understanding are presented first followed by the test results. Afterwards, the results of the analysis of the questionnaire as well as the thematic analysis of the data gathered from the interview sessions is presented to answer the research questions in Chapter One. The chapter also covers findings based on the six null hypotheses formulated for the study.

4.1 Demographic Data

4.1.1 Gender distribution of respondents

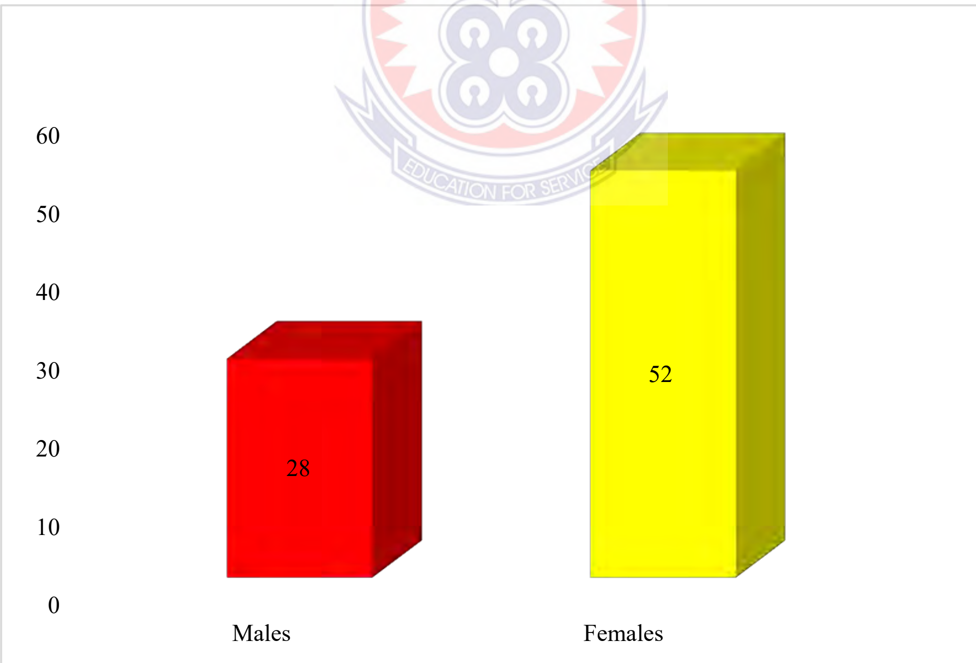

Figure 7: Gender distribution of respondents

The data provided on Figure 6 shows the gender breakdown of respondents. Out of the 90 student teachers involved in the study, 28 were males. This shows the number of female student teachers who took part in the study was 52.

4.2 Research Question 1

What are the misconceptions held by student teachers about some selected science topics?

This question basically sought to establish the level of conceptual understanding as well as misconceptions held by student teachers about the three selected science concepts. It was answered using the responses provided to the items on the two-tier questionnaire on conceptual understanding. The results obtained are provided on Tables 4, 5 and 6.

Table 4: Student teachers' level of conceptual understanding in concept of states of matter

Item	Understand Freq (%)	Do not understand Freq (%)	Misconception Freq (%)
1.	23(25.6)	24(26.6)	43(47.8)
2.	42(46.7)	28(31.1)	22(24.4)
3.	10(11.1)	33(36.7)	47(52.2)
4.	22(24.4)	39(43.3)	29(32.2)
5.	23(25.6)	30(33.3)	47(52.2)
6.	67(74.4)	11(12.2)	12(13.3)
7.	40(44.4)	31(34.4)	19(21.1)
8.	55(61.1)	22(24.4)	23(25.6)
9.	68(75.6)	10(11.1)	12(13.3)
10.	41(45.6)	17(18.9)	32(35.6)

The first item under matter sought to test student teachers' understanding of atoms. From Table 5, it is evident that almost half (47.8%) of the respondents held the view that all atoms are the same. It can be seen from Table 5 that the item that the student teachers held most misconception about was item 3 which demanded respondents to provide the name of any phenomenon that confirms the particulate nature of matter. Only ten (10) participants exhibited understanding by providing the correct example of phenomenon and a corresponding accurate reason. The item which student teachers understood the most was item 9 which focused on examples of substances in the state of matter. Sixty eight (68) participants representing 75.6% of the 90 respondents demonstrated understanding by selecting the correct answer and the corresponding appropriate response. With regard to item 6, majority of the student teachers were able to show understanding of examples of matter by identifying wind energy as a wrong example of matter. As evident in Table 5, 74.4% of respondents provided accurate responses to that item.

Majority of participants provided wrong responses to item 5, which reveals that they held misconceptions on the concept under consideration. Item 5 sought to find out whether respondents can apply their knowledge of rate of movement of particles in different states to answer a question on movement of Bromine molecules in the liquid and gaseous states. Only 25.6% of respondents showed understanding in answering that item. Notably majority (55) student teachers answered correctly that liquid ammonia travelled more slowly compared to gaseous ammonia, as evident in their responses to item 8. The data provided in Table 5 reveals that most student teachers either did not understand or held misconceptions about items 1, 3, 4 and 5.

Table 5 gives a breakdown of student teachers' responses to the items that sought to find out their misconceptions about the concept, "forces". It was found out that student teachers held misconceptions on item 14 than any other item under the concept, forces. That is to say majority of the respondents (68.9%) believed that both friction and magnetic force were contact forces

Table 5: Student teachers' level of conceptual understanding on the concept of forces

Item	Understand Freq (%)	Do not understand Freq (%)	Misconception Freq (%)
11	35(38.9)	14(15.6)	41(45.5)
12	50(55.6)	14(15.7)	26(28.9)
13	31(34.4)	24(26.7)	35(38.9)
14	13(14.4)	15(16.7)	62(68.9)
15	39(43.3)	23(25.6)	28(31.1)
16	25(27.8)	17(18.9)	48(53.3)
17	21(23.3)	20(22.2)	49(54.4)
18	30(33.3)	35(38.9)	25(27.8)
19	28(31.1)	25(27.8)	47(52.2)
20	31(34.4)	18(20)	41(45.6)

The data available on Table 5 shows that 39(43.3%) out of the 90 student teachers involved in the study exhibited understanding of the concept of forces at work when an object is at rest. Similarly, 25 of the 90 respondents understood item 16, which also focused on the forces at work on a body at rest. Fifty (50) respondents understood item 12 on the net force felt when two vehicles of different size collide. Notably, that was the only item under this concept (forces) which majority of respondents understood. As many as 59 out of the 90 respondents either did not understand or held misconceptions about the fact that objects of different sizes released from a height above the ground are expected to fall at the same time (because acceleration due to gravity is constant). Forty-Nine respondents held the misconception that weight cannot be classified as a force, as seen in their responses to item 17 on Table 6. The data provided on Table 5 shows that generally, the number of respondents that did not understand or held misconceptions about various items under the concept of forces were higher than those who understood the concept.

Table 6 provides a summary of student teachers' responses to items bothering on different aspects of the concept, energy. Regarding Item 23, Sixty-seven of the respondents (representing 74.5%) understood that energy was not an example of a force.

Table 6: Student teachers' level of conceptual understanding on the concept of Energy

Item	Responses		
	Understand	Do not understand	Misconception
21	37(41.1)	22(24.4)	31(34.4)
22	50(55.6)	18(20)	22(24.4)
23	67(74.5)	13(14.4)	10(11.1)
24	59(65.6)	18(20)	13(14.4)
25	40(44.4)	19(21.1)	31(34.4)
26	23(25.6)	13(14.4)	54(60)
27	31(34.4)	18(20)	41(45.6)
28	23(25.6)	13(14.4)	54(60)
29	45(50)	21(23.3)	24(26.7)
30	41(45.6)	20(22.2)	29(32.2)

From Table 6, Item 24 sought to test student teachers understanding of the concepts of energy conservation and transformation. Majority of them (59) showed understanding by answering the question and the follow up correctly.

Notably 60% of respondents wrongfully believed that both energy conversion and conservation are the same (item 28). Based on the responses to item 26, it is seen that only 23 out of the 90 respondents understood that all forms of energy can be classified under potential and kinetic energy. The data provided in Table 6 reveals that half (45) of the student teachers understood why some sources of energy are classified as renewable. This is evident in their responses to item 29. The other 45 student teachers either did not understand or had wrong ideas about renewable sources of energy. Item 22 sought to find-out whether the study subjects understood the varied applications of energy in daily life (apart from its role in movement). Fifty (50) student teachers, representing 55.6% of the total number of respondents showed understanding in this stead, as compared to 18 who did not understand and 22 who held misconceptions about the applications of energy.

4.3 Research Question Two

To what extent will the use of ICT-based teaching strategies improve the conceptual understanding of student teachers in Science?

The purpose of this question was to explore the extent to which the use of ICT-based teaching strategies will improve student teachers' level of conceptual understanding of the three science concepts (Matter, Forces and Energy). This question was answered by comparing the responses of the student teachers to the questionnaire items before and after the intervention. The breakdown of results is provided in Table 7.

Table 7: Comparison of student teachers level of conceptual understanding on states of matter before and after the intervention

Item	Understand		Do not understand		Misconception	
	Before	After	Before	After	Before	After
1.	23(25.6)	60(66.7)	24(26.6)	12(13.3)	43(47.8)	18(20)
2.	42(46.7)	71(78.9)	28(31.1)	9(10)	22(24.4)	10(11.1)
3.	10(11.1)	40(44.4)	33 (36.7)	21(23.3)	47(52.2)	29(32.2)
4.	22(24.4)	61(67.8)	39(43.3)	10(11.1)	29 (32.2)	19(21.1)
5.	23(25.6)	58(64.4)	20(33.3)	18(20)	47(52.2)	14(15.6)
6.	67(74.4)	81(90)	11(12.2)	6(6.7)	12 (13.3)	3(3.3)
7.	40(44.4)	66(73.3)	31(34.4)	13(14.4)	19(21.2)	11(12.3)
8.	55(61.1)	67(74.4)	22(24.4)	11(12.3)	23(25.6)	12(13.3)
9.	68(75.6)	81(90)	10(11.1)	8(8.9)	12(13.3)	1(1.1)
10.	41(45.6)	65(72.2)	17(18.9)	15(16.7)	32(35.6)	10(11.1)

Table 7 contains data on the level of understanding of student teachers on the various items covered under matter. On the Table, the responses provided to each item before and after the intervention are presented as a basis for evaluating the impact of the intervention on student teachers' conceptual understanding. The first item under matter sought to test student teachers' understanding of atoms. From Table 8, it is evident that after the intervention, the number of respondents who understood that all atoms are not the same had increased from 23 to 60 (66.7%). With regard to item 3 which demanded respondents to provide the name of any phenomenon that confirms the particulate nature of matter, the percentage of respondents that exhibited comprehension of the concept, increased from 11.1% to 44.4%. The number of student teachers who did not understand the concept reduced from 47 to 29. From a previous number of 12 student teachers who held misconceptions about examples of substances in the various states of matter, only 1 student teacher still had wrong ideas about examples of substances in the three states of matter (as inferred from their responses to item 9) . With regard to item 10, majority of the student teachers were able to identify the building blocks of matter with correct reasons. The number of student teachers who showed understanding of the concept increased from 41 to 65. The number of participants who were able to give correct responses and corresponding valid reasons as to why a bottle of sand is heavier than a bottle of water of the same size increased from 40 to 66.

Prior to the intervention, majority of participants provided wrong responses to item 5, which sought to find out whether respondents can apply their knowledge of rate of movement of particles in different states to answer a question on movement of Bromine molecules in the liquid and gaseous states. The percentage of respondents that showed understanding increased to 64.4% from an initial 25.6%. Seventy-one

(71) participants had correct ideas about why solids have fixed shapes, an increase from a previous number of 42. The number of respondents who understood why liquid ammonia travelled more slowly compared to gaseous ammonia, increased from 55 to 67 as can be inferred from their responses to item 8. The data provided in Table 8 gives a clear indication that based on the intervention, majority of student teachers understood most of the concepts covered under the concept, matter.

Table 8 contains a summary of responses provided by student teachers to the items that sought to find out their misconceptions about the concept, forces. It gives a breakdown of their responses before and after the intervention. Notably the percentage of respondents who perceived that both friction and magnetic force were non-contact forces (item 4) reduced from an initial 68.9% to 15.5%. The data available on Table 8 indicates that 68 (75.6%) of the 90 student teachers involved in the study understood that inertia and surface tension could not be classified as forces (item 8).

Table 8: Comparison of Student teachers' level of conceptual understanding on Forces before and after the intervention

Item	Understand		Do not understand		Misconception	
	Before	After	Before	After	Before	After
11	35(38.9)	67(74.4)	14 (15.6)	10(11.1)	41(45.5)	13(14.5)
12	31(34.4)	73(81.1)	24(26.7)	6(6.7)	35(38.9)	11(12.2)
13	50(55.6)	45(50)	14(15.7)	24(26.7)	26(28.9)	21(23.3)
14	13(14.4)	61(67.8)	15(16.7)	15(16.7)	62(68.9)	14(15.5)
15	39(43.3)	63(70)	23(25.6)	15(16.7)	28(31.1)	12(13.3)
16	25 (27.8)	61(67.8)	17(18.9)	(20(22.2)	48(53.3)	9(10)
17	21(23.3)	55(61.1	20(22.2)	19(21.1)	49(54.4)	16(17.7)
18	30(33.3)	68(75.6)	35(38.9)	13(14.4)	25(27.8)	9(10)
19	28(31.1)	71(78.9)	25 (27.8)	9(10)	47 (52.2)	10 (11.1)
20	31(34.4)	40(44.5)	18(20)	20(22.2)	41(45.6)	30(33.3)

This was a marked improvement on the number of 30 (33.3%) respondents who exhibited accurate understanding prior to the intervention. The percentage of student teachers who had misconceptions on the concept of forces at work when an object is at rest reduced from 28 to 12. Item 16, focused on the forces at work when a body is at rest. The number of student teachers who showed understanding of this item increased from 25 to 61, which represented an increment of more than 100 percent. Fifty-five respondents understood item 7 on the net force felt when two vehicles of different size collide. Notably, that was the only item under this concept (forces) which majority of respondents understood. After the intervention, only 16 (17.7%) held the misconception that weight cannot be classified as a force, (as seen in their responses to item 17) compared to 47 before the intervention. The data provided on Table 8 clearly reveals that after the intervention, a greater number of respondents had conceptual understanding of various items under the concept of forces compared to those who did not. Table 9 provides a summary of student teachers' responses to items bothering on different aspects of the concept of energy.

Table 9: Comparison of student teachers' level of conceptual understanding on the concept of energy before and after the intervention

Item	Understand		Do not understand		Misconception	
	Before	After	Before	After	Before	After
21	37(41.1)	73(81.2)	22(24.4)	8(8.8)	31(34.4)	9(10)
22	50(55.6)	72(80)	18(20)	13(14.4)	22(24.4)	5(5.6)
23	67(74.5)	79((87.8)	13(14.4)	5(5.6)	10(11.1)	6(6.7)
24	59(65.6)	67(74.4)	18(20)	14(15.6)	13(14.4)	9(10)
25	40(44.4)	76(84.4)	19 (21.1)	6(6.7)	31(34.4)	8(8.9)
26	23(25.6)	70(77.8)	13(14.4)	9(10)	54(60)	11(12.2)
27	31(34.4)	73(81.1)	18(20)	8(8.9)	41(45.6)	9(10)
28	23(25.6)	82(91.1)	13(14.4)	3(3.4)	54(60)	5(5.6)
29	45(50)	80(88.8)	21(23.3)	5(5.6)	24(26.7)	5(5.6)
30	41(45.6)	77(85.6)	20(22.2)	6(6.7)	29(32.2)	7(7.7)

As can be seen in Table 9, seventy-six (76) student teachers responded correctly to the question (item 25) on energy being a vector quantity just like force, compared to the previous number of 40. Similarly the number of participants who responded correctly to Item 23, increased to 79 from an initial number of 67, indicating that more of them (respondents) understood that energy cannot be classified as an example of a force. Item 24 sought to test student teachers' understanding of the concepts of energy conservation and transformation. As was the case before the intervention majority of the respondents (67 out of 90) showed understanding by answering the question and the follow up correctly.

The percentage of respondents who held the misconception that both energy conversion and conservation are the same reduced from 60% to 12.2%. The responses to item 26, shows the number of student teachers who understood that all forms of energy can be classified under potential and kinetic energy increased from 23 to 70. It can be seen that half (45) of the student teachers initially understood why some sources of energy are classified as renewable. This number increased to 80 (this is evident in their responses to item 29). Only 5.6% of respondents held misconceptions on the varied applications of energy in everyday life. This was a marked reduction from the previous percentage of 24.4. As was the case with their conceptions on matter and forces, the percentage of student teachers who developed conceptual understanding of various aspects of the concept energy increased after the intervention.

4.4 Research Question Three

What effect will the use of ICT–based teaching strategies have on the performance of student teachers in Science?

This question sought to find out how the effect of ICT-based teaching strategies in improving the academic performance of student teachers in the selected science concepts. It was answered through the use of the pre-tests and post-tests on the three concepts. The breakdown of scores attained by the 90 research participants in both the pre-test and post-test is shown in Table 10.

Table 10: Pre-test and post-test performance of student teachers in the concept of matter

Range	Pre-Test Freq (%)	Post-Test Freq (%)
1 – 4	21(23.3)	0
5 – 8	55(61.1)	8(8.9)
9 – 12	14(15.6)	13(14.4)
13 – 16	0	51(56.7)
17 – 20	0	18(20.0)
Total	**90 (100%)**	**90 (100%)**

In the pre-test as many as 21 student teachers attained a score between 1 and 4. In the post test though, none of them attained a score below 5. The number of respondents with scores ranging between 5 and 8 reduced from 55 in the pre-test to 8 in the post-test. Whereas majority of respondents had scores between 5 -8 in the pre-test, the modal score in the post –test was 13 -16. No student-teacher attained a score higher than 12 in the pre-test compared to a total of 69 student teachers who attained scores within the range of 13 to 20 in the post test. The mean score increased from 8.32 in the pre-test to 16. 88 in the post-test as presented on Table 10.

4.5 Testing of Hypothesis 1

4.5.1 Hypothesis one

H_{01}: There is no statistically significant difference between the pre-test scores and post test scores of student teachers in the concept, matter.

The independent sample 2-tailed t-test was used to test hypothesis 1 at p-value of 0.05 and the results are provided in Table 11.

Table 11: T-test results on pre-test and post-test performance of student teachers in the concept of matter

Compared Group	N	Mean Score	S.D	T	d.f	p-Value
Pre-test	90	8.32	5.04	1.812	89	0.014
Post-test	90	14.21				
Effect size value	1.17					

*P> 0.05

The t-test results in Table 11 reveals that there was a statistically significant difference in the pre-test and post-test scores of student teachers in the concept of matter (t (89) = 1.812, p>0.05). Thus the null hypothesis was rejected. Further, the Cohen's effect size value (d = 1.17) suggested a high practical significance which shows that in reality there was a high difference between the performance of the student teachers in the pre-test and post-test. As noted by Sullivan and Feinn, (2012) Cohen's effect size can be classified as small (d = 0.2), medium (d = 0.5), and large (d ≥ 0.8). The scores distribution of student teachers in the pre-test and post-test on Forces is presented in Table 12.

Table 12: Pre-test and post-test performance of student teachers in the concept of forces

Score	Pre- Test Freq (%)	Post Test Freq (%)
1 – 4	31(34.4)	3(3.3)
5 – 8	47(52.2)	14(15.6)
9 – 12	12(13.4)	16(17.8)
13 – 16	0	40(44.4)
17 – 20	0	17(18.9)
Total	**90 (100%)**	**90 (100%)**

In the pre-test, the highest score attained by any student teacher was in the range of 9 – 12, but as many as 67 students had scores between 13 and 20 in the post-test. Additionally, the number of student teachers who scored between 1 and 4 reduced from 31 in the (pre-test) to 3 in the post test. Also the modal score range changed from 5 – 8 to 13 – 16. The mean score of 14.16 in the post test shows a vast improvement compared to the 6.88 attained for the pre-test.

4.6 Testing of Null Hypothesis 2

4.6.1 Null hypothesis two

H_{02}: There is no statistically significant difference between the pre-test scores and post test scores of student teachers in the concept forces.

The independent sample 2-tailed t-test was used to test hypothesis 2 at p-value of 0.05 and the results are provided in Table 13.

Table 13: T-test results on pre-test and post-test performance of student teachers in the concept of forces

Compared Group	N	Mean Score	S.D	T	d.f	p-Value
Pre-test	90	8.88	4.36	1.770	89	0.025
Post-test	90	13.16				
Effect size value	0.98					

*P> 0.05

The t-test results showed that statistically, there was a significant difference in the pre-test and post-test scores of student teachers in the concept of forces (t (89) = 1.770, p>0.05). Thus, the null hypothesis was rejected. Further, the effect size value (d = 0.98) suggested a high practical significance of the p-value in terms of the differences between the mean scores of student teachers in the pre-test and post test.

The scores distribution of respondent student teachers in the pre-test and post-test on energy is presented in Table 14.

Table 14: Pre-test and post-test performance of student teachers in the concept of energy

Score	Pre-Test Freq (%)	Post Test Freq (%)
1 – 4	23(25.6)	0
5 – 8	54(60)	3(3.3)
9 – 12	12(13.3)	32(35.6)
13 – 16	1(1.1)	41(45.6)
17 – 20	0	14(15.5)
Total	**90 (100%)**	**90 (100%)**

As evident in Table 14, none of the respondents scored below 5 in the post-test, in contrast to the pre-test which recorded a total of 23 respondents attaining scores between 1 and 4. Twelve student teachers had scores between 9 -12 in the pre-test, but this number increased to 32 in the post-test. Whereas only 1 person scored above 12 in the pre-test, 55 participants recorded scores above 12 in the post-test. The mean pre-test score was 8.28 and this increased to 15.72 in the post-test. The entire breakdown of respondents' performance is seen in Table 15.

4.7 Testing of Hypothesis 3

4.7.1 Hypothesis three

H_{03}: There is no statistically significant difference between the pre-test scores and post test scores of student teachers in the concept, energy.

The independent sample 2-tailed t-test was used to test hypothesis 3 at p-value of 0.05 and the results are provided in Table 15.

Table 15: T-test results on pre-test and post-test performance of student teachers in the concept of energy

Compared Group	N	Mean Score	S.D	T	d.f	p-Value
Pre-test	89	9.46	4.53	1.686	88	0.028
Post-test	89	14.72				
Effect size value	1.16					

*P> 0.05

From Table 15, it is seen that there was a statistically significant difference in the scores attained by student teachers in the pre-test and post-test in the concept, energy (t (89) = 1.686, p>0.05). Therefore, the null hypothesis was rejected. Further, the effect size value (d = 1.16) suggested a high practical significance of the differences in the pre-test and post-test mean scores of the respondents.

4.8 Testing of Hypothesis 4

4.8.1 Hypothesis four

H_{04}: There is no statistically significant difference between the overall pre-test scores and overall post-test scores of student teachers in the concepts under study.

The independent sample 2-tailed t-test was used to test hypothesis 4 at p-value of 0.05 and the results are provided in Table 16.

Table 16: T-test results on overall pre-test and post-test performance of student teachers in the selected science concepts

Compared Group	N	Mean Score	S.D	T	d.f	p-Value
Pre-Test	90	8.89	4.64	1.701	89	0.001
Post-test	90	14.03				
Effect size value	1.10					

*P> 0.05

From Table 16, the t-test conducted shows that there was a statistically significant difference in the overall pre-test and post-test scores of student teachers in the various concepts under study (t (89) = 1.701, p>0.05). Thus, the null hypothesis was rejected. Further, the effect size value (d = 1.10) suggested a high practical significance of the differences in the mean scores of the student teachers in the pre-test and post test.

4.9 Testing of Hypothesis 5

4.9.1 Hypothesis five

H_{05}: There is no statistically significant difference in the post-test performance of student teachers in Matter, Forces and Energy.

Table 17 gives the summary of the ANOVA conducted to test null hypothesis five.

Table 17: Results of one- way ANOVA on performance of student teachers in the three concepts after the intervention

Compared Group	N	Mean Score	S.D	F	d.f	p-Value
Matter	90	14.21	1.40	0.001	88	0.658
Forces	90	13.16	1.43			
Energy	90	14.72	1.31			

*P> 0.05

ANOVA analysis was performed on the mean post-test scores of student teachers in the concepts of Matter, Forces and Energy. The results indicated no statistically significant difference (F (2, 88) = 0.001, p = 0.658) in the performance of student teachers within the three science concepts (Matter, Forces and Energy). Therefore, the null hypothesis was not rejected. This implies that in actual fact, there was no statistically significant difference in terms of the performance of student teachers in these three concepts after the ICT-based intervention.

However, the overall mean scores of student teachers in Matter which was recorded as 16.88 was higher than the mean scores in Forces and Energy which were recorded as 14.16 and 15.72 respectively. This suggests that student teachers performed most creditably in the tests on Matter, followed by Energy.

4.10 Research Question 4

What are the differences in performance of the male and female student teachers in the selected science concepts ?

This research question sought to find out the differences in performance of student teachers in the tests, with respect to gender.

Table 18 provides a summary of the scores attained by respondents (in terms of gender) in the three pre-tests (Matter, Forces and Energy) as well as the post-tests.

Table 18: Distribution of pre-test and post-test scores of student teachers based on gender

Score	**Pre-Test Males Freq (%)**	**Females Freq (%)**	**Post Test Males Freq (%)**	**Females**
1 – 12	8(28.5)	23(45.1)	0	2(7.1)
13 – 24	9(32.2)	24(47.1)	1(3.6)	7(13.7)
25 – 36	9(32.2)	2(3.9)	2(7.1)	18(35.3)
37 – 48	2(7.1)	3(3.9)	15(53.6)	20(39.2)
49 – 60	0	0	10(35.7)	4(7.8)
Mean Score	25. 8	21.03	47.32	46.74
Total	**28 (100%)**	**52 (100%)**	**28 (100%)**	**52 (100%)**

From Table 18, it can be seen that the range of scores increased from 1 – 20 to 1 – 60. It is evident from the data provided that overall, males performed better than females in both the pre-test and post-test.

Only 28.5% of male respondents attained a score between 1 and 12 in the pre-test compared to 45.1% of females. Similarly, 32.2% of males scored within 13 – 24, whilst 47.1% of female students attained scores within the same range (in the pre-test).

A total of 11 males (representing about 40% of males) attained marks above 24, compared to 4 females (7.8% of females) who attained similar scores (in the pre-test).

It is observed in Table 18 that although the performance of participants in both genders improved in the post-test, males outperformed females, as was the case in the pre-test.

Two females attained a score between 1 and 12 in the post-test, but none of the 28 males scored less than 13. The number of females who attained scores between 13 -24 reduced from 24 in the pre-test to 7 in the post-test. The number of males who attained scores within the same range (13 -24) reduced from 9 in the pre-test to 1 in the post-test. Notably, most of the male student teachers scored between 37 and 60 (a total of 89.3%). The percentage of females who had scores within the range of 37 and 60 was 47.

Testing of hypothesis 6

Null hypothesis six

H_{06}: There is no statistically significant difference in the performance of student teachers with respect to gender.

Table 19: T-test results on post-test performance of male and female student teachers in the selected science concepts

Compared Group	N	Mean Score	S.D	T	d.f	p-Value
Males	28	47.32	2.02	0.133	89	0.235
Females	52	46.74				
Effect size value	-0.28					

*P> 0.05

Table 19 provides details on the outcome of a t-test conducted to test hypothesis 6. The t-test results showed that statistically, there was no significant difference in the mean post-test scores of male and female student teachers in the science concepts under study (t (89) = 0.133, p>0.05). Thus, the null hypothesis was not rejected. Further, the effect size value (d = -0.28) suggested a low practical significance of the differences in the mean scores of student teachers in the pre-test and post-test.

4.11 Research Question 5

How does the use of ICT-based instruction influence trainee teachers' attitudes, views and intent about teaching of Science using ICT resources?

The purpose of this research question was to find out the influence of the intervention on the attitude of student teachers towards the teaching and learning of science. It also sought to find out the views of student teachers on the benefits and challenges associated with the use of ICT in teaching as well as their intent to use ICT in their future classrooms. This question was answered with the aid of a questionnaire as well as an Interview Guide. Table 20 provides a summary of student teachers' responses to various items on the questionnaire on their views concerning science learning, challenges associated with ICT usage as well as their intent to use ICT in science teaching.

Table 20: Student teachers' views on the impact and use of ICT in science teaching and learning

Statement	Responses				
	SA	A	NC	D	SD
1. The intervention has improved my attitude towards science Learning	41(45.6)	33(36.7)	6(6.7)	7(7.8)	3(3.3)
2. I am better equipped to teach science	39(43.3)	30(33.3)	3(3.3)	11(12.2)	7(7.8)
3. I will be able to assist learners to study science effectively	45(50)	31(34.4)	2(2.2)	8(8.9)	4(4.4)
4. I have no interest to teach science in the future	5(5.6)	18(20)	5(5.6)	35(38.9)	27(30)
5. I have gained better understanding of some concepts after the Intervention	55(61.1)	31(34.4)	2(2.2)	2(2.2)	0
6. The traditional method helped me to understand science concepts better	4(4.4)	5(5.6)	3(3.3)	43(47.8)	35(38.9)
7. The use of ICT made lessons interactive and engaging	32(35.6)	39(43.3)	5(5.6)	9(10)	5(5.6)
8. The use of ICT did not make any difference in my learning of science	11(12.2)	5(5.6)	0	38(42.2)	36(40)
9. ICT usage in lesson delivery is cumbersome	21(23.3)	16(17.8)	4(4.4)	42(46.7)	7(7.8)
10. The use of ICT to teach science is time consuming	18(20)	18(20)	9(10)	34(37.8)	11(12.2)
11. ICT resources for teaching are expensive	22(24.4)	19(21.1)	6(6.7)	31(34.4)	12(13.3)
12. I will prefer to use other teaching methods rather than ICT-based strategies	11(12.2)	11(12.2)	6(6.7)	35(38.9)	23(25.6)
13. I will use ICT actively in my future lesson delivery	51(56.7)	21(23.3)	2(2.2)	9(10)	7(7.8)
14. I intend to use ICT only as a back-up teaching method	6(6.7)	8(8.9)	5(5.6)	43(47.8)	28(31.1)
15. If I have access to the relevant resources, I will use ICT actively in lesson delivery	61(67.7)	21(23.3)	2(2.2)	5(5.6)	1(1.1)
Total	**90 (100%)**				

From Table 20, it is seen that a total of 78% of respondents indicated that the intervention had improved their attitude towards the learning of science. On another positive outlook, 69 out of the 90 respondents revealed they were better equipped to teach science after the intervention. In spite of the intervention, 23 respondents pointed out that they had no interest to teach science in their future classroom. Two out of the 90 respondents revealed the intervention had had no positive impact on their conceptual understanding of the three concepts under review, whilst 9 respondents indicated that they understood lessons better when the traditional lecture method was used.

Regarding challenges associated with ICT usage a significant 37 respondents pointed out that ICT usage in science teaching was cumbersome. A similar number of 36 student teachers also agreed with the statement that the use of ICT for lesson delivery was time consuming. Fifty-eight student teachers disagreed with the statement that ICT resources needed for science teaching are expensive to purchase.

In terms of the benefits and intent to use ICT, only 22 respondents indicated they would prefer to use traditional teaching methods to ICT-based teaching in their future classrooms. Notably, 80% of the 90 respondents pointed out that they would use ICT actively in lesson delivery as basic school teachers.

4.12 Analysis of Data gathered with Interview Guide

- **Attitude towards teaching science**

From the interviews conducted, it came to light that most respondents were keener to teach science at the basic school level, after the intervention. Interviewees gave several reasons for this observation. For instance FR1, stressed that "*I feel I am better prepared to serve as a science teacher, because I have better understanding in the concepts*". MR3, a male student teacher also explained that, "*I felt jittery and wasn't confident about teaching science because I always score low marks in science, but after the intervention I attained above average scores in all the post tests. This makes me believe that I have what it takes to teach science and do so effectively as well*". The main reason was that their performance in science had improved as a result of the intervention. Another key reason was that, participants had gained better conceptual understanding of the various science concepts. In the words of MR4, "*since my JHS days, I have struggled to understand why objects of different sizes released from the same height above the ground, are expected to fall at the same time, but the use of the* *videos helped me to understand the impact of gravity on falling objects perfectly. Also, I am now able to explain the real-life application of Newton's Laws of motion*". Generally, the student teachers believed they had been empowered to teach these topics in their future science classrooms. A few respondents linked their eagerness to teach science to the use of ICT. In their view, ICT usage had opened their minds on how to teach abstract science concepts and also cater for the learning needs of students, in the absence of resources. One female respondent (FR2) elaborated that "*I have always been concerned about the absence of science laboratories as well as the lack of appropriate resources for teaching science in our primary and Junior High schools. I am happy to have learnt about how I can use various ICT resources to help teach abstract science concepts in a way that my students will understand easily*"

According to two respondents (FR2 and FR4), the use of animations to explain concepts in forces and energy, helped them to build a mental framework that aided their understanding.

Several respondents indicated that their cold attitude towards science was based on the manner in which they had been taught back in the Junior High and Senior High Schools. One interviewee. MR1 explained that, "*our SHS integrated science teacher only gave us notes after explaining each topic. In science lessons we only listened to the teacher, and lessons were devoid of the use of resources or active involvement of the class*". This response gives an indication that teaching at the SHS was conducted in a teacher-centred manner (lecture method) devoid of the use of relevant resources or active student engagement.

4.12.1 Challenges in the use of ICT for science teaching

With regard to the challenges that might deter them from actively using ICT in the science classroom, the respondents provided a number of reasons. Some of the reasons cited are:

- ICT usage is unreliable because of persistent power outages in the country. FR3, a female student teacher said " *In many parts of the country there is unreliable or no electricity connectivity in schools, and I can foresee that this will make the use of ICT resources such as computers, projectors and Internet routers very difficult if not impossible*".
- The use of digital resources is expensive, since data needs to be procured for internet access. MR1 remarked that, "*apart from PowerPoint presentations which can be prepared without relying on the internet, other ICT services such as the downloading of videos, pictures, and access to online educational websites require internet connectivity, and in some cases users are required to pay before they can access the educational materials, all this comes at a cost, which may be too high in relation to the salary that I may receive as a teacher*."
- Lack of familiarity on how to operate computers, projectors, prepare slides and also how to access various website content. Particualrly, FR3 shared the concern that " *I am only familiar with how to use my phone to watch videos or visit the LMS. Honestly speaking, I don't see myself being able to operate all those sophisticated ICT equipment all because of one science lesson*".
- Organising ICT resources for a lesson takes a lot of time.
- Most basic schools in Ghana do not have access to electricity or ICT laboratories or internet facilities.

- Absence of personal ICT-based resources such as laptop computer, internet router, projector and speakers.

MR 1 explained that, "*since Ghanaian basic school learners are used to the traditional method of using the chalk or marker to teach, introducing ICT as a key pedagogical tool will mean disrupting the status quo*". Another Interviewee MR3 was of the view that "*the inability to operate various functions on computers and also access digital resources was widespread among their colleagues as well as teachers in various basic schools*".

Irrespective of these challenges identified, most of the respondents interviewed, indicated their intent to use various ICT-based resources in their lessons.

4.12.2 Attitude towards the use of ICT in science teaching

Out of the 10 interviewees, 7 expressed eagerness to use ICT actively in the teaching and learning of science. This number consisted of 4 males and 3 females.

FR5, stressed that "*I will use ICT in my lessons when I become a science teacher, because it will help me to explain topics more easily. I believe it will also help my learners to develop more interest in the learning of science*". MR4 a male student teacher also said "*Though I have not started work as a teacher yet, I can foresee that the use of online videos on YouTube will make it easier for me to explain some topics such as respiration, blood circulation, formation of day and night amongst others which I found difficult to understand as a basic school learner*". He further stressed that "*the whole world is going digital so I believe it is high time that Ghanaian teachers follow suit*".

Notably, some interviewees indicated they were not interested or unlikely to use ICT for lesson delivery. For instance, MR1 remarked that "*For me I don't think using ICT resources will make much of a difference. I believe the most important thing is for me to understand what I am teaching and to master the content*". FR3 was of the view that "*considering the challenges in our schools, and the expensive nature of such ICT resources, I don't think it will be feasible for me to use those resources when I become a teacher*."

4.12.3 Benefits of ICT usage in science lesson delivery

Reasons cited by the group of respondents who intended to use ICT as science teachers include:

- It is a convenient method of teaching. In the words of FR5, "*In the lessons we just had, ICT was used not just for explaining concepts but also for us to submit assignments and comlete tasks. I was able to use my phone to complete taks or search for videos and other relevant materials online, which is better than going to the library*".
- It helps to understand concepts better. MR1 was of the view that " *I can confidently explain different concepts under energy, matter and forces after the intervention. This makes me believe that, the use of ICT resources will definitely help to explain other abstract science concepts in the curriculim such as Efficiency of Machines, Pressure, Electricity and Electronics*". Further MR2 said " *It was through the use of the Videos that I finally understood Newton's third law of motion even though I have studied the laws of motion since my SHS days*."

- There is easy access to videos, pictures and lessons on various science concepts. "*I always watch videos on Youtube and other websites, but it never occurred to me that the same YouTube contains many videos that are related to what I learn in class*".
- It promotes active student engagement, eliminates boredom and also generates interest in lessons.

Particularly, respondents cited the use of videos and images as the key digital resources that they would most likely use in teaching science at the basic level. As MR 2 indicated, "*I am more likely to use ICT for lesson delivery, rather than for student assessment*". Several respondents including FR1, indicated that "*Particularly, ICT usage will be more beneficial to me during lesson note preparation*". Another interviewee remarked that, "*prior to the intervention, I didn't realise I could make use of common sites such as YouTube to access a wide range of videos on various science concepts*". Another respondent asserted that "*Now I have come to learn that, I can use my mobile phone to access a wide range of content and educational resources, apart from using it (the mobile phone) for interacting on social media platforms".*

4.13 Discussions

4.13.1 The misconceptions held by student teachers about some selected science topics

4.13.1.1 Matter

The use of the questionnaire brought to fore the degree of misconceptions held by respondents in various science concepts (Matter, Forces and Energy). Considering the fact that the study subjects are prospective teachers, there was the need for them to fully understand each concept in terms of its practical applications. Regarding the concept of matter, as many as 43 respondents out of 90 held the misconception that all atoms were the same. This observation is bothersome, considering the fact that, understanding the particulate nature of matter is a fundamental to the study of the concept (matter). Thus individuals must fully know that the differences between atoms of different elements gives rise to differences in their properties and their behaviour in chemical reactions. This finding corroborates the work of Pozo (2001) in which approximately 7 out of every 10 student teachers could not describe the relationships between different concepts in matter.

Though student teachers were generally aware that solid substances had fixed shapes, 28 respondents were unable to explain why solids had fixed shapes. This suggests that the curriculum for teacher education and the senior high school science curriculum need to focus on proving in-depth explanation on the relation between the molecular packing and types of bonds in substances in the three main states of matter and its effect on the physical properties of substances (in various states) such as shape, boiling point, ease of compression, rate of movement. Unsurprisingly, the respondents were unable to explain why liquid bromine and liquid ammonia travelled more slowly than the gaseous forms of these substances. Inferably, all these boils down to the lack of understanding about the effect of types of bonds on properties of substances in each state of matter.

Kapici and Akcay (2016) revealed that students did not fully understand the concept of the particulate nature of matter. Özalp and Kahveci (2011) showed that similarly a significant proportion of student teachers were unable to give examples of phenomena that demonstrate that matter consists of particles. In trying to explain the misconceptions of students on various science concepts, Awan et al. (2011) and

Omari and Chen (2016) stressed that the predominant mode of teaching which is characterised by the lecture method and rote learning compels students to memorise concepts without fully grasping their real-life applications.

The fact that most respondents accurately identified substances that could be classified as matter, proves that they were fully aware of the criteria for classifying substances as matter (volume and mass). A study of the SHS integrated science curriculum shows there is focus on helping students to know why substances are classified as matter based on the two main criteria (mass and volume). Miller, McNeal & Herbert (2010) affirm that when students are provided with opportunities to rationalise and make meaning of new knowledge, integrating this new information into their existing knowledge promotes better understanding of concepts.

4.13.1.2 Forces

Compared to the concept of matter, the results of the study showed that student teachers held more misconceptions about forces. Rosenblatt et al. (2014) affirmed that students have difficulties understanding the concept of force. According to Martín-Blas et al. (2011), this trend is seen from the basic level of schooling right up to the tertiary level.

Most respondents wrongly believed that the main effect of forces on objects is movement of the objects. A study by Driver et al. (2014) also found out that many students held the view that once there is no motion, then no force is being applied. This also suggests that participants are not familiar with the concept of balanced and unbalanced forces. A key reason could be the absence of the concept of net forces in the integrated science curriculum for SHS. As it stands the SHS curriculum looks mainly at some effect of forces such as movement, change of direction, change in speed and shapes of objects. Rosenblatt et al. (2014) also observed that students had limited knowledge about net forces.

Although student teachers are aware that acceleration due to gravity is constant, it can be inferred from their responses that a significant percentage were not aware of its real-life applications. Thus they erroneously believed that the heavier object would fall to the ground faster than the lighter one, when the two objects are released at the same time. This finding is similar to the one made by Rosenblatt et al. (2014).

Cheng and Gilbert (2014) averred that misconceptions are borne out of wrong representations of concepts. Thus, though student teachers were familiar with magnetic force and friction as examples of forces, majority could not correctly categorise them as non-contact and contact force respectively. The inability of respondents to identify weight as a force, is probably due to the definition that a force is a push or a pull on an object. Respondents were unable to understand that objects exerted their weight on the earth.

Some respondents were unable to explain why centripetal force was not the only force that kept the moon moving in a circular path around the earth. This is probably because students had wrong ideas about the force of gravity as also identified by Dostal (2005). Thus Kirya et al. (2022) suggest that teachers must not only provide students with new knowledge but also assist them to align their knowledge in a way that will assist them to gain better understanding.

Overall, it can be inferred from the responses provided by the study subjects that they did not understand Newton's laws of motion and their applications on forces. Fadaei and Mora (2015) also discovered that most students hold common sense ideas about everyday motion, which are generally in contradiction with the laws of motion. It came to light in the present study that 48 (53.3%) respondents held misconceptions about the forces at work when an object is at rest. Also, as many as 40 respondents held misconceptions or did not understand the concept of net forces felt when two objects of different sizes collide. This is in line with the suggestion that teacher educators need to focus more efforts on teaching concepts of net forces, balanced and unbalanced forces (Kirya et al., 2022).

4.13.1.3 Energy

Although majority of respondents correctly indicated that it was erroneous to say Energy existed only in living objects, the inability of a good number of respondents to provide the correct reason, shows that they did not understand the concept of energy clearly in terms of energy transformation and the two main forms of energy. Chabalengula et al. (2012) found out that even students at the higher levels of education harboured wrong views about energy.

The misconception that energy is associated only with movement (and for that matter work) can be partly explained that respondents were unable to identify the real-life application of potential energy as energy of a body by virtue of its position (stored energy). Demirbas (2009) also identified students' challenges in associating energy related concepts to everyday living.

Majority of respondents correctly identified that the energy in a kerosene stove does not get finished but is actually converted to different forms. This shows that generally they were able to apply the concept of energy transformation in different contexts.

The percentage of respondents who did not agree to the statement that all forms of energy can be classified under potential and kinetic energy is noteworthy. Arguably the genesis of this misconception can be traced to the SHS curriculum in which kinetic and potential energy are captured as other forms of energy just like, chemical energy, sound energy, heat energy, electrical energy and nuclear energy. Thus, students are not taught to understand that chemical energy, electrical energy, heat energy, and other forms are either in motion (kinetic energy) or stored form (potential energy). This corroborates the work of Gulcicek and Yagbasan (2004) who found out that students were unaware of the fact that the total energy of a system was a sum of its potential and kinetic energies.

In studying the law of conservation of Energy at the SHS level, students are taught that, “Energy cannot be created nor destroyed, but is converted from one form to another. This is a possible reason why a sizable proportion of student teachers held the wrong view that both energy conservation and conversion talk about the same thing. For this reason, Trumper, Raviolo and Shnersch (2007) in their study of prospective teachers’ conceptions about energy conservation suggested that the teaching of this concept must be strongly supported with the use of computer animations.

Majority of respondent exhibited conceptual understanding about renewable energy and non-renewable energy as evident in their responses to the items on definition of renewable energy and examples. This is encouraging, because more recently, stakeholders are focusing on promoting the usage of renewable energy through the school curriculum (Çoker, Çatlioğlu & Birgin, 2010). In promoting conceptual understanding of renewable energy, Çoker et al. (2010) suggest the need for contextualisation of content.

4.13.2 The effect of ICT-based teaching strategies on the conceptual understanding of student teachers in Science

Conceptual understanding is basically a measure of the extent to which a person knows the principles and theories behind a given concept. As Koniceck-Moran and Keeley (2015) put it, conceptual understanding entails application of a concept in different contexts, thus promoting deeper understanding. As implementers of the curriculum, teachers are crucial to the attainment of the learning outcomes expected of our students (Rittle-Johnson et al., 2001). The NTS describes a qualified teacher as one having the appropriate pedagogical and content knowledge required to deliver effectively in the classroom (Asare & Nti, 2020). In the TPCK theory, knowing what entails in a subject or discipline is key to knowing the right approaches to knowledge dissemination in that discipline or subject area (Shulman, 1986). This kind of knowledge is described as Content Knowledge (Harris, Mishra & Koehler, 2019). Koehler and Mishra (2008) stated that the use of appropriate technologies helps to improve the content knowledge of student teachers, hence their conceptual understanding. Having deep conceptual understanding of concepts within the science curriculum is a requirement expected of all basic school teachers (Bahr & de Garcia, 2010). It came to light in the study that, the intervention had a significant impact on the conceptual understanding of the student teachers. This finding is very encouraging, as previous studies found out that many student teachers lacked in-depth understanding of science topics (Halim, Yong & Meerah, 2014). The root causes of poor conceptual understanding are several (Wong & Sulaiman, 2008; Osman, Halim, & Meerah, 2006). These include textbooks, poor teaching approaches and previous knowledge. In the education of student teachers, it is the duty of the lecturer to ensure that any misconceptions about the concept are addressed through the use of appropriate pedagogical strategies and resources. Halim et al., (2014) as well as Bayraktar (2009) observed that unfortunately some educators rather seem to be the sources of misconceptions. The use of teacher-centred methods of instruction inhibit deep conceptual understanding. Additionally, some teachers provide wrong information and explanations about concepts to students. In the present study the ICT resources employed helped to provide in-depth explanation and also aided students to develop correct mental constructs of various science phenomena. The advantages associated with the acquisition of deep conceptual understanding include more confidence, increased self-esteem, improved attitude towards academic work. These ultimately translate into enhanced learning outcomes (Liu, Hou, Chiu, & Treagust, 2014).

The poor performance of students in science examinations is an age-long challenge in Ghana (Owusu-Ansah, 2012). Particularly concepts such as forces, light, balancing of equations, organic chemistry, IUPAC nomenclature, chemical bonding and genetics have proven to be difficult to most candidates (WAEC, 2020). The study has revealed that when utilised effectively, ICT can ameliorate the situation and promote effective teaching and learning. Particularly the use of ICT has an advantage of providing deep insight and in-depth knowledge into a concept for teachers prior to teaching the concept as noted by Abdulla, Al-Hawaj & Twizell. (2008). It also enables students to get in-depth understanding whilst addressing any misconceptions in the area of interest. The outcome of the study aligns with the assertion by Karim and Hassan (2006) that in the absence of reagents, charts, apparatus and other resources critical to the effective understanding of science by students, teachers need to take a more critical look at the use of ICT in effective teaching.

Through the interview sessions, it came to light that the use of varied ICT modes helped to consolidate the gains made in the given concept. The use of pictures helped students to visualise concepts, whilst animations helped to provide further clarity as well as step-by-step guidelines on the relation between different concepts.

At the advanced level, educators can assist students to use ICT in undertaking assessment tasks such as creation of digital concept maps, word clouds, or recording, editing and upload of educational videos (Yusop, Habibi & Razak, 2021). The findings of the study are in line with Shulman's (1986) PCK theory further highlighted by Mishra and Koehler (2006) who stressed that knowledge and use of ICT can be used to support the content and pedagogic knowledge of the teacher for an effective teaching and learning outcome. Mishra and Koehler (2006) in their TCKP theory also emphasised on the effect of technology in improving on the status quo regarding the attainment of teaching and learning targets. The present study lays credence to the effectiveness of the TCKP theory in undertaking studies in the use of technology in the delivery of education at all levels.

4.13.3 Influence of ICT–based teaching strategies on the performance of student teachers in Science

The observation that ICT usage led to an improved performance is noteworthy. It proves that instructors can leverage on such resources to effectively teach abstract science concepts. It also lays credence to the fact that, it is possible to make use of virtual resources as a substitute for inadequate or unavailable resources for undertaking practical science lessons (Westera, 2015).

In particular, the use of simulation videos and pictures helped to ensure detailed explanation of abstract aspects of the concept forces and energy. In the present study the use of a video explanation the real-life Application of Newton's Laws of motion, helped to improve the respondents' conceptual understanding of net forces and the concept of inertia. This ultimately translated to improved performance in the post-test. Unsurprisingly, 86 out of the 90 respondents indicated that they had gained better conceptual understanding in various concepts after the ICT-based intervention (as revealed in their responses to the questionnaire). Chabalengula et al. (2012) also found out that the performance of students in energy improved after an ICT-based intervention was introduced.

In relation to the concept of matter, a comparison of the responses provided to the questionnaire before and after the intervention reveals a vast improvement in the level of their (student teachers') conceptual understanding. For instance, the number of respondents who understood that all atoms are not the same increased from 23 (prior to the intervention) to 60 (66.7%). With regard to item 3 which demanded respondents to provide the name of any phenomenon that confirms the particulate nature of matter, the percentage of respondents that exhibited comprehension of the concept, increased from 11.1% to 44.4%. Out of the three concepts, student teachers performed best in matter. This tends to suggest that the theoretical approach to teaching the concept was a bane to students' understanding of the concept. Considering the practical nature of science, teachers must refrain from teaching it theoretically or adopting the lecture method of science teaching (Yeboah et al., 2019).

This particular intervention was devoid of the use of science equipment or reagents that have been suggested for use in teaching these concepts to student teachers as enshrined in the new curriculum for teacher education. However, the ICT resources still played a crucial role in ensuring that concepts were thoroughly treated and understood. Agarwal (2013) and Goel (2003) recommended that ICT usage should be integral in the school system.

Notably, the improved performance was recorded after a similar improvement in the conceptual understanding of student teachers. This observation is in line with that of Rittle-Johnson et al. (2001) and Vosniadou (2001) who stated that improvement in conceptual understanding ultimately enhances the academic output of learners.

It is important for stakeholders to pay critical attention to an enhanced role of ICT in teacher education. Funds must also be allocated to the purchase of ICT resources for usage by lecturers.

Halim et al. (2014) found out that the concept of forces was one of the science concepts which student teachers found most difficult to understand. The findings of the present study tend to suggest that adequate training of teachers on how to identify and make use of appropriate ICT resources can be an effective panacea to this phenomenon.

Based on the results of the study, it is evident that a number of respondents still recorded low scores in spite of the intervention. A number of reasons can account for this observation. Because ICT usage has a limitation in terms of the extent to which students can interact with teaching and learning resources, teachers must supplement the usage of ICT resources with other teaching approaches such as use of realia, practical activities and collaborative learning (Olawale, 2013; Vosniadou, Skopeliti &

Ikospentaki, 2005). This will help to address the challenges of students who are slow learners or have varied learning challenges.

Whilst teaching the concept of energy, simulation videos were used to explain energy transformation. Further student teachers were tasked to complete worksheets on the LMS about the concept.

Finally, student teachers were shown PowerPoint lessons containing images depicting energy usage, transformation and conservation. The cumulative effect of the usage of these three strategies was the increase in their mean score from 4.14 to 7.86. Anderman, Sinatra and Gray (2012) indicate that the use of different strategies to teach the same concept boosts students understanding and performance. In their daily teaching based on ICT, teachers must avoid using only one ICT mode. Different approaches help to address the diverse needs of students and promotes deeper understanding. Using varied ICT resources also consolidates the gains made by students.

The important role of teachers in the attainment of students' learning outcomes is well documented (Ell & Grudnoff, 2013). Thus, it is imperative for our universities and colleges of education to train teachers who are well-equipped to nurture a new generation of globally competitive Ghanaian school graduates. Therefore, the problem of poor performance of student teachers requires urgent attention. The present study has provided evidence to show that the effective use of ICT by educators can help ensure better learning outcomes, thus contributing to the effective training of student teachers as noted by Desimone et al. (2002).

4.13.4 Relation between Gender and Academic Performance of Student teachers in the selected science concepts

Gender identity refers to self-identification of one's self as male or female (Price & Skolnik, 2017). According to Schachter and Rich (2011) the uniqueness of each gender can be used to foster and promote student success. Trepet (2006) reveals that gender has an influence on the way and manner that males and females interact with technology. He explains further that this is as a result of gender differences in attitude towards ICT usage.

Azman (2014) identifies gender as a key factor in predicting the academic performance of students.

In the study it was revealed that statistically, there were no significant differences in the performance of male and female student teachers both in the pre-test and the post-test. This finding is similar to that found in some previous studies such as Adigun, Onihunwa, Aghiomesi, Yusuf and Olubunmi (2015). It is however in contradiction with the study by Godpower-Echie and Amadi (2013), where gender was found to be a key predictor of students' performance.

However, the mean scores of males were higher than that of females in all the three concepts being studied. This finding is probably due to the fact that males are more familiar and comfortable with ICT usage as compared to females thus find it more convenient studying with the aid of ICT-based resources (Ashong & Commander, 2012). Anthony (2012) points out though that as the years go by the gender differences in attitude towards ICT usage in education is decreasing. In contradiction, a study by Adigun et al. (2015) revealed that girls performed slightly better than boys in science-related subjects.

Considering the fact that the mean scores of males in the pre-test was higher than females (as was still the case with the post-test), it can be argued out that gender was not an influential factor in the performance of the student teachers.

4.13.6 Effect of ICT-based instruction on student teachers' attitudes, views and intent about teaching of science using ICT resources

The findings of the study reveal that generally student teachers are keen on the usage of ICT resources for lesson delivery. From the interview sessions and the responses to the questionnaire items, it became evident that the intervention had resulted in an improved attitude of student teachers so far as using ICT as a key pedagogical tool is concerned. Similarly, Bidin, Hashim, Sharif & Shamsudin. (2011) found out that an ICT-based intervention had a positive effect on respondents' attitude to use ICT for academic purposes. Similarly, Valtonen et al. (2014) found out that an ICT-based intervention had a positive effect on student teachers' intent to use ICT in their future teaching. This clearly aligns with Davis' (1989) Technology Acceptance Model that proposes that perceived ease of use and usefulness of a technological tool determines the extent of consumer acceptance. (Charness & Boot, 2016). In the TAM, perceived ease of use is one of the main factors accounting for the decision to use a given technology. Mafang'Ha (2016) cited social factors such as language, skills and facilitating conditions as contributing to the perceived ease of use. In the current study, the application of various technologies by the researcher and research subjects ensured that the social factors (chiefly skills and facilitating conditions) were well taken of thus influencing positively the self-efficacy beliefs and intent of the student teachers to use such technologies.

It became evident that the intervention had made student teachers realise that contrary to their assertions, ICT was easy to use in lesson delivery, convenient and promoted deep understanding. Beckers and Schmidt (2003) also found out that the more teachers were exposed to ICT based professional training, the greater the probability to use ICT-based resources in their professional activities.

For students who were not keen to use ICT as substantive teachers they explained that inconveniences such as the expensive nature of ICT resources as well as the absence of electricity and ICT resources in many basic schools across the country are possible challenges that they envisage will prevent them from using ICT in lesson delivery. This is in tandem with the findings of Aslan and Zhu (2016) that issues such as human resource and infrastructure affected the intent of student teachers to use ICT in their future teaching.

Other respondents cited poor ICT usage skills as a factor which will definitely prevent them from using ICT to deliver lessons. Factors such as low ICT skills, poor preparations at the SHS as well as failure of teachers to use such resources actively in teaching may be directly responsible for teachers' ambivalent attitude towards ICT usage (Teo & Lee, 2010). This observation calls for immediate attention, against the backdrop of the fact that ICT is recognised as a key pedagogical tool in the new curriculum for basic schools (NaCCA, 2019). Interventions can focus on strengthening ICT teaching at the pre-tertiary level as well as a more prominent usage of ICT by teachers at the tertiary level. Further efforts should be made by lecturers handling various courses to ensure students are given tasks that require them to apply ICT to complete. These could include group or individual projects, assignments or even end of semester assessments. Invariably, the lecturer plays a key role in the student teachers' attitude and intent to use ICT to deliver lessons (Yusop et al., 2021). A more prominent usage of ICT by teacher educators will translate into a more active usage by student teachers upon their postings to schools.

The fact that most respondents stated that they had the skills required to employ ICT in their daily teaching lays credence to the fact that when teachers act out the behaviour they expect their student teachers to practice in the classroom, it becomes easier for the student teachers to follow suit. As confirmed by Pamuk and Peker, (2009) the self-efficacy beliefs of students improved significantly after their teachers taught several concepts based on ICT resources. Fundamentally, self-efficacy is determined by factors such as perceived ease of use and the perceptions of others about the behaviour (Ajzen, 1985). Inferably the use of ICT to treat such concepts regarded as difficult and abstract by most students, helped to allay the fears of respondents. It helped them to realise that firstly they would be able to use ICT on their own as teachers and secondly, respondents admitted that the benefits of using ICT outweighed the disadvantages associated with its usage. In Wilfong's (2006) study, the respondents cited the advantages as the main reason behind their intent to apply ICT in teaching.

One cannot overlook the bottlenecks inhibiting the effective usage of ICT in the Ghanaian educational system (Adu-Gyamfi, 2014). From the absence of resources to poor maintenance and storage structures as well as the expensive nature of some of these resources, there exists a myriad of issues that need to be addressed so far as this crucial 21st century tool is concerned. Stakeholders must put in concerted efforts to address these bottlenecks. At the tertiary level, intentions to promote ICT usage must focus on training for lecturers on the use of simple, efficient and cost-effective resources such as PowerPoint projectors, videos and animations as well as free web resources.

The findings of the study also suggest the need for policymakers and teacher educators to consciously educate student teachers on the advantages and need for ICT usage in their future classrooms. Ashrafzadeh and Sayadian (2015) emphasise that educators' refusal to use ICT is partly due to the fact that they are unaware of the full benefits associated with its usage. This may require the review of the content of the current ICT course being offered by student teachers.

As the world becomes more and more digitalised, digital literacy is a key skill that all school graduates must exhibit in order to fit into the world of work (Kaware & Sain, 2015). The best place to acquire this skill is the school. In the absence of a digitally literate teacher, the target cannot be achieved. Teacher Education needs to place a greater focus on equipping prospective teachers to carry on the mantle of e-learning at the basic school. In many jurisdictions the use of ICT in educational delivery has been cemented for decades and plays roles in teaching, assessment and grading of students' work (Schindler, Burkholder, Morad & Marsh, 2017).

It is noteworthy that the current status of ICT provisions in our basic schools leaves much to be desired. In most schools, the required resources for teaching computing are unavailable, a scenario which renders the teaching of computing to be more theoretical rather than activity-based (Donkoh, 2016). This anomaly most certainly has a negative impact on the ability of teachers to utilise ICT resources in teaching science within the school. A recommended approach to addressing this issue is the use of laptops provided to teachers as a stop gap measure. School authorities need to purchase a projector for use by science teachers and other practitioners within the school on a rotational basis. Considering the content of the science curriculum for basic schools, it is possible for science teachers to gain access to relevant and interesting videos, task sheets and other resources from the internet to be used in lesson delivery. The provision of laptops to teachers is necessary for enhancing the ICT skills of teachers in order to enable them leverage ICT for lesson note preparation, accessing curriculum documents and other resources vital for their effective functioning as educators.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter summarises the entire study, discusses the research findings and conclusions, gives recommendations and makes suggestions for future research.

5.1 Summary

The study mainly focused on identifying the misconceptions of student teachers in some selected science concepts (Matter, Forces and Energy) and the implementation of an intervention in the form of ICT-based instruction to improve upon their conceptual understanding and performance in these science concepts. The study subjects were ninety (90) student teachers in the Department of Basic Education at the University of Education, Winneba. The instruments used for data gathering were a two-tier questionnaire for identifying misconceptions, pre-tests and post-tests, a questionnaire and an interview schedule. The various tools for data gathering were validated with the help of expert science educationists. Similarly, the reliability of the instruments were determined through pilot testing in a College of Education with similar background characteristics (demography and respondents) as the actual population for the study. Five research questions were formulated to guide the study. Specifically, the targets of the study were to:

- Identify the misconceptions of the student teachers on the three cocnepts under consideration (Matter, Forces and Energy)
- Assess the impact effect of an ICT-based intervention on improving student-teachers' conceptual understanding in the selected science concepts.

- Examine the influence of the intervention on the student teachers academic performance in the science concepts.
- determine the difference in the performance of respondents in the science concepts in terms of males amd females.
- Identify the attitude, views and intent of student teachers on the usage of ICT in science teaching as well as their intent to use ICT-based resources for teaching science in their future classrooms.

The intervention was in the form of various ICT modules including the use of Videos, PowerPoint presentations, an Online Learning Management System (LMS), various websites and an E-platform (Padlet) for submission of learning tasks by student teachers. The intervention and administering of various research instruments were done within one academic year.

The two-tier instrument was used to identify the level of student teachers' conceptual understanding in the three concepts (Matter, Forces and Energy) before and after the intervention. The tests were administered to determine the impact of the intervention on student teachers' academic performance.

Through T-test analysis, the gender differences in performance of the respondents (student teachers) were investigated. Finally, the questionnaire and Interview Guide were used to gather the views, and intent of student teachers regarding ICT usage for lesson delivery.

5.2 Summary of Findings

- It has been revealed from the study that the student teachers held misconceptions in all three science concepts (Matter, Forces and Energy) under consideration.
- After the intervention, the level of conceptual understanding of student teachers in all three concepts was improved significantly ($p < 0.05$). This improvement in conceptual understanding was translated into improved performance. A comparison of the pre-test and post-test performance of student teachers revealed a statistically significant difference ($p < 0.05$) following the intervention.
- A total of six (6) null hypotheses were formulated for the study. Testing of the various null hypothesis revealed statistically significant differences ($p < 0.05$) in the pre-test and post-test performance of student teachers in each of the three concepts. There was also an overall statistically significant difference ($p < 0.05$) in the performance of student teachers in the pre-test and post-test scores for the three science concepts (combined).
- However, there was no statistically significant difference ($p > 0.05$) in the performance of student teachers in the three concepts (comparing their performance in each of the three science concepts) after the implementation of the intervention.
- Notably the gender of respondents (as in male or female) was not a significant factor in the performance of student teachers as the testing of the null hypothesis revealed no statistically significant difference in the performance of males and females.

- The findings of the study also revealed that the intervention had improved the attitude and intent of student teachers towards the usage of ICT in science teaching as prospective teachers. Most of them indicated that they were keen to use ICT as an integral tool for lesson delivery in science, compared to the traditional method of lesson delivery.
- However some challenges such as the expensive nature of ICT logistics, lack of expertise as well as the absence of requisite ICT infrastructure in many Ghanaian basic schools were cited as key issues that could inhibit the usage of ICT resources in lesson delivery by these prospective science teachers.

5.3 Conclusions

The overarching focus of the study was to identify the misconceptions of student teachers in some selected science concepts and apply appropriate ICT-based interventions to address these misconceptions and also to improve upon their (student teachers) performance in science.

The findings that most student teachers held misconceptions about concepts such as forces, energy and matter is noteworthy. These three concepts are captured as key learning areas in two out of the five (5) strands in the primary school science curriculum and also in the Junior High school curriculum implemented in the 2021/2022 academic year. Considering the integral role of Science as a subject of study at the pre-tertiary level of education as well as in nation building, there is the need for professional development interventions to tackle the conceptual understanding of science teachers.

The issue of absence of adequate resources for science teaching is an age-long canker that impedes the teaching and learning of science within the Ghanaian context.

Bearing in mind the practical nature of science, the absence of such requisite resources could be cited as a contributory factor to the poor levels of conceptual understanding of students in various science concepts.

On a good note, the present study has added to the growing evidence of the potential that ICT-based interventions hold in helping to address some of the challenges faced in science learning due to the absence of required science equipment, reagents and apparatus. Most of these ICT resources including hardware devices such as mobile phones, laptops, projectors and multi-media resources such as videos, PowerPoint presentations and images have become a mainstay of lesson delivery in many jurisdictions and can be given a more prominent role in science teaching and learning within the Ghanaian context.

The finding that the implementation of the intervention culminated in improved conceptual understanding of student teachers lays credence to the efficacy of the ICT resources in addressing some age-long challenges in the learning of science. This supports the call for an increased role of ICT in teacher education as well as in our basic schools for purposes such as teaching, learning, assessment and record keeping.

The study has provided further evidence that there is a connection between the level of conceptual understanding and the academic performance of student teachers. Before the intervention, student teachers generally harboured many misconceptions about the science concepts under consideration and this was evidenced in their poor performance in the pre-tests on Matter, Forces and Energy. As their conceptual understanding improved after the intervention, the performance in the post test also showed a significant improvement. In order to enhance the performance of their students, science teachers need to focus on approaches and strategies that improve upon conceptual understanding, rather than promoting rote learning by students. Notably, the improvements in performance was recorded in all the three concepts under study, laying credence to the impact of the intervention on the academic achievement of the research subjects.

The issue of the relation between gender and the study of science is a recurring one. Different studies identify different relations between attitude and performance of students in science with respect to gender. The results of the study have proved that both males and females can succeed in science if the right interventions are put in place. This replenishes the armoury of gender activists who seek to promote the active participation of females in science teaching and learning at all levels.

In the study, it came to light that the intent of student teachers to use ICT-based resources to teach science is influenced by a myriad of factors. Factors such as the method used by the science teacher, the perceived ease of use and challenges associated with ICT usage are all influential factors. The influence of the intervention in addressing many of these factors proves that science educators have a crucial role to play as advocates on the integral role of ICT by science teachers, during their preservice training. It also calls for the conduct of regular in-service training sessions on ICT usage for science teachers. The need for an enhanced role of ICT under our current dispensation is well captured in the standards-based curriculum for basic schools which identifies digital literacy as a key 21st century skill that needs to be acquired by all learners. Through the concerted effort of science teachers, teacher educators and other relevant stakeholders, ICT can take a more prominent role in science teaching and learning leading to improved learning outcomes.

Stakeholders at the colleges of education and universities that train teachers as well as the MoE and GES need to undertake an audit of teachers' ICT skills and challenges in order to ensure the provision of adequate training interventions for both pre-service and in-service teachers. With the introduction of weekly Professional Learning Community (PLC) sessions in basic schools across the country, resource persons could be identified to provide training sessions for teachers to update their skills in ICT usage.

There is the need for regular in-service training for science teachers to enable them update their skills on the utilisation of ICT resources as a key pedagogical tool. This call is pertinent to ensure that teachers can effectively apply ICT for undertaking for various roles in science teaching and learning including lesson planning, setting of learning targets, delivering of lessons and assessment of students.

Curriculum developers must ensure that ICT is integrated as a key learning tool in the science curricula for basic schools and also for teacher education. Further the requirements for increased ICT usage by science teachers as captured in the basic school science curriculum must be linked to commensurate provisions in the teacher education curriculum for ensuring the training of a new generation of science teachers who are digitally literate.

The government of Ghana, the Ministry of Education, GES and other concerned agencies must ensure the provision of ICT resources such as laptop computers and projectors for all schools. The ongoing initiative of providing laptop computers to teachers could be expanded to include the provision of projectors for each school to help science teachers make use of these resources to teach science concepts more effectively.

Currently, most public second cycle schools have access to internet connectivity. This intervention needs to be expanded to primary and Junior High Schools in Ghana. This will go a long way to foster the usage of ICT by teachers and students for educational purposes such as research, completion of learning tasks and preparation of lessons.

The finding that there is no statistically significant difference in the performance of male and female student teachers in the various science concepts under study supports the drive to increase female participation in science education. This supports the call for the implementation of various interventions both within and outside the school level that demystify the concept that science is a preserve subject of males. For instance, measures must be put in place to change the attitudes and perceptions of male teachers towards the attainment of female students in science education. Also, avenues must be created for female science students to receive mentorship from male teachers in order to improve their attitude towards the study of the subject.

5.4 Recommendations

Based on the findings and conclusions that emanated from the study, the following recommendations have been made towards improving the delivery of quality science education in Ghana:

5.4. 1 Recommendations to Science Educators

- Science teachers must make a concerted effort to identify the misconceptions held by their students in various concepts and use this as a basis to improve their teaching and learning. This can be done through asking of questions, administering of tests or pre-lesson assignments that help to identify the student-teacher's level of understanding of concepts before the actual lesson is taught. This will enable the teacher educator to use the right approaches to tackle student's conceptual understanding challenges.

- Under the current dispensation, ICT is used in every aspect of human life from trade and commerce to education delivery and even in industry. There is a wealth of valuable information on various science concepts which are easily and freely accessible on the internet to all users. Thus, science student teachers need to be encouraged to use ICT more actively in their learning of science for purposes such as further studies, completing class tasks or seeking clarifications on complex science phenomena or concepts.
- The study revealed serious gaps in conceptual understanding of the research subjects. In order to improve the conceptual understanding of their students, science teachers are encouraged to actively integrate the usage of teaching and learning resources in science lesson delivery. Teachers need to use approaches that promote easy understanding and eliminate rote learning of various science concepts.
- Through the intervention in the form of ICT-based learning, there was a vast improvement in the conceptual understanding of student teachers in the various science concepts. It is recommended that science teachers at all levels of schooling endeavour to apply learner-centred methods of teaching that ensure the active participation of the learner in lesson delivery. This will go a long way to make science learning meaningful to the student and enhance their conceptual understanding.

5.4.2 Recommendations to Stakeholders

- Since student teachers are prospective basic school science teachers, science educators must put in place measures to equip them with the relevant ICT skills needed to apply ICT usage effectively in science teaching. This can be done by assigning learning tasks to student teachers that require the use of ICT based resources or approaches such as online researches, preparation and upload or submission of Videos for explaining various science concepts, preparation and delivery of PowerPoint presentations, use of online platforms for submission of class tasks etc.
- It came to light that there was no statistically significant difference in the performance of male and female students in the various science concepts under study. Thus female students need to be motivated and encouraged to develop positive attitudes towards the study of science and also enroll in science-related programmes.

5.5 Uniqueness of the Study

To the best of the researcher's knowledge, the study is the foremost one that has focused on the conceptual understanding and academic performance of student teachers in the three selected science concepts (matter, energy and forces) since the introduction of the four-year bachelor of education curriculum for teacher education was implemented. It thus becomes the premier study that brings to light the misconceptions held by student teachers (for that matter prospective science teachers) in these three integral science concepts within the 4-year teacher education for redress by stakeholders.

It is also the first study that looked at how ICT could be used effectively to promote conceptual understanding and address the issue of unavailability of resources for ensuring effective science instruction as required in the new four-year curriculum for teacher education.

In the light of the four-year curriculum for teacher education, the study is the first to study the influence of gender on the academic performance of student teachers in science.

5.6 Suggestions for Further Studies

In view of the important role of conceptual understanding in improving the academic performance of students, there is the need for further research on students' conceptual understanding in other key science concepts in the four-year curriculum for teacher education being implemented in 46 colleges of education and selected universities across the country. The study could also be replicated for other levels or year groups of students within the University of Education, Winneba and other tertiary institutions that are also implementing the four-year Bachelor of Education Curriculum.

Future research could focus on the sources of student teachers' misconceptions. This will help to identify and address some challenges at the pre-tertiary level before students are enrolled in the teacher education programme. This will also go a long way to increase the enrolment level in science at the tertiary level of education.

Considering the increasingly crucial role of ICT under the current dispensation, it might be expedient to look into the factors that inhibit science teacher educators and science teachers from actively using ICT in their day-to-day work.

It came to light that after the intervention, most student teachers were keen on using ICT for lesson delivery. Future studies could focus on assessing student teachers attitudes and intent on ICT usage, before and after an ICT-based intervention in order to determine the exact impact of the intervention on student teachers attitude and behavioural intentions so far as ICT usage in their future classrooms is concerned.

There could be a study to investigate the adequacy of the provisions in the current science curriculum for ensuring the effective utilisation of ICT as a pedagogical tool.

Furthermore, research using similar methods, could be undertaken at different tertiary institutions and pre-tertiary institutions across the country with a larger scope to promote active ICT usage in science lesson delivery across the country.

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APPENDICES

APPENDIX A

Questionnaire on Student Teachers' Conceptual understanding of Science Topics in the Integrated Science Course (Matter, Forces and Energy)

Select the correct answer to each item from the options provided by circling the Letter (A or B) or Roman numeral (I – IV). Where necessary, *write the appropriate sentence(s) or words that best answers the questions in the spaces provided.*

1. Fundamentally, all atoms are the same

   C. Yes
   D. No

   I chose my answer because:

   v. All atoms contain protons, neutrons and electrons
   vi. Atoms are different in terms of the number of electrons and protons
   vii. Atoms are the basic unit of an element that can take part in a chemical reaction
   viii. All atoms have the same number of protons and electrons

2. Substances in the solid state have definite shapes

   A. Yes
   B. No

   The reason for my choice of answer is:

   I. Solids diffuse very slowly
   II. The attractive forces within solids determine the shapes
   III. Because the particles of solids cannot be compressed easily
   IV. Because the particles within the solid cannot move

3. An example of a phenomenon or process that proves the particulate nature of matter is …………………… I chose/wrote that answer because:

   ………………………………………………………………………………

4. A coloured gas was compressed in a gas syringe until the plunger could not be pushed any further. The experiment was repeated using the same volume of a coloured liquid. It was found that the final volume of the gas was:

   A. Much less than that of the liquid.
   B. Much greater than that of the liquid.

   The reason for my choice of answer is:

   I. The particles in the gas are more widely spaced.
   II. The particles in the gas move more freely.
   III. The particles in the gas move randomly in all directions.
   IV. The liquid particles travel faster than

5. A small glass bulb containing liquid bromine was dropped into a tall jar of air and the jar was immediately covered with a stopper. The bulb was broken on hitting the bottom of the jar, releasing bromine vapour. After several hours, reddish bromine vapour had diffused uniformly throughout the jar. If the experiment is repeated after pumping out most of the air from the jar, we would expect the reddish bromine vapour to diffuse and fill the jar within a few seconds.
   A. True
   B. False

   The reason for my choice of answer is:

   I. The particles in the gas have lower kinetic energy.
   II. The particles in the gas move more freely.
   III. The particles in the gas move less freely than in the liquid.
   IV. The particles in the gas are restricted from moving

6. If there is no motion, then there is no force acting.
   A. True
   B. False

   I chose my answer because:

   I. there cannot be a force without motion
   II. when an object is moving, there is a force in the direction of its motion
   III. a moving object stops when its force is used up
   IV. There can be several forces acting on it but the resultant of all the forces must be zero.

7. Two metal balls are of the same size but one weighs twice as much as the other. The balls are dropped from the roof of a single storey building at the same instant of time. Will the balls drop on the ground at the same time?
   A. Yes
   B. No

I chose my answer because actually the time taken for the balls to hit the ground will be …

I. about half as long for the heavier ball as for the lighter one.
II. about half as long for the lighter ball as for the heavier one.
III. about the same for both balls.
IV. considerably less for the heavier ball, but not necessarily half as long.

8. A large truck collides head-on with a small compact car. Will the two cars suffer the same impact?

A. Yes

B. No

I chose my answer because during the collision:

I. the truck exerts a greater amount of force on the car than the car exerts on the truck.
II. the car exerts a greater amount of force on the truck than the truck exerts on the car.
III. the truck exerts a force on the car but the car does not exert a force on the truck.
IV. the truck exerts the same amount of force on the car as the car exerts on the truck.

9. Magnetic force and friction are both contact forces.

A. Yes

B. No

I chose my answer because …

I. they are both contact forces
II. they are both non-contact forces
III. friction is a contact force, but magnetic force is a non-contact force
IV. they both require physical interaction with a surface before they can be felt.

10. An empty office chair is at rest on a floor. Consider the following forces:

1. A downward force of gravity.

2. An upward force exerted by the floor.
3. A net downward force exerted by the chair.

Which of the forces is/are acting on the office chair?

I. 1 only.
II. 1 and 2.
III. 2 and 3.
IV. 1, 2, and 3.

11. Energy is found only in living objects.

A. Yes

B. No

I chose my answer because …

I. energy exists to help living things work
II. non-living things do not require energy
III. energy exists in all things, in one form or the other
IV. Energy is required for work by both living and non-living things

12. Energy is associated only with movement.

A. Yes

B. No

I chose my answer because:

I. Energy is the ability to do work and work involves movement
II. There is a relation between force and energy, since the application of force causes movement, energy also relates to movement.
III. A body can have energy by virtue of its position, rather than its motion.
IV. Not all movements can be attributed to the application of energy

13. Energy is a force.

A. Yes

B. No

I chose my answer because …

I. a force causes movement to take place and energy also causes movement

II. because energy is the ability to do work, and force must be applied for work to be done
III. energy is needed to apply a force
IV. because the magnitude of the force is directly proportional to the energy applied.

14. When energy in a kerosene stove is used for cooking, the energy gets finished after a while.

A. Yes

B. No

The reason for my choice of answer is:

I. the energy is converted from one form to another
II. the kerosene gets used up with time
III. kerosene is a non-renewable source of energy
IV. the fire of the stove is eventually quenched.

15. Energy is a fuel.

A. Yes

B. No

The reason for my choice of answer is ……………………………………

………………………………………………………………………………

16. Which of the following is not an example of matter?
A. Steam
B. Solar Energy
I chose my answer because

I. it does not have mass and volume
II. it has mass but does not occupy space
III. it occupies space but has no mass
IV. it has no magnitude nor direction

17. A 500ml bottle of sand of is expected to be heavier than a bottle of same size filled with water.
A. True
B. False

The reason for my choice of answer is:

I. The particles of solids are compactly packed

II. The particles of liquids are loosely packed.

III. The heaviness depends on the type of solid

IV. The weight depends on the external conditions

18. The molecules of liquid ammonia travel faster than molecules of ammonia gas

A. True

B. False

The reason for my choice of answer is:

I. Liquid molecules have a stronger smell than gaseous molecules

II. Gaseous molecules travel faster than liquid molecules

III. Ammonia gas cannot be seen with the naked eye

IV. Liquid molecules have relatively weaker forces of attraction between them

19. Consider the items stated: Vinegar, blood, ice, water.

The odd one out is ice.

A. True

B. False

I chose my answer because:

I. All the other substances have lower ease of compression

II. Vinegar is rather the odd one out.

III. Ice is a solid, but the rest are not

IV. All the four substances have weight and occupy space

20. Atoms, Ions and molecules are the only building blocks of matter.

A. True

B. False

I chose my answer because:

I. Radicals can also be classified as building blocks of matter

II. All substances are made up of either atoms, ions or molecules

III. In recent times, atoms can further be broken down into simpler forms

IV. There are other building blocks of matter beside the three mentioned above.

21. Kwame applies a force of 40N to move a box across a distance of 10m. which of the following is true about the force Kwame applied?
    A. Only the magnitude is provided
    B. Only the direction is provided
    C. Only magnitude and effect are provided
    D. both magnitude and direction are provided

I. A only.
II. B only
III. A and C only
IV. A and D only.

22. Weight unlike mass, is classified as a force
    A. Yes
    B. No

I chose my answer because
V. The weight of an object is the force of gravity acting on the object
VI. Mass and weight are all density related
VII. The Weight and mass of a body are directly proportional
VIII. The weight and mass of a body are inversely proportional

23. Which of the following is/are examples of forces?
    A. Friction
    B. Inertia
    C. Surface tension

I. A only.
II. B only
III. A and C only
IV. A, B and C

24. The only force that enables the moon to move in a circular orbit around the earth is gravity.
    A. Yes
    B. No

I chose my answer because:
I. Gravity is the force of attraction between two objects in contact with each other
II. Centripetal force is rather needed to keep an object in a circular path
III. Both centripetal and gravitational forces are required to keep the moon in its orbit around the earth
IV. Centripetal and centrifugal forces are needed to keep objects in circular paths

25. One main difference between force and energy is that they are both vector quantities.
    A. Yes
    B. No

The reason for my choice of answer is

I. Energy is a scalar quantity
II. They are both scalar quantities
III. Force is a scalar quantity
IV. Force is a vector quantity

26. All forms of energy can be classified under potential and kinetic energy.
    A. Yes
    B. No

The reason for my choice of answer is:

V. there are other forms of energy such as electrical energy, solar energy, sound energy and heat energy
VI. potential and kinetic energy are just components of mechanical energy
VII. all forms of energy are either in motion or are in stored form (position)
VIII. potential and kinetic energy are only associated with movement.

27. Wind is both a force and energy.
    A. Yes
    B. No

I chose my answer because:

I. because it can be used to do work and can also cause motion in objects.
II. As with all moving things, it is caused by a force acting on it. So it is not in itself a force.
III. Wind is a form of force, rather than form of energy.
IV. Just like water, wind is a strong force that can sweep everything in its part, additionally it can be used to generate electricity.

28. Energy conversion is different from energy conservation.

A. Yes
B. No

I chose my answer because:

I. They both focus on change of energy from one form to another

II. In both instances energy is not created nor destroyed.

III. One focuses on change of form of energy, whilst the other talks about the fact that energy cannot be created nor destroyed.

IV. They basically have the same meaning in principle.

29. Renewable forms of energy are the forms of energy that do not run out after use.

A. Yes
B. No

I chose my answer because:

I. Renewable energy is the form of energy that needs to be replaced by the user e.g., petroleum, car battery and dry cells

II. Renewable energy refers to the sources of energy that are self-replenishing such as the sun and water.

III. Renewable energy refers to the sources of energy within the environment such as coal that run-out after use and need to be replaced regularly.

IV. Renewable energy refers to all sources of energy that exist naturally.

30. Water, Wind and Biomass are examples of renewable sources of energy.

A. Yes
B. No

I chose my answer because:

I. they all do not run-out after use

II. some run-out whilst others do not

III. they all occur naturally

IV. they all introduce no pollutants to the environment.

APPENDIX B

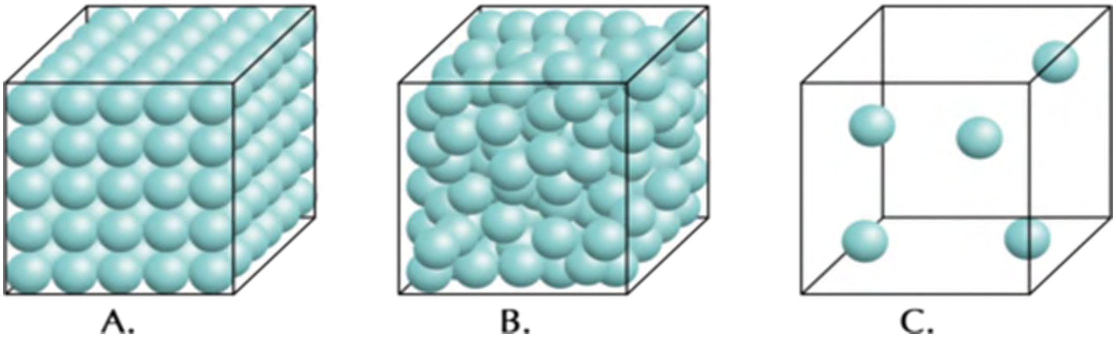
Pre-test Questions on Matter

Choose the option that best answers each question from the options provided (A to D) by <u>circling</u> the letter.

1. Matter takes up-------------------------
   A. heat and temperature.
   B. space and heat
   C. space and mass
   D. space and temperature
2. (i) Pick the odd one out
   A. Gas
   B. Liquid
   C. Solid
   D. Vacuum

   (ii) Give a reason for your answer ……………………………………………
3. One of the following best describes the particles in the Hausa Kooko which is sold in town.
   A. completely free from all binding forces
   B. less freely moving than a solid
   C. more freely moving than a liquid
   D. more freely moving than a solid
4. Adzovi wants to fill a vessel with a substance that is light in weight and can easily be compressed. Which of the following is most suitable for her to use?
   A. Gaseous substance
   B. substance in liquid state
   C. substance in plasma state
   D. substance in solid state
5. What determines a material's state of matter?
   A. How hard or soft a material is
   B. Motion and strength of attraction between particles
   C. Strength of attraction between solid particles and liquids
   D. The ease of compression of its molecules

Use the diagram below showing the arrangement of particles in the three main states of matter to answer questions 6 – 7.



6. A box containing ice was placed in the sun till all the ice melted. What was the change in the arrangement of the molecules after the change of state?
   A. From A to B
   B. From A to C
   C. From B to A
   D. From C to B
7. Which of the arrangements in the figure above shows the state at which particles have the highest ease of compression?
   A. A
   B. B
   C. C
   D. Both A and B
8. which of the following has the highest rate of diffusion ?
   A. ammonia gas
   B. Kerosene
   C. Petrol
   D. A bottle of perfume
9. What causes the change of state of matter?
   A. Loss of heat
   B. Gain of heat
   C. Formation of bonds
   D. Both A and B
10. Why are the properties of liquids in-between that of gases and solids?
   A. Because the forces of attraction between liquids is weaker than that in gases, but stronger than that in solids
   B. Because the forces of attraction between liquids is stronger than that in gases, but weaker than that in solids
   C. Because liquids have the weakest inter-molecular forces of attraction
   D. Because liquids have the strongest inter-molecular forces of attraction.

APPENDIX C

Pre-test Questions on Forces

Choose the option that best answers each question from the options provided (A to D) by circling the letter.

1. Kofi applied the brakes on his bicycle and it came to a halt. What is the name of the force between the ground and bicycle tyres that caused the bicycle to stop moving?

A. electrostatic force
B. frictional force
C. magnetic force
D. Molecular force

1. Which of the following is not an example of a force?
A. Wind
B. Friction
C. Inertia
D. weight

2. How much force must a boy apply to accelerate a body of mass 50kg to $10m/s^2$ across a distance of 5m?
A. 5N
B. 2500N
C. 65N
D. 10N

4. When an unbalanced force acts on an object, the force ….

A. changes the motion of the force
B. is cancelled by another force
C. has no effect on the motion of the object
D. equals the weight of the object

5. What can force change?
A. speed, shape and colour of an object
B. speed, direction and components of an object
C. Shape, position and speed of an object
D. Position, direction and magnitude of an object.

6. Identify the incorrect statement about forces from the options below.
A. A force has magnitude and direction
B. A force has only magnitude, but no direction
C. Forces can change the shape of objects
D. Forces can have effect only if they come into contact with an object.

7. Why does a rider on horseback fall when the horse starts running all of a sudden?
    A. The rider is suddenly afraid of falling
    B. The lower body of the rider moves forward with the horse but the inertia of rest keep the upper body at rest
    C. The rider is pushed backwards
    D. None of the above options
8. Why does a man getting off a moving bus fall down?

A. He falls because of his habit of leaning forward
B. Due to inertia of motion, the upper body continues to be in motion in the forward direction but the feet comes to rest as soon as they touch the ground
C. Due to inertia of rest, the road is left behind and the man reaches forward
D. Due to all of the reasons stated above

9. An example of a non-contact force is
    A. Friction
    B. Magnetic force
    C. Tensional force
    D. Air resistance force

10. Select the odd one out in terms of the classification of forces into contact and non- contact forces.
    A. Gravitational force
    B. Electrostatic force
    C. Nuclear force
    D. Muscular force

APPENDIX D

Pre-test Questions on Energy

1. Larissa is a very energetic person and has a hard time sitting still in class. One time in math class, her teacher asked Larissa where she got all of her energy. Since Larissa had just studied energy in science class, she knew the correct answer was….

    A. I create it
    B. My body just transforms it
    C. I can get energy anywhere I want
    D. I make energy anytime I need it.

2. One characteristic of renewable sources of energy is that

    A. They are exhaustible
    B. They are self-replenishing
    C. They have a life span
    D. They produce pollutants

3. Ramatu kicked a ball on the school field. What are the energy changes involved in this activity?

    A. Chemical energy > mechanical energy > sound energy > kinetic energy
    B. Chemical energy > sound energy > kinetic energy
    C. Mechanical energy > sound energy > kinetic energy
    D. Sound energy> kinetic energy > electrical energy

3. Why would you discourage people from depending on non-renewable sources of energy?
    a. They are environmentally friendly
    b. They release a lot of pollutants into the air
    c. Their establishment is cost intensive
    d. They are not dependable
4. Friction is a force that opposes motion. When friction is present, heat is usually generated. According to the law of conservation of energy, which of the following statements is true about the energy associated with friction?
    A. It has no relation with energy
    B. The law of conservation of energy does not apply
    C. Some of the the energy is converted to thermal energy
    D. Energy is created with friction
5. Identify the source of energy among the following options which is not self-replenishing.
    A. Biomass
    B. Fossil Fuel
    C. The Sun
    D. Water

6. Which of the energy sources below is the main source of energy in Ghana?
   A. Biomass
   B. Fossil Fuel
   C. The Sun
   D. Water

7. What are the advantages of solar power?
   A. Sunlight is free
   B. Doesn't produce the greenhouse effect
   C. Both a and b
   D. None of the above
8. What three forms of energy are involved when a Television is switched on for 30 minutes?
   A. Electricity, heat and nuclear energy
   B. Solar energy, magnetic energy and gravitational energy
   C. Electrical energy, light energy and sound energy
   D. Electrical energy, light energy and chemical energy

9. Which statement BEST explains why a bouncing basketball will not remain in motion forever?
   A. The energy is transferred to sound and heat energy
   B. The energy is transferred to light and potential energy
   C. The energy is used up and destroyed
   D. The energy is transferred to heat and chemical energy

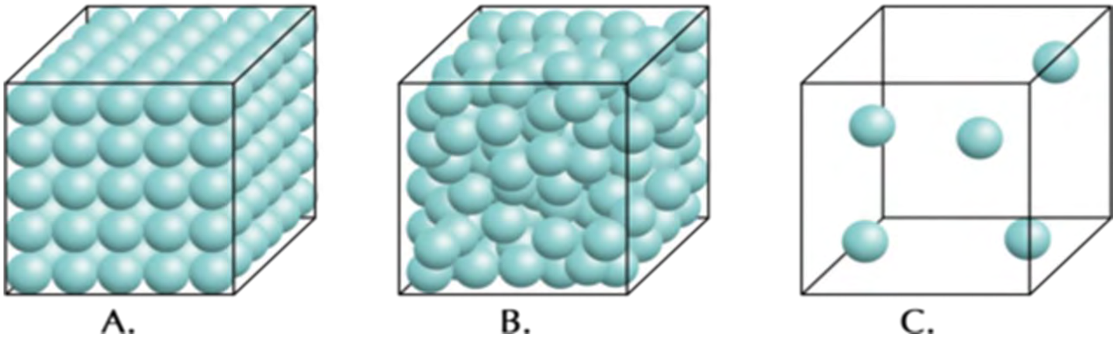
APPENDIX E

Post-test Questions on Matter

Choose the option that best answers each question from the options provided (A to D) by circling the letter.

1. Which of the following reasons **best explains** why water vapour is an example of matter?
   A. it is the gaseous form of liquid water
   B. it particles are loosely packed
   C. It has mass and also occupies space
   D. It can be preserved in a container.
2. (i) Pick the odd one out
   E. Gas
   F. Liquid
   G. Solid
   H. Vacuum
   (ii) Give a reason for your answer ……………………………………………
3. Why does a wooden box have a fixed shape?
   E. Because its particles are tightly packed
   F. Because the particles are loosely packed
   G. Because its particles have a high rate of diffusion
   H. Because it particles are more freely moving compared to water
4. Memunatu is working with a substance in the laboratory whose rate of diffusion is neither too high nor too low. The susbtance is most likely to be in the ..
   E. Gaseous state
   F. liquid state
   G. plasma state
   H. solid state
5. What determines a material's state of matter?
   E. How hard or soft a material is
   F. Motion and strength of attraction between particles
   G. Strength of attraction between solid particles and liquids
   H. The ease of compression of its molecules

Use the diagram below showing the arrangement of particles in the three main states of matter to answer questions 6 – 7.



6. Which of the boxes shows the arrangement of the particles in atoms of gold?

A. A

B. B

C. C

D. none of the boxes

7. If a bowl of water is heated to reach its boiling point, what will be the change in the arrangement of its particles?
A. From A to B
B. B to A
C. From B to C
D. From C to B

8. Which of the following is most likely to have the fastest rate of diffusion ?
   A. smoke
   B. a bar of soap
   C. Petrol
   D. Palm oil

9. What causes the change of state of matter?
   A. Loss of heat
   B. Gain of heat
   C. Formation of bonds
   D. Both A and B

10. Why are the properties of liquids in-between that of gases and solids?
   A. Because the forces of attraction between liquids is weaker than that in gases, but stronger than that in solids
   B. Because the forces of attraction between liquids is stronger than that in gases, but weaker than that in solids
   C. Because liquids have the weakest inter-molecular forces of attraction
   D. Because liquids have the strongest inter-molecular forces of attraction.

APPENDIX F

Post-test Questions on Forces

Choose the option that best answers each question from the options provided (A to D) by circling the letter.

1. A car skidded off the Winneba roundabout. Which of the following forces is most likely to blame for the accident?

A. Centrifugal force
B. Centripetal force
C. Friction
D. Molecular force

2. What will happen if a force is applied to a body moving with a constant speed along a straight line?

A. The speed increases
B. The direction changes
C. The momentum decreases
D. Continues to move with uniform velocity

3. How much force must a boy apply to accelerate a body of mass 50kg to 10m/s^2 across a distance of 5m?

A. 5N
B. 2500N
C. 65N
D. 10N

4. When an unbalanced force acts on an object, the force ….

A. changes the motion of the force
B. is cancelled by another force
C. has no effect on the motion of the object
D. equals the weight of the object

5. Kwame can apply forces to achieve all of the following effects except …

A. Change the colour of objects B. change the direction of moving objects C. change the shape of objects D. increase the speed of moving objects

1. Walking is possible on the account of

A. Newton's First Law of Motion
B. Newton's Second Law of Motion
C. Newton's Third Law of Motion
D. Newton's Law of Gravitation

2. A moving car suddenly comes to a stop and the passengers jerk forward. Which of the laws of motion is applied as they jerk forward (though the car stopped moving)?
   A. First law of motion B. second law of motion C. third law of motion D. law of inertia

3. Amadu used a piece of magnet to separate iron filings from sand. What type of force is exerted by the magnet?
   C. Contact force B. gravitational force C. non-contact force D. electromotive force

4. In order for an aircraft to move in the direction of travel, the aircraft engine exerts a force on the air.
   State which of the following completes the "Newton pair" of forces.

A. The force of the air on the aircraft engines

B. The force of friction between the aircraft engine and the air

C. The force of friction between the aircraft and the aircraft engine

D. The force of the Earth on the aircraft engine

E. The force of the aircraft engine on the Earth

10. Select the odd one out in terms of the classification of forces into contact and non-contact forces.

A. Gravitational force
B. Electrostatic force
C. Nuclear force
D. Muscular force

APPENDIX G

Post-test Questions on Energy

1. Which of the following sources of energy is most environmentally-friendly?

   A. Dry cells
   B. Petroleum
   C. Water
   D. Biomass

2. One characteristic of renewable sources of energy is that

   A. They are exhaustible
   B. They are self-replenishing
   C. They have a life span
   D. They produce pollutants

3. Ramatu kicked a ball on the school field. What are the energy changes involved in this activity?

   A. Chemical energy > mechanical energy > sound energy > kinetic energy
   B. Chemical energy > sound energy > kinetic energy
   C. Mechanical energy > sound energy > kinetic energy
   D. Sound energy> kinetic energy > electrical energy

4. Which of the following activities does not involve the use of energy?
   A. eating
   B. sleeping
   C. digestion of food by the body
   D. none of the above

5. Which of the follwing are correct reasons why a community must make use of wind energy?
   A. Renewable and free
   B. Operating life is long
   C. Not too expensive
   D. All of the above
6. Identify the source of energy among the following options which is not self-replenishing.
   A. Biomass
   B. Fossil Fuel
   C. The Sun
   D. Water

7. As the cars of a rollercoaster race down a hill, energy transformations take place. Which of the following is true?
   A. Some energy is destroyed as the car goes down
   B. The kinetic energy of the cars is equal to the potential energy of the cars
   C. Some potential energy is transformed to kinetic energy and other forms of energy
   D. Kinetic energy is stored in the cars as they move downhill

8. Identify the source of chemical energy from the list below.
   A. A bowl of rice and fufu
   B. Akosombo Dam
   C. A stretched guitar string
   D. A moving car

9. How does listening to music on a radio obey the law of conservation of energy?
   A. sound energy is changed to potential energy
   B. electrical energy is gradually destroyed
   C. electrical energy is converted to other forms of energy such as sound
   D. electrical energy remains unchanged.

10. All forms of enrgy are classified under two main forms. These are …
   A. Chemical and Thermal Energy
   B. Sound and Electrical Energy
   C. Potential and Kinetic Energy
   D. Mechanical and Kinetic Energy

APPENDIX H

Questionnaire on Student Teachers, Views, Attitudes and Intents

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION

The Purpose of this questionnaire is to find-out the views, attitudes and intents of student teachers about science teaching and the use of ICT to teach science in their future classrooms. Please show the extent to which you agree or disagree with each of the following statements by ticking (√) one column only for each statement.

SCHOOL……………………………………………………………………………….

GENDER: MALE [ ] FEMALE [ ]

AREA OF SPECIALISATION…………………………………………………………

QUALIFICATION……………………………………………………………………….

YEARS OF EXPERIENCE: 1-5 [ ] 6-10 [ ] 11-15 [ ] 16-20 [ ]
20 years and above [ ]

Statement	Strongly Agree	Agree	Not Certain	Disagree	Strongly Disagree
1. The intervention has improved my attitude towards science learning					
2. I am better equipped to teach science					
3. I will be able to assist learners to study science effectively					
4. I have no interest to teach science in the future					
5. I have gained better understanding of some concepts after the intervention					
6. The traditional method helped me to understand science					

concepts better					
7. The use of ICT made lessons interactive and engaging					
Statement	**Strongly Agree**	**Agree**	**Not Certain**	**Disagree**	**Strongly Disagree**
8. The use of ICT did not make any difference in my learning of science					
9. ICT usage in lesson delivery is cumbersome					
10. The use of ICT to teach science is time consuming					
11. ICT resources for teaching are expensive					
12. I will prefer to use other teaching methods rather than ICT-based strategies					
13. I will use ICT actively in my future lesson delivery					
14. I intend to use ICT only as a back-up teaching method					
15. If I have access to the relevant resources, I will use ICT actively in lesson delivery					

APPENDIX I

Interview Schedule for Student Teachers

- **Attitude towards teaching science**

2. Generally what have been your impressions about the entire intervention?
3. Did the use of various ICT resources help you to understand some science concepts that you previously had difficulties in?
4. Would you say that the intervention has had an impact on your like or dislike for science?
5. Please give further details on how the intervention has influenced your attitude and interest to study or teach science.

- **Attitude and intent to use ICT in science Teaching**

1. Are you very familiar with the use of ICT gadgets such as laptops, projectors, internet routers?
2. Do you think they will be beneficial to you as a future science teacher?
3. (a) Do you have any intent of using these resources in your future science class?

   (b) If yes, would you say your decision was influenced by the intervention?

   (c) If no, what are your reasons?

- **Perceived benefits of ICT usage in Science Lesson delivery**

11. Based on the lessons you received so far, can you share some of the benefits of using ICT in the teaching and learning of Science?

12. Personally as a student teacher, for that matter a future teacher, how do you think ICT will be beneficial to you in your future classroom?

- **Challenges in the use of ICT for science teaching**

1. What do you think are some of the factors that make the use of ICT resources in our basic schools difficult?
2. Personally, what are the reasons that will prevent you from using ICT actively in your future science classroom?

APPENDIX J

List of Student Teachers Interviewed

Males	Females
MR 3	FR1
MR6	FR2
MR12	FR3
MR16	FR4
MR5	FR5

Note: MR= Male Respondent FR = Female Respondent

Appendix K

Permission Letter from Department

UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF INTERGRATED SCIENCE EDUCATION
P. O. Box 25, Winneba, Ghana
ise@uew.edu.gh
+233 (020) 2041077

22nd March 2022

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

INTRODUCTORY LETTER

The bearer of this letter Mr Cosmos Eminah is a Doctor of Philosophy Student in the Department of Integrated Science Education of the University of Education, Winneba. He is conducting a study on "Effect Of ICT-based intervention on Conceptual Understanding and performance of student-teachers in selected concepts in Science".

I would appreciate if you could assist him to conduct the study.

I count on your cooperation for a successful thesis write-up.

Thank You.

Yours faithfully,

HEAD
DEPT. OF INT. SCIENCE EDU.
UNIVERSITY OF EDUCATION, WINNEBA
P. O. BOX 25
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Appendix L

SAMPLE STUDENTS' COMPLETED QUESTIONNAIRE

Appendix M

SAMPLE STUDENTS' COMPLETED TEST PAPER