UNIVERSITY OF CAPE COAST

PRE-SERVICE TEACHERS' CONCEPTUAL UNDERSTANDING AND INTEREST IN BASIC ELECTRONICS, BALANCING OF CHEMICAL EQUATION, INFECTIOUS AND NON-INFECTIOUS DISEASES IN INTEGRATED SCIENCE

OBED BAAH-YANNEY

2023

UNIVERSITY OF CAPE COAST

PRE-SERVICE TEACHERS' CONCEPTUAL UNDERSTANDING AND INTEREST IN BASIC ELECTRONICS, BALANCING OF CHEMICAL EQUATION, INFECTIOUS AND NON-INFECTIOUS DISEASES IN INTEGRATED SCIENCE

BY

OBED BAAH-YANNEY

Thesis submitted to the Department of Science Education of the Faculty of Science and Technology Education, College of Educational Studies, University of Cape Coast, in partial fulfillment of the requirements for the award of Master of Philosophy degree in Science Education

JULY 2023

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree at this University or elsewhere.

Candidate's Signature:……….................................. Date:…………………

Name: Obed Baah-Yanney

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision laid down by the University of Cape Coast.

Supervisor's Signature:………….................. Date:…………………..

Name: Godwin Kwame Aboagye PhD

ABSTRACT

Conceptual understanding and interest in integrated science concepts have been a challenge to most pre-service teachers. Therefore, this research focused on pre-service College of Education teachers' conceptual understanding and interest in some Integrated Science concepts, mainly basic electronics, balancing of chemical equations, and infectious and non-infectious diseases. Second-year pre-service teachers from the three Colleges of Education affiliated with the University of Education, Winneba, in the Eastern Region of Ghana, were used as the study population. Simple random sampling technique was used to select second year Pre-service Teachers. In all, 255 pre-service teachers were used for the study. The instrument adapted for the study was achievement tests on integrated science concepts, and a questionnaire on students interest in integrated science concepts was used to gather the data. The quantitative data was analysed using frequency, means, standard deviation and correlation and the qualitative data was thematically analysed. The results revealed that pre-service teachers conceptual understanding of balancing of chemical equation were very low, followed by basic electronics but have a partial scientific understanding of infectious and non-infectious diseases. Pre-service teachers' exhibited a moderate interest in basic electronics, balancing of chemical equations, and infectious and non-infectious diseases could be due to the abstract nature of the concepts. There was no correlation between interest and performance. It was recommended that tutors at the Colleges of Education use conceptual change strategies to help improve pre-service teachers' conceptual understanding and interest in the selected concepts in integrated science.

KEY WORDS

Balancing Chemical Equation

Basic Electronics

Conceptual change theory

Conceptual Understanding

Infectious and Non-infectious Disease

Interest

Light Emitting Diode (LED)

Pre-service teachers

The N-P-N and P-N-P Junction

ACKNOWLEDGEMENTS

I would like to express my profound gratitude to my supervisor, Dr. Godwin Kwame Aboagye of the Department of Science Education, for his professional guidance and constructive criticism that has helped shape my work. I am sincerely grateful. I also want to express my heart felt gratitude to Mr. Benjamin Anim-Eduful, Mr. Emmanuel Kabutey Koranteng, and Mr. Messiah Abeiku Morgan for the face Validity, sharing of other relevant documents, and more computer knowledge of my research work.

Most of all, to my wife, Margaret N. Baah-Yanney, and my children, Stephanie Baah-Yanney and Michelle Baah-Yanney, for being there for me always.

DEDICATION

To my Father, Very Reverend Isaac Baah-Yanney, the Superintendent Minister of Breman Asikumah Circuit of the Methodist Church Ghana.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

This section of the study comprises the background to the study, the problem statement, the purpose of the study, and research questions. It further discusses the significance of the study, delimitation, and limitations of the study. The section ends with the organisation of the rest of the study.

Background to the Study

Learning at higher levels of science in Ghana is built upon the groundwork laid at the country's primary and secondary institutions. Students, teachers, and policymakers in Ghana agree that the elementary school years are crucial for laying the groundwork for future scientific inquiry (Adu-Gyamfi & Ampiah, 2016). An understanding of environmental responsibility and a concern for the health of both local and global ecosystems may be developed via scientific education (Azure, 2015). Understanding the interconnectedness of all life and the planet on which it depends is aided by this perspective. Exploring the natural world and teaching pupils about ethics are two ways to ensure humanity's continued existence in the modern world (Bybee, 2010). To promote teaching and learning of school science at all levels of pre-tertiary education in Ghana is to help in the development of creativity, enterprising, innovation, and morally sound learners who will understand the scientific process of investigation and experimentation in order to widen their scope and understanding of the natural world (Azure, 2015). In agreement with Ofori-Appiah et al.(2018), we may say that the scope of science includes both the content and the methodology behind our understanding of natural and built environments. Furthermore, Ofori-Appiah et al., (2018) indicated that quality teaching and learning of integrated science is crucial for developing scientifically literate citizens and improving economic productivity for sustainable development. Integrated science concepts are important as they bring together scientific knowledge from different science disciplines perspectives and link to solve problems within the learners' environment (Leischow et. al, 2008).

In order to help its member nations promote scientific literacy uniformly across both the elementary and secondary education levels. introduced the idea of integrated science curricula. Arokoyu (2012) argue that combining different lines of thinking enhances scientific discovery. Therefore, Arokoyu believe contemporary science education should be multidisciplinary, based on a cohesive society, and targeted at increasing students' scientific literacy. Those are the main features, aspects, and elements of integrated science. The potential and difficulties of teaching integrated scientific ideas are related to science in a manner that transcends the traditional boundaries between disciplines (Otarigho & Djagbo, 2013). They further claimed that integrated science concepts are taught through a dynamic process approach to understanding and study. The significance of integrated scientific possibilities for Africa and the world cannot be overstated. There is a worldwide push for scientific integration in primary schools, and many developed countries reportedly include science instruction at the secondary and tertiary levels. Sakpaku (2016) reported that implementing integrated science at the junior secondary school level has been very useful in Ghana and Nigeria. The teaching of science has become a staple in classrooms all around the globe, and Ghana is no different (Ansah, Amoah & Baah, 2018). This is because development in the current world is knowledge based on science and technology.

For this reason, there is a need for many professionals to be knowledgeable in several areas of science. This results from problems that can only be solved by the co-ordination of research in several specialties (Ansah, Amoah & Baah, 2018). As a result, every country is under pressure to raise scientific literacy in their populations.

Through effective science education, learners can show that a wider spectrum of scientific thoughts and ideas can be created, modified, and developed (MOE, 2010). In order to work scientifically, learners must observe, inquire, discuss, forecast, analyse, explore, investigate, and experiment while using the knowledge and skills they have learned to create projects (Tam, 2000). Science education prepares students for a more scientifically and technologically oriented world and encourages them to value scientific inquiry and work together with others to solve problems (Bukhari & Jita, 2009). Learning integrated science facilitates students' investigations and problem-solving tasks, which greatly develops students' inventive and creative capacities (MOE, 2010).

In Ghana, integrated science is one of the important subjects taught at the various pre-tertiary levels (primary, junior high, and senior high schools) and the tertiary levels (Colleges of Education and universities). Integrated science is made up of four major science subject areas: chemistry, biology, physics, and agriculture science (MOE, 2010). Integrated science is compulsory for every student in pre-tertiary schools and those in the Colleges of Education in Ghana to study because of its interdependence of science concepts to solve societal problems. The major objective of teaching and learning integrated science in Ghanaian schools is to promote national development and push the country to achieve a strategic programme of scientific and technological literacy and also help these students to apply concepts learned in their daily life activities to help students solve environmental problems (MOE, 2010). Objectives and aims of teaching and learning integrated science at Ghana's pre-tertiary level can be achieved based on certain favorable conditions. For instance, teachers teaching the subject are well-trained and grasp both the subject matter (content knowledge) and the pedagogical content knowledge (teaching methods in science). Again, when needed, teaching and learning materials required for teaching the subject are readily available (Ofori-Appiah et al., 2018).

Integrated Science is one of the foundation courses offered in Ghanaian Colleges of Education Curriculum, this is because graduates from the Colleges of Education teach at pre-tertiary schools, specifically at the primary and Junior high levels. Pre-service teachers are allowed to learn different concepts in integrated science in aspects of chemistry, biology, physics and agricultural science. Among the concept in chemistry are the balancing of chemical equations, metals, and non-metals, exploitation of minerals, rusting, organic and inorganic compounds, and acids, bases, and salts. Concepts in physics include energy concepts, basic electronics, solar, heat, sound, nuclear, electrical, magnetism, forces, motion and pressure, work, and machines. Concepts in biology include: photosynthesis, atmosphere and climate change, infectious diseases, forms of energy and energy transformation, variation and inheritance, and concepts in agricultural science include: endogenous technology, biotechnology, and safety in the community.

Teaching integrated science at the primary school level aims to instill a scientific mindset in instructors and pupils as they instruct and learn about its subject matter. Adu-Gyamfi and Ampiah (2016) mention that one goal of the integrated science curriculum was to create more capable scientists in the many scientific disciplines who could conduct scientific research at the highest level of education. At the Basic School, teachers who teach integrated science are supposed to educate students on how to investigate and learn about their surroundings. To achieve this, teachers must ensure learners develop the two types of integrated science concepts through conceptual or procedural understanding (MOE, 2010).

The growth of students' scientific literacy and comprehension of core scientific concepts is of primary importance (Anim-Eduful & Adu-Gyamfi, 2022b). Due to the importance of conceptual knowledge in making sense of scientific phenomena, Anderson, Krathwohl, and Bloom (2001) advocate its inclusion in science education. To obtain conceptual understanding, make meaningful knowledge, interpret and apply concepts learned in other disciplines (Anderson et al., 2001). Problem-solving, abstract thinking, application to new contexts, and making connections between seemingly unrelated facts are all areas in which students who are guided towards conceptual understanding can excel (Ormrod, 1999), whereas procedural understanding concerns with the scientific process of acquiring knowledge (Wang & Berlin, 2010).

For learners to conceptualise the Integrated Science concept, the interest of the learners must be considered and developed (Abdi & Rahmania, 2023). Students' interest in learning science concepts directly affects the learners' performance, and teachers play vital roles in developing students' interest in science learning (Adu-Gyamfi, 2013). Students' interest in learning science concepts is very important, and learning interest greatly influences learning outcomes (Abdi & Rahmana, 2023). Abdi and Rahmania (2023) espoused that students with high positive learning interests will have positive learning outcomes towards a particular concept learning. Again, students' interest in learning science concepts will yield a high attachment to learning (Ainley, 2012). According to MOE (2010), the primary goal of science education is to ensure that students have a firm grasp of the fundamentals of scientific inquiry. The integrated science curriculum aims to improve students' scientific literacy so that they can first earn a livelihood and then contribute meaningfully to the nation's economy (MOE, 2010).

Mensah and Somuah (2013) indicated that certain integrated science concepts are perceived to be difficult for teachers and students to teach and learn. Among such concepts are: basic electronics, chemical equations, electrical energy, acids-bases and salts, and infectious and non-diseases. Twissel (2018) reiterated that teachers and students perceive basic electronic concepts as abstract and difficult for students to understand at the high school level. Adu-Gyamfi (2014) investigated challenges in-service teachers encounter when teaching integrated science in Senior High Schools at Mampong Municipality in the Ashanti region of Ghana. The findings of the study suggested that concept a such as basic electronics was perceived to be difficult to teach as it appeared to be abstract for in-service teachers.

The basic electronics concept is perceived to be difficult because its functioning cannot be readily observed in the real world, but only the technological products that can be observed (Kocijanic, 2018). For instance, Twissel (2018) revealed that students could not determine a capacitor and LED in an electronic circuit. Although basic electronics is hinged on the voltage and current concepts of Ohm's Law, it is difficult for students to learn (Metioui & Trudel, 2012). Learning basic electronics is very important in this fast-changing technological world (Kocijanic, 2018). In this rapid economic world, basic electronic devices are fast changing our life. Industry, communication, transport, food and nutrition, and medicine all depend on electronic devices even more than we are able to realise (Kocijancic, 2018). Basic electronics concept in the ever-changing technological world, which is treated in the Colleges of Education is incorporated into the Integrated Science II course and the major purposes of learning basic electronics are to identify household electronic appliances and functions of these household Electronic appliances and to also comprehend the flow of electricity through electronic appliances.

Osei-Himah, Amoah, and Parker (2018) employed action research to help improve pre-service teachers' understanding of basic electronics through practical activities. It was revealed through the pre-test results before the intervention stage of the study that pre-service teachers of Atebubu College of Education in Ghana had a weak understanding of basic electronics. The subsequent result of the study indicated that the experimental group's performance significantly improved better than the control group's. Osei-Himah et al. (2018) concluded that using activity-oriented teaching strategies improves students understanding of basic electronic concepts in integrated science.

However, none of the studies on basic electronics reviewed above have investigated pre-service teachers' conceptual understanding using a quantitative study that uses a two-tier diagnostic test. The two-tier diagnostic test instrument would help identify pre-service teachers' conceptual difficulties, either factual or alternative conceptions (Anim-Eduful & Adu-Gyamfi, 2022b). Again, the two-tier diagnostic test would enable pre-service teachers to bring to bear conceptions they have in basic electronics and balancing chemical equations.

Balancing chemical equations is another concept considered difficult to comprehend by students (Mensah & Somuah, 2013). Hanson (2016) posited that students have difficulties understanding chemical phenomena like chemical reactions. Chemical equations are an essential part of a Scientist's language. How to relate symbols and formulas to chemical names and writing full symbolic expressions were identified as abstract among Ghanaian pre-service teachers at the tertiary level (Hanson, 2017). Hanson (2017) argues that pre-service teachers at the tertiary level had challenges identifying and naming chemical compounds that needed remediation. Hanson also indicated that pre-service teachers had difficulties identifying the valency of atoms in a molecule and radicals. Using stoichiometric coefficients to indicate the mole ratio of compounds in a balanced chemical reaction was difficult for students to conceptualize (Hanson, 2017). Johnstone (2000) asserted that concepts of atoms and atomicity, molecules and molecular formula, atomic structure, and bonding are difficult for students to learn. Reports from WAEC Chief Examiners (2013) indicated that students who attempted to answer questions about balancing chemical equations performed poorly and exhibited some difficulties. For instance, some students copied exactly the skeletal equations as their answers, while others introduced the wrong co-efficient to balance the chemical equations. The reports also indicated that students who attempted to answer these questions had chemical formulae of compounds wrongly written. For example, some students provided Cu_2SO_4 as the chemical formula for Copper (II) tetraoxosulphate (VI) instead of $CuSO_4$ in a chemical equation. Again, some students provided Fe_3O as the chemical formula for Iron (II) oxide instead FeO. Even though studies have found the concepts of balancing chemical equations are difficult for students to learn, there is no evidence about pre-service teachers' conceptual difficulties in balancing chemical equations at the College of Education level. This is evident that the concept of balancing chemical equations needs professional teachers who have had training in this difficult area of chemistry to help learners understand.

The West African Examination Council (WAEC) chief examiner's report in the Integrated Science for Senior High Schools (WAEC: 2014; 2015; 2016; 2017; 2018 and 2019) lamented students' poor performance in integrated science. According to the WAEC Chief Examiner's Report (2015), students' performance in questions relating to basic electronics, such as transistor junctions, circuit symbols for N-P-N transistors, circuit diagrams, and functions of parts of electronic circuits, were poorly answered. It was stated categorically by the WAEC Chief Examiner's report (2018) that students exhibit general weakness and have inadequate knowledge of scientific concepts in basic electronics as those who attempted questions regarding the concepts gave answers of resistor for a diode and the function of an inductor shows the presence of current instead of generate a magnetic field/ allows direct current (DC) to pass through it but blocks alternating current (AC)/ filters circuits.

Disease is defined as “a specific abnormal condition that adversely affects the structure or function of all or part of an organism. Diseases are classified based on the causative organism that causes the disease (pathogens). Pathogenic diseases are diseases caused by a living organism that can be transferred to individuals, whereas non–pathogenic diseases are not caused by a living organism and is mostly caused by genetic and environmental factors such as lifestyle (Adjibolosoo et al. 2018). Examples of pathogenic diseases include the following: Cholera, Measles, Typhoid, Polio, Tuberculosis, Tetanus, Yaws, and HIV AIDS. To the biologist, a vector is an organism that transfers the parasite from individual to individual (Baqui et al., 1993) or through air, water, and food. Non-pathogenic diseases have varied implications on the lives of both children and adults, from which pre-service teachers are not exempted. Infectious and non-infectious diseases have not seen many studies in educational research; most studies on infectious and non-infectious diseases are done in the medical field.

A Plethora of studies has revealed the existence of misconceptions among pre-service teachers (Halim, Yong, Subahan, & Meerah, 2014; Santyasa, Warpala, & Tegeh, 2018). The misconception in science occurs and exists from primary school to the tertiary level (Santyasa et al., 2018).

It has become crucial for a number of reasons to address students and pre-service elementary teachers' misconceptions about fundamental scientific concepts. For instance, teacher explanations were frequently the main focus of science instruction in elementary schools (NRC, 1997). As a result, the pupils frequently see the instructor as the only source of knowledge they can rely on to understand concepts and learn (NRC, 1997). For science concepts to be effectively taught at the basic level, teachers must have a solid foundation in their subject matter (Appleton, 2006). Good knowledge of the subject matter is relevant (Anim-Eduful & Adu-Gyamfi, 2022b) for the teacher to effectively deal with questions from students during instruction since level of teacher content knowledge influence how well students conceptualize the contents taught (Anim-Eduful & Adu-Gyamfi, 2021). Teaching elementary school students effectively requires that science teacher educators pay close attention to pre-service elementary school teachers' conceptual understanding of science concepts that are central to teaching elementary school students. Misconceptions among educators about important scientific ideas may have far-reaching consequences for students' grasp of those ideas being taught in the classroom (Anim-Eduful & Adu-Gyamfi, 2021). Etobro and Banjoko (2017) state that misconceptions are concepts with unusual interpretations and meanings in students' perceptions that have not been scientifically proven to be correct. Naive views, wrong notions, prejudices, and repeated hazards are all names for the same thing: a misconception (Etobro & Banjoko, 2017). However, learners at various levels brought emerging ideas or concepts about science before formal education. Students' initial ideas are sometimes contradictory and inappropriate to generally accepted ideas or concepts.

Students develop misconceptions about scientific concepts through poor teaching due to teachers' lack of understanding of the concepts (Herr, 2021), inadequate observation and false assumptions by teachers (Vosniadou, 2014), and understanding of natural phenomena before formal teachings (Halim et al., 2014) and learning process, and teacher's paradigm that learning is the transfer of knowledge.

The word misconception or alternative conception has several meanings. A correct understanding of a concept, its misuse, the erroneous classification of concept examples, confusion between various concepts, improper hierarchical relationships, or the over- or under-generalization of concepts are all examples of alternative conception. Adu-Gyamfi (2013) revealed that non-science students lack interest in learning school science. Most often than not, students re-engage better with learning materials and explore.

Nevertheless, the level of preparation offered to science instructors determines whether or not students will grasp and use the scientific principles they are taught to bring about the necessary growth (Ansah, Amoah, & Baah, 2018). Much attention must therefore be paid to the training of science teachers at the various universities and colleges of education. Quality training of science teachers will go a long way to ensure scientifically literate citizens, which would positively impact the country's development. Against this background, the researcher investigated pre-service teachers' conceptual understanding and interest in some selected topics in integrated science.

Statement of the Problem

Junior high school pupils struggle to understand topics in integrated science (Mensah & Somuah, 2013). Mensah and Somuah noticed that some topics in the integrated scientific curriculum were difficult for teachers and students. Chemical compounds, electrical energy, acids, bases, salts, basic electronics, and infectious and non-infectious diseases were all included in the Integrated Science Syllabus. Basic electronics, balancing equations, Disease, and infection were difficult. Teachers and students perceive these concepts (basic electronics, electrical energy, acids, bases and salts, and infectious diseases) in integrated science to be difficult to teach and learn (Sakpaku, 2016). What makes students perceive these concepts in integrated science as difficult to learn is unknown. This implies that students' conceptual difficulties in learning these concepts in integrated science need to be diagnosed. The studies by (Mensah & Somuah 2013, and Sakpaku, 2016) did not attempt to unravel the specific challenges in the students' conceptual understanding of these selected concepts; therefore, the need to fill that knowledge gap. This knowledge gap could result from pre-service teachers' Conceptual difficulties and alternative conceptions, lack of interest, and misconception.

Alternative science conceptions have been found and are still prevalent among primary school students (Halim et al., 2014; Santyasa, Warpala, & Tegeh, 2018). Misconception can be described as ideas that provide an incorrect understanding of the original facts constructed based on people's interaction with nature. Many reasons could account for students' misconceptions. First, it could be due to the difficult and abstract nature of science concepts to students (Anim-Eduful & Adu-Gyamfi, 2022b; Tatli & Ayas, 2013); lack of appropriate teaching and learning materials (Anim-Eduful & Adu-Gyamfi, 2022a); teachers' insufficient content knowledge in the subject matter (Anim-Eduful & Adu-Gyamfi, 2021) and use of inappropriate instructional strategies (Adu-Gyamfi, Ampiah & Appiah, 2018). For instance, Anim-Eduful and Adu-Gyamfi (2022a) concluded in their study that teachers' content knowledge of a particular science concept greatly influences what and how the concepts have been taught to the students, and this also influences how well the students understand the concepts. Again, Anim-Eduful and Adu-Gyamfi (2022a) revealed that the nature of science concepts influence how the concepts are taught by teachers and learned by students. This could imply that students' misconceptions about science concepts could be directly transferred from the teacher that taught the concepts (Anim-Eduful & Adu-Gyamfi, 2021). Findings from the abovementioned studies mean that students' misconceptions are mostly conceived directly by their classroom teachers during lesson instructions.

Addressing students' alternative conceptions about fundamental integrated science ideas, particularly those of pre-service elementary teachers, has become critical for various reasons. First, at the elementary school level, science is frequently taught through reading or teacher explanations of concepts to students, where students frequently view the teacher as the sole authority and dispenser of science knowledge, and students rely on teachers for their learning (NRC 1997). Second, subject matter knowledge (Adu-Gyamfi & Asaki, 2023; Anim-Eduful & Adu-Gyamfi, 2022a) is required to teach science concepts efficiently and effectively (Appleton, 2006). Hence, the teacher teaching the science concepts should be well-equipped with the content knowledge to ensure good content delivery and understanding for students to conceptualize (Anim-Eduful & Adu-Gyamfi, 2021).

The purpose of elementary school science instruction is to enhance students' learning through the teacher's explanation of science concepts, the teacher must have a firm grasp of the subject matter to respond effectively to questions raised by students during instruction. Elementary school is where children's scientific education often begins, it is crucial that teachers and educators in the field pay special attention to the conceptual grasp of science ideas held by pre-service elementary school teachers. Pre-service elementary teachers with strong and deep science content knowledge would be appropriate personnel suited for teaching science and students learning science(Anim-Eduful & Adu-Gyamfi, 2021).

These reports suggest that students at every level of education, from Junior High School, Senior High School through to the Colleges of Education, and even pre-service teachers at the tertiary (Hanson, 2016) have conceptual difficulties in answering questions on basic electronics, balancing of chemical equation and infectious and non-infectious diseases concepts in integrated science. However, there appears to be no evidence in the literature that directly points to the exact conceptual difficulties colleges of education pre-service teachers have in basic electronics, balancing of chemical equations, and infectious and non-infectious diseases concepts in integrated science. However, another factor that needs to be considered is the pre-service teachers' interest in the study of integrated science. As explained by Ainley (2012), interest is considered a way and manner to achieve educational goals.

According to Ainley(2012), students will learn science better and subsequently choose science concepts because of their interest.

According to Häussler and Hoffmann (2000), there are three components that contribute to students' enthusiasm for science: the environment in which they study science, the substance of their coursework, and the activities they do in connection with their coursework. Therefore, the setting where children learn about science is a robust indicator of their engagement. Science as a) a socioeconomic venture, b) a method of enriching emotional experience, c) an intellectually demanding endeavour, d) a way of qualifying for professional life, e) a means of increasing practical competence in a variety of settings piques curiosity. Morgan and Aboagye (2022) conducted a study on teachers' classroom management practices: Predictors of students' interest in science, and their findings revealed that, generally, students' interest correlate moderately with classroom management practices. From their study, it makes it clear that how classroom management practices influence students learning of science is much to be desired. Studies on students' interests have been found to correlate significantly with students' academic achievement (Amadi, 2021). For instance, Amadi (2021) investigated whether there is a correlation between students' interest and their academic achievement in Nigeria using a correlational research design. The study employed a simple random sampling technique using a ballot method to collect quantitative data from 1715 secondary school science (chemistry) students. Interest and performance on chemistry exams were positively and significantly related ($r = 0.814$, $p<0.00$). Amadi (2021) concluded that this positive correlation (0.814) indicated that students' interest increases with an increase in students' academic achievement in science (Chemistry).

As pre-service teachers in the Colleges of Education are trained to teach these scientific concepts in integrated science to pupils at the basic school level, it is, therefore, appropriate to investigate the relationship between Colleges of Education, pre-service teachers conceptual understanding and interest in basic electronics, balancing chemical equations and infectious and non-infectious diseases.

Purpose of the Study

This study investigated pre-service teachers' conceptual understanding and interest in basic electronics, balancing chemical equations, and infectious and non-infectious diseases in integrated Science at the Colleges of Education level. To achieve this, the study:

1. Explore colleges of education pre-service teachers' level of conceptual understanding in basic electronics, balancing chemical equation, infectious and non-infectious disease in integrated science.
2. Explore what conceptual difficulties colleges of education pre-service teachers have on basic electronics, balancing chemical equation, infectious and non-infectious disease in integrated science.
3. Explore the level of interest of colleges of education pre-service teachers' have in basic electronics, balancing chemical equation, infectious and non-infectious disease in integrated science?
4. Explore the relationship between colleges of education pre-service teachers' interest and their conceptual understanding in basic

electronics, balancing chemical equation, infectious and non-infectious disease in integrated science.

Research Questions

The following research questions were formulated to guide the study:

1. What is the level of conceptual understanding of colleges of education pre-service teachers' in basic electronics, balancing chemical equation, infectious and non-infectious disease in integrated science?
2. What conceptual difficulties and alternative conceptions do colleges of education pre-service teachers in basic electronics, balancing chemical equation, infectious and non-infectious disease in integrated science?
3. What is the level of interest of colleges of education pre-service teachers' have in basic electronics, balancing chemical equation, infectious and non-infectious disease in integrated science?
4. What is the relationship between colleges of education pre-service teachers interest and their conceptual understanding in basic electronics, balancing chemical equation, infectious and non-infectious disease in integrated science?

Significance of the study

This study would inform participants about students' learning and the necessity of obtaining a conceptual understanding of key science ideas in integrated science. The study's findings would inform Tutors in Colleges of Education about the importance of assisting, developing, and improving pre-service teachers' conceptual understanding of Basic Electronics, Balancing Chemical Equations, and Infectious and Non-infectious diseases in Integrated Science. The findings will help the Ghana Education Service (GES) and the

Ministry of Education (MoE) to determine how to collaborate with Ghana Tertiary Education Commission to improve pre-service teachers' conceptual understanding in order to facilitate effective and efficient teaching and learning of integrated science at the primary school level.

Delimitation

There are forty-six (46) Colleges of Education in Ghana pursuing four-year Bachelor of Education in Basic Education, of which pre-service teachers are being introduced to Integrated Science II, but the study was delimited to Colleges of Education in the Eastern region affiliated to the University of Education Winneba.

Many science concepts stipulated in integrated science curricula and taught at the Colleges of Education are perceived to be difficult. However, the study focused on basic electronics, balancing chemical equations, and infectious and non-infectious diseases.

Limitations

Since the concepts of basic electronics, balancing of chemical equations, and infectious and non-infectious diseases are taught to students from the primary school level to those at the Colleges of Education, students' poor performance and conceptual difficulties in the concepts could not solely be attributed to how the concepts were taught at the College level only, but also to other levels as well. Hence, there could be other factors this study could not address.

Definition of Terms

A-Tier: Answer Tier

ATISC: Achievement Test on Integrated Science Concepts

PST: Pre-Service Teachers

QSIISC : Questionnaire on Students Interest in Integrated Science Concepts

R-Tier: Reason Tier

Organization of the Study

The study was presented in five chapters. Chapter one dealt with the introduction, background to the study, statement of the problem, the purpose of the study, research questions, the significance of the study, delimitations, and limitations. The second chapter examined the theoretical framework, conceptual and literature review highlighting research and other writers' perspectives. Chapter three covered the research methods, including design, population, sampling processes, data collection instrument, pre-testing, validity and reliability of the research instruments, data collection procedures, data processing and analysis, and ethical considerations. The results were presented in chapter four, and the outcomes were examined. Chapter five focused on the study summary, major findings of the study results, conclusions, recommendations, and suggestions for inquiry.

CHAPTER TWO

LITERATURE REVIEW

The literature review is divided into three main sections: theoretical review, empirical review, and conceptual framework of the study. The theoretical review consists of a review of conceptual change theory and its relevance to the selected concepts under study. The empirical review delves into studies on conceptual understanding in integrated science and delimits it to the selected concept under study, the conceptual difficulties and misconceptions students encounter in the form of conceptual misunderstanding and factual misunderstanding in integrated science, to understand these concepts in detailed, the scope, structure and the organization of J.H.S, S.H.S, and Colleges of Education integrated science curriculum was reviewed in addition. The conceptual framework of this study was structured to direct the study making use of all the variables in the study: students conceptual understanding, in the form of their achievement and their reasoning ability in these selected concepts, students' conceptual difficulties and alternative conceptions in the form of conceptual misunderstanding and factual misunderstanding and how these variables relate to the interest of the colleges of pre-service education teachers.

Conceptual Change Theories

The theory of conceptual change that Posner, Strike, Hewson, and Gertzog developed in 1982 is currently considered as one of the most influential ideas on the process of conceptual change. According to this idea, learners experience conceptual change when they come into contact with new knowledge that contradicts their preexisting beliefs or mental models.

Learners are said to participate in a process called accommodation, in which they change their preexisting mental models to make room for the new knowledge they have acquired. The notion of conceptual transformation has significantly impacted the direction that research on science education has taken, and it has been utilised in various educational settings. In 1982, Posner, Strike, Hewson, and Gertzog devised a framework for understanding how people modify their beliefs and understandings of the world around them called the conceptual change theory.

This theory provides a framework for understanding how individuals rewrite their beliefs and understandings of the world. The idea proposes that individuals' previous knowledge and beliefs greatly impact how they perceive new information and that learning is frequently characterized by a process in which new information is reconciled with previously held views and knowledge.

According to the conceptual change theory proposed by Posner and colleagues, people's previous knowledge and beliefs are organised into mental frameworks or "schemas." By offering a framework for interpretation, these schemas assist individuals in making sense of new information. Individuals, however, may feel cognitive dissonance or bewilderment when new knowledge disagrees with preexisting schemas. Individuals may participate in the process of accommodation or assimilation in order to resolve this conflict. During this process, they may alter their schemas or build new ones to accommodate the new knowledge. Conceptual transformation is seen as more than merely a social interaction or a teaching approach, according to Ozdemir and Clark (2007), expanding on the work of Posner et al. (1982). Instead, we see conceptual transformation as a process through which students' existing, potentially harmful beliefs about a topic are exposed and revised, or new, more helpful, reasonable, and understandable conceptions are introduced. This study's conceptual shift focuses on pre-service teachers' struggles with understanding fundamental electronics, chemical equation balancing, and infectious vs non-infectious illness. This gives room to how Mezirow's looked at transformative learning as a conceptual change approach.

Mezirow's transformative learning theory

Jack Mezirow established the idea of transformational learning in the 1990s, and it has become one of the most important theories of conceptual change. According to Western Governors University (2020), transformative learning is the concept that learners change their worldviews as they learn new information and through critical reflection. This is done by analysing their prior ideas and understanding as they acquire new knowledge. In accordance with this idea, humans are capable of experiencing a significant shift in their worldview due to a change in the fundamental assumptions and beliefs that guide their viewpoint on reality. Mezirow claims that the transformation process comprises a series of phases, each of which entails critical reflection on one's experiences, assumptions, and beliefs. This theory strongly emphasizes the value of critical thinking and discourse in encouraging conceptual growth.

The theory postulates that learners experience transformational learning when they participate in meaningful discussions with individuals who hold diverse viewpoints and critically reflect on their assumptions and beliefs. Learners have the opportunity to acquire new ways of thinking about themselves and the world around them as a result of participating in this process. The disorienting dilemma is the first stage of conceptual change theory. This stage occurs when an individual confronts a circumstance or event that questions their preexisting ideas. One could have feelings of perplexity, uncertainty, and even worry. The individual then moves on to the next step, of self-examination, when they reflect critically on their beliefs and preconceptions in light of the unsettling situation. The third step is called the critical examination of assumptions, and it is when the individual assesses the validity and correctness of their already-held ideas and assumptions. The individual reaches the fourth stage, recognizing different views, when they become conscious of alternate ideas and opinions contradicting their preexisting beliefs. The individual will then begin to explore new ways of thinking and behaving based on the new information and comprehension they have obtained, which brings us to the fifth stage, which is the investigation of new alternatives. The last stage is taking action based on new insights. This is when the individual uses their newly acquired knowledge and understanding of circumstances that occur in the actual world, and this will help pre-service teachers form appropriate concepts on these selected areas in the integrated science. (Kitchenham, 2008; Western Governors University, 2020).

Jean Piaget's Stages of Cognitive Development and Theory

The idea of assimilation and accommodation is another of Jean Piaget's contributions to conceptual transformation research. According to this school of thought, students and, in this study, pre-service teachers actively develop their view of the world by engaging in a process that involves assimilation and accommodation of new information. The process of assimilating new knowledge into preexisting mental structures is referred to as accommodation, whereas the process of accommodating preexisting mental structures to new information is referred to as assimilation.

According to Piaget, the process of cognitive development may be broken down into a number of distinct phases, each of which is distinguished by a qualitatively unique way of thinking. These ideas have significant repercussions for the field of education since they can serve as a basis for developing instructional approaches that promote learning and conceptual development. If a learner's current conception is useful and the learner can handle problems within the existing conceptual schema, then the learner will not feel the need to revise the current conception, as stated by Posner, Strike, Hewson, and Gertzog (1982). However, if the student's present notion is not useful and cannot address difficulties using the student's current conceptual schema, more instruction may be necessary. When the learner's current line of thinking does not adequately address a number of challenges, only modest revisions to that line of thinking are required. This phenomenon has been referred to as "conceptual capture" (Hewson, 1981) or "weak restructuring" (Carey, 2000). In situations like this, the process of assimilation continues without any requirement for accommodation being met. According to one school of thought, for a student to successfully adopt a scientific notion in place of their first conception, the learner must first feel unhappy with their prior belief. The term "conceptual exchange" (Hewson, 1981) or "radical restructuring" (Carey, 1985; 2000) is used to refer to this more significant shift in perspective. According to Posner et al. (1982), for effective conceptual transformation, the scientific theory must also be comprehensible, credible, and productive.

A new idea must be explicable and comprehensible to the person acquiring the knowledge to be considered intelligent. To be considered plausible, the new idea in question has to have some basis in reality. To be considered fruitful, the new thought must give the learner the impression that it may be useful in resolving existing issues. The viewpoint of Posner and colleagues is that these cognitive criteria ought to be satisfied throughout the learning process to achieve fruitful conceptual transformation. The primary objective is to induce cognitive dissonance in the learner so they feel unhappy with their current understanding of the topic. The learner may then come to adopt a normative position as one that is comprehensible, credible, and productive. This perspective has been particularly significant as a theory to discover a learner's specific conceptions, which come from the interplay between the learner's beliefs and knowledge.

Relevance of the Study of Integrated Science

Different authors and researchers have defined integrated science as a subject. Brown (1977) states that there are three major categories that may be used to conceptualise integrated science as the unity of all knowledge. This means that integrated science takes a unifying perspective of knowledge. The numerous conceptual components that make up the framework are recognised, which offer the same notion and distinct meanings in different fields of study and represent a conceptual unity of the sciences. Last but not least, the idea is seen as a unified process of scientific research, with this feature highlighting the methodological differences and similarities across the disciplines, making it an interdisciplinary study. The field is a group effort including several subjects and multiple perspectives on a given topic or theme, with the final synthesis being up to the individual student (Brown, 1977). Instead of focusing too much on the distinctions between the many branches of science, an integrated approach to education and research highlights the commonalities between them.

Brown (2007) defines integrated science as a program that gives students experiences to help them build an operational understanding of the structure of science. This understanding helps students improve their lives and help them become more responsible members of society. The idea of integration in science classes in schools emphasizes concepts, themes, and instructional strategies. The integration of science courses indicates the presentation of science courses in society, according to. Brown (2007) also believes that integrated science as a program of study can be described in four major ways. Thus, integrated science can be explained as follows:

i. Integrated science has a broad perspective of knowledge, seeing it as fundamentally indivisible or one.
ii. Identifying and naming the many conceptual pieces that comprise the framework constitutes the conceptual unity of the sciences.
iii. A standardised approach to the scientific investigation: this feature highlights the methodological differences and similarities within disciplines.
iv. A field of study that draws from other fields to examine a single topic or theme from various angles allows the student to draw whatever conclusions he sees fit.

Many African nations are currently investigating the viability of introducing integrated science at all levels of the educational system as a result of its unmeasurable advantage, due to its capacity to enable people to comprehend the natural world and address problems in life and at work methodically and rationally, the study of science is extremely significant today (MOE, 2010). Science and technology allow one to learn more quickly. With more knowledge, Nations can progress toward greater development and advancement (MOE, 2010). For this knowledge to be fast understanding by students, Students must be instructed in problem-solving techniques for any nation to advance more swiftly.

Scientific education aims to instill in students an appreciation for and knowledge of the natural world and all that it has to offer, including the need to preserve and protect its resources. According to Ansah, Amoah, and Baah (2016), enhancing students' capacity to acquire information and increase their conceptual understanding is one of the primary goals of scientific education. The Ghana Education Service integrated Science Syllabus (MOE, 2010) argues that students have excellent opportunities to develop good attitudes and values through their exposure to science. These include:

1. the desire to investigate their surroundings and question what they discover.
2. a desire to identify and answer questions through scientific research.
3. inventiveness in proposing novel and meaningful solutions to issues.
4. the ability to accept all knowledge as tentative and to modify their position if the evidence is convincing.

5. persistence and patience in investigating a problem until a satisfactory solution is discovered.
6. concern for living things and understanding of their responsibilities toward sustaining the quality of the environment.
7. honesty, integrity, and precision in documenting and reporting scientific data.
8. a love of, respect for, and admiration for nature, as well as a desire to preserve natural balance (MOE, 2010)

Findings revealed in this literature review provides adequate evidence of the importance of the study of science and the relevance of integrating the various branches of science.

The Rationale for Ghanaian Integrated Science Syllabus

The Ministry of Education (MOE, 2010) of the Ghana Education Service (GES) argues that utilizing scientific knowledge is essential in various everyday contexts. As a result, it is crucial that every person in Ghana has a solid grounding in the basics of science. To accomplish the country's strategic programme of scientific and technical literacy as quickly as possible, this is intended to foster a culture of scientific inquiry. Every student in the nation, at every educational level, must be exposed to science education to foster the kind of scientific thinking and culture that will make this scientific literacy agenda a success. Improving people's ability to think critically about phenomena and other real-world problems is a major goal of fostering a scientific mindset and culture. The basic goal of science education is to ensure that students have a firm grasp on the fundamentals of scientific methods and scientific inquiry, as stated by Bell, Blair, Crawford, and Lederman (2003). As stated in the 2010 integrated science syllabus there is an intentional attempt to improve students' scientific literacy and provide them with the foundational scientific knowledge they will need to first make a living and then make significant contributions to the nation's economy. The integrated science syllabus is aimed at helping the student to:

1. analyse and resolve issues in one's local surroundings using experimentation and analysis.
2. maintain a healthy equilibrium between the many forms of life and non-life by considering their interdependence and the cyclical nature of change.
3. employ environmentally responsible practices for the benefit of humanity and society.
4. make good use of home equipment by thoroughly familiarising oneself with its fundamental functions and design.
5. See energy as a vital resource for life should be investigated, conserved, and optimised.
6. embrace a scientific worldview that emphasises objective observation and careful analysis of events.
7. seek answers to real-world issues by integrating scientific and technological knowledge (MOE, 2010).

Scope, Structure and Organization of the J.H.S, SHS, and Colleges of Education Integrated Science Curriculum.

The material covered in integrated science follows a curriculum progression beginning in elementary school and continuing through high school and into teacher training institutions. The subjects of Health, Agriculture, and Industry are all part of the Integrated Science curriculum, which also covers the more fundamental sciences. The goal in compiling these topics was to give a solid grounding for students interested in furthering their education in science-related fields, as well as the knowledge and skills necessary to fulfil the demands of daily life.

Teachers and students both see some integrated scientific curriculum components as challenging, as reported by Mensah and Somuah (2013). They determined that the following sections of the Integrated Science Syllabus were the most challenging: elementary electronics (43.3%), chemical compounds (21.7%), electrical energy (20.0%), acids, bases, and salts (11.7%), and diseases and infections (11.7%). The most challenging subject on the list was "basics electronics," scoring about 43%, followed by "electrical energy," which is connected to electronics. The most straightforward category was illness and infection.

The integrated scientific curriculum also makes use of a spiral method. This is characterised by a gradual but steady repetition of previously learned material at ever higher levels of complexity. With the spiral method, students' scientific knowledge and abilities may be tailored to their learning pace (MOE, 2010).

The Integrated Science curriculum spans all three years of secondary education: elementary, junior high, and senior high. The five themes that permeate our annual projects are the following: Matter's Variety; Cycles; Systems; Energy; and Matter's Interactions. The three-year curriculum is divided into five portions, each corresponding to one of the five topics Integrated Science Syllabus (MOE, 2010).

Pre-Service Teachers' Conceptual Understanding in Integrated Science

It takes the capacity to create meaning, interpret, and explain to grasp a notion (Anderson et al., 2001). Having a firm understanding of the principles that govern a domain and the interrelations between units of knowledge in a domain (Johnstone et al.,1976). Students need to develop two primary forms of comprehension throughout their education, notably in integrated science. In particular, the ability to understand both concepts and processes. Procedural understanding is focused on learning how science is done, whereas conceptual understanding focuses on learning new scientific information and expanding one's understanding of core scientific concepts(Wang & Berlin, 2010). Specifically, conceptual science understanding is the knowledge that requires an in-depth understanding of underlying and foundation concepts behind the algorithms performed in Science. While conceptual knowledge is important in any field of study, it is especially crucial in scientific education due to the need to make sense of phenomena (Anderson et al., 2001).

Lin, Yen, Liang, Chiu, and Guo (2016) posited that all these processes of conceptual change must occur to aid students in appreciating the fact that "there are other competitive conceptions that may be more appropriate for explaining a phenomenon" (p. 2633). One such conception is the alternative conception. Individuals' scientific ideas that differ from expert scientific opinions are referred to as alternative ideas. These concepts have been given various names, the most popular and appealing of which is 'alternative conceptions (Wandersee et al. 1994), which are mentally constructed ideas that make sense to the individual and help the individual make sense of new information. It is personal information that differs from public (accepted) knowledge. Alternative conceptions are not limited to pre-service teachers; advance scientists also have them.

Therefore, one of the major responsibilities of the teacher in the classroom is to identify students' misconceptions and guide them in achieving conceptual change. Teachers should not expect students to give up their alternative conceptions, as Hewson et al. (1992) argued; instead, they should use instructional strategies that give those conceptions a fair shot at competing with the accepted scientific ones. For this reason, science educators need to foster an environment where students feel comfortable questioning and debating the material's validity. (Dass and Yager, 2009) recommends that teachers teach inquiry-driven project-based learning to promote conceptual change in science among students. Thomberg believes teachers could be equipped with the skill to facilitate inquiry-driven project-based learning through regular staff development programs.

Pre-service teachers are those students in the various colleges of education, technical universities, and universities who are being prepared to teach at the various basic schools and second-cycle institutions in the country. For several reasons, it is now crucial to determine the level of scientific literacy among future teachers and uncover any misunderstandings. To begin, many elementary schools use reading and teacher explanations to introduce scientific concepts to their students. That is why it is not uncommon for pupils to look at their teachers as their only source of knowledge (NRC, 1997). In addition, advanced pedagogical content knowledge is required to successfully teach scientific ideas (Appleton, 2006), and this cannot be achieved without first acquiring subject matter knowledge. Therefore, it is crucial in scientific education that pre-service instructors fully grasp key concepts, particularly in areas that pupils find challenging. This is because if pre-service teachers have misconceptions or a lack of conceptual understanding in areas students find challenging, then those 'wrong' scientific concepts will be perpetuated up the education system, from elementary school to college. The development of a scientific culture essential to rapidly implementing a national strategy to improve citizens' knowledge of science and technology would be hampered by this issue. If science education fails to adequately teach students how science works and how scientists conduct their research, it will fail to achieve its primary instructional goal (Bell, Blair, Crawford, & Lederman, 2003).

Elementary school teachers have been studied for over two decades, and the results show that many of them lack the subject understanding and pedagogical acumen to effectively teach fundamental scientific principles to their students (Abell & Smith, 1994; Appleton,2006). According to Crawford, and Lederman, 2003, educators surveyed had views on fundamental scientific notions that were at odds with those generally accepted in the scientific community. Ansah, Amoah, and Baah (2018) conducted a research to evaluate the grasp of the mole idea among future science educators. The research they conducted was based on a survey. The research participants were selected using a systematic process of purposeful sampling. Two first-year science classrooms at Wesley College of Education served as the study's sample. Sixty (60) students made up the entire sample size. The research results showed that the future science instructors who participated in the study had various misconceptions regarding the mole notion because they lacked a solid conceptual knowledge of it. Studies show that students often utilise formulas to answer issues involving stoichiometry because they have different mental models of the subject (Dahsah & Coll, 2008). The capacity to solve numerical issues and conceptual knowledge was shown to be unrelated in the research conducted by Boujaoude and Barakat (2000) on students' capacities to do stoichiometric calculations. Relatedly, Hanson (2016) examined how preservice teachers in Ghana conceptualised stoichiometry. Despite the algorithmic foundations, the trainees still had trouble translating word problems into mathematical equations, indicating more chronic conceptual interpretation challenges. According to research by Schmidt and Jigneus (2003), Swedish students shared these shortcomings and used logical reasoning, the mole method, and proportionality to translate sentence problems into mathematical equations, which often led to the development of Para conceptions when solving problems involving stoichiometry. To answer identical stoichiometric issues, both instructors and students resorted to formulas, as was also found by Dahsah and Coll (2008), rather than using a more proactive learner-centered or constructivist approach. Sanger (2005) observed that while assessing students' conceptual grasp of balanced equations and stoichiometric ratios, many were unsure of the difference between subscripts and coefficients and whether or not to include unreacted chemical species in the equation. The students were tasked with doing two stoichiometric calculations using the balanced equation they developed. The students' ability to do basic stoichiometric calculations and understand the relative reaction rates of the two reactants was tested by analysing their written replies. Students who struggled with understanding the relationship between subscripts and coefficients in stoichiometric calculations had a lower average score. Most of the stoichiometric calculations conducted by the students, whose balanced equations included unreacted chemical species, used inaccurate reacting ratios of the starting ingredients.

In an attempt to ascertain the possible contributing factors to the lack of conceptual understanding among science students, it was discovered that science topics are hardly taught as conceptual lessons (Antwi, 2013). Antwi noted in his study of physics teacher trainees' experiences with interactive engagement that practical activities were hardly carried out in teacher training institutions, as was observed in chemistry teaching and learning. Unfortunately, research shows that learning in most Ghanaian schools is limited to one's ability to learn sets of guiding steps, especially where mathematical expressions and solutions are required. These practices do not result in a holistic conceptual understanding (Antwi, 2013). It is also worth noting that science students' success in quantitative problem-solving is not a reliable measure of conceptual understanding (McDermott & Shaffer, 1992; Mazur, 1997). According to studies (McDermott & Shaffer,1992; Von Korff et al., 2016), students who excel in addressing quantitative problems often have trouble with more abstract conceptual concerns. Despite a lack of familiarity with fundamental physics ideas, some students do well on exams (McDermott & Shaffer, 1992; Hussain, Latiff, & Yahaya, 2012). Many pupils in many underdeveloped nations reportedly do not demonstrate enough conceptual comprehension when presented with issues that need such understanding. It has been found in the past by Talabi and Hanson (2004) that few Ghanaian schools conduct pre-assessments in the sciences to determine students' prior conceptions and practical activities. Since students' existing knowledge affects their ability to absorb new concepts, it is crucial to consider it before teaching (Hanson, 2016). This may help alleviate the problem of pupils lacking conceptual comprehension. Educators in the field of science have a responsibility to take the appropriate measures to ensure that students are taught using effective approaches that foster conceptual comprehension.

Pre-Service Teachers' Conceptual Difficulties and Alternative Conception in Integrated Science.

Ideas developed by students which differ from scientific explanations are known as misconceptions (Halim, Yong, & Meeran 2014). Misconceptions are ideas that go against mainstream scientific consensus. According to Kuczmann and Budapest (2017), misconceptions are alternative conceptions that contradict established scientific ideas yet seem well-grounded based on certain tests and experiences or logical conclusions.

According to Science Teaching Considered: A Handbook (Science Teaching Reconsidered) (NRC, 1997), science teaching misconceptions are classified into five types. The five types of misconceptions are discussed below:

i) Preconceived notions: These are popular beliefs formed due to incomplete observations or prior experiences. It is also views that are formed without proof or evidence, also known as unconscious biases. Prejudices, stereotypes, and numerous other unconscious biases are examples. Ground water, for example, exists as underground rivers.

ii) Nonscientific beliefs: Students acquire beliefs from nonscientific sources, such as religious or mythical teachings (NRC, 1997). For example, the cause of species extinction is due to a predicted flood.

iii) Conceptual misunderstandings occur when a general principle or example is misapplied. For example, blood flows like ocean tides and tornadoes are drawn to mobile home parks.

iv) Vernacular misunderstandings: These are caused by a misunderstanding of the meaning of the words. For example, work is misunderstood in its meaning by different people in their local dialect.

v) Factual misunderstandings: These are lies that people frequently acquire early in life and continue to believe into adulthood (NRC, 1997). For instance, in movies, a rocket explodes outside the earth's cell, and there is a loud detonation. Sound requires a carrier to be heard; a vacuum lacks such mediums.

A number of misconceptions have been found to occur among students at the primary and tertiary levels. These misconceptions are still prevalent among students, although these misconceptions have been revealed overtimes (Halim, Yong, Subahan, & Meeran, 2014; Santyasa, Warpala, & Tegeh, 2018). In contrast to conceptual comprehension, conceptual misunderstanding includes ideas that are "wrong and flawed" (Gurel, Erylmaz, & McDermott, 2015) and at odds with accurate scientific information or assertions. These "wrong and flawed" perspectives are also known as "preconceptions," "alternative frameworks," or "naive conceptions" (Calyk, Ayas,& Ebenezer, 2005, p. 49). Misunderstandings and alternative conceptions can be persistent (Sangam & Jesiek, 2012), inhibit learning and repel change (Turgut, Gurbuz & Turgut, 2011). Ensuring an effective understanding of scientific concepts among students involves guiding students from their alternate conceptions or preconceptions towards a more scientific one through conceptual change.

Discovering and exploring one's conceptions, discussing them with peers in one's learning community, evaluating one's conceptions in light of "scientific models and explanations for plausibility," and finally, "refining, reconstructing, reconciling, or rejecting personal conceptions to align with the scientifically sound and agreed upon conception" (p. 2) are all steps in the process of conceptual change, as described by (Sel, & Sözer, 2019). Misconception, in its simplest form, is the outcome of pupils' fostering a mistaken notion rather than proper information, leading to a lack of comprehension of a topic. Misconceptions provide unique challenges in the classroom while teaching courses in the natural sciences (Stein, Larrabee, & Barman, 2008).

Pre-service and in-service educators, like the rest of us, tend to misunderstand key scientific ideas that are fundamental to their job (Asoko, 2002). There are several sources for student misunderstandings. A lack of access to conceptual resources and experiences, inadequate teaching of these concepts, and previous exposure to scientific phenomena in natural contexts are only a few reasons students struggle to grasp abstract ideas. (Disessa, 2002; Mayer, 2002; Vosniadou, 2014). Many of these are learned early via faulty observation and incorrect assumptions, while others are disseminated through inaccurate textbooks and fictional media. Careful observation and critical thinking skills are usually sufficient to detect misunderstandings (Herr, 2021). Previous research has also shown that pupils' comprehension of natural phenomena often develops before introductory lessons are taught formally (Halim, Yong, & Meeran, 2014). The learning process, curriculum, and teacher's perspective that learning is the transmission of information are all possible suspects as to why misunderstandings occur in a classroom context (Üce & Ceyhan, 2019). Based on the nature of student mistakes, Kuczmann and Budapest (2017) found that student misunderstandings indicate a unique knowledge gap. This shortcoming may reflect an inability to recall specific information or understand the connections between different types of information.

The effects of misunderstandings on students' education may be profound. As students continue to expand on their knowledge, correcting the misunderstandings holding them back from learning more sophisticated ideas becomes increasingly challenging. Students who do not actively engage their prior knowledge are more likely to either not absorb the material taught in class or to memorise it for an exam but then forget it once they are back in their natural environment. There is credible data demonstrating that students' misunderstandings might impede their learning. Sirhan (2007) suggests pupils' prior knowledge may contribute to certain misunderstandings. According to Roschelle (1995), textbooks, instructors, or the instruction itself may contribute to students' misunderstandings of scientific concepts. This latter factor is frequently blamed for disseminating false beliefs, sometimes known as "school-made misconceptions" (Barke et al., 2009). This suggests that the approach to teaching a certain idea may lead to misunderstandings on the side of the pupils. As a result, students should not shoulder all the guilt for their misunderstandings (Sirhan, 2007).

Trundle et al. (2007) advocated for studies that use interventions to grow pre-service elementary teachers' content knowledge. Other findings suggest that eradicating misconceptions among students calls for conceptual change by providing all the essential information and factual knowledge. The emergence of misconceptions could be avoided. (Kuczmann & Budapest, 2017).

The Concept of Basic Electronics in the Study of Integrated Science

The physics component of integrated science has been plagued by low effort or poor performance across the board (Aina, 2013). The field of physics is heavily reliant on mathematics and quantitative analysis. It is sometimes referred to as a “measurement science” (Omosewo, 2009). Several studies have shown that students’ performance in introductory physics is dismally poor. The literature on this topic is sparse (Akanbi, 2003; Aiyelabegan, 2003). Students in other countries, not only Ghana, also have a dismal track record. It has been documented in various parts of Africa, including Nigeria and Kenya. According to Wanbugu, Chiangeiywo, and Ndirit (2013), the perceived difficulty of the subject makes physics unpopular among Kenyan students. Because of this, most students avoid it, and as a result, their physics grades suffer. Adeyemo (2010) ascribed the low performance to the challenging (mathematical) character of the topic, whereas others (Oladejo, Olosunde, Ojebisi, & Isola, 2011) linked it to the inadequate teaching pedagogies used by physics professors. According to Atsumbe, Owodunni, Raymond, and Uduafemhe (2018), and Santosh (2021), Electronics is the discipline of science that examines the flow and control of electrons (electricity) as well as their behaviour and effects in vacuums, gases, and semiconductors. Similarly to this, according to Atsumbe, Owodunni, Raymond, and Uduafemhe (2018), electronics is an area of science and technology that focuses on the investigation of electron flow and regulation in electrical circuits as well as their behaviour and effects in vacuums, gases, and semiconductors. Electronics is sometimes referred to as a discipline of physics and electrical engineering that deals with the emission, behaviour, and consequences of electrons utilising electronic equipment.

The Institute of Electrical and Electronics Engineers (IEEE), the top professional association in the field, produces standards that frequently include electronic components (Steinberg, Andrews-Todd, Forsyth, Chamberlain, Horwitz, Al Koon, Rupp, & McCulla, 2020). Electronics plays a unique role within the engineering community. Students who study electronics have a thorough understanding of the engineering involved in the production, upkeep, and repair of residential and commercial electronic devices. (MOE, 2010). Forces, energy, earth movement, and fundamental electronics are all included in the integrated science's physics component at a certain Ghana institution.

The first year of physics courses for students at Ghanaian institutes of education must include a course in fundamental electronics. In an electronics course, students will learn about the flow of electricity through gases and evacuated tubes, induced electricity and its applications, cathode rays, positive rays and their properties, simple electronic devices, diode properties, and oscilloscope television tubes. They will also learn about the band theory of solids, energy level diagrams for conductors, semi-conductors, and insulators, doping, and the types of semiconductors P- and N-types, P A few more include n-p-and p-n, fundamental terms and structures and their uses, colour coding, and integrated circuits (ICS). In addition to all of these electronics principles, pre-service teachers are exposed to the fundamentals of the subject, learning how to recognise the parts of an electronic circuit and understand the purpose of common home appliances as well as the parts that enable a variety of uses for them. Though the content of basic electronics is not mathematical compared to other branches of physics, Pre-service teachers still perceive it as difficult and perform poorly in electronics. It is, therefore, a matter of concern (MOE, 2010).

Knowledge of electronics is crucial to the development of modern civilization (MOE, 2010). Every nation is seeing a rise in electronics and communication engineering thanks to the discovery of the electron. It plays a crucial role in various fields, from the military and space programmes to the internet and the entertainment business. Electronics and Communication Engineering covers much ground (Lo, 2023). Electrical and electronic engineers are at the cutting edge of applied technology, always striving to improve the tools and systems we rely on daily. We develop new solutions to the world's energy, communication, and information problems, from solar panels to cell phones. Below are a few of the numerous challenges electrical and electronic engineers address

i. Rapid technological growth, a revolution in information and consumer technology and digital media
ii. Urgent need for alternative and sustainable solutions for energy and transport
iii. Development of advanced networks, such as the smart grid
iv. The automated transport revolution
v. The intertwining of computing and manufacturing in Industry
vi. Advances in medical science, aerospace, robotics and artificial intelligence.

The study of electronics plays a very crucial role in the 21st century. The knowledge of electronics and the application of electronic engineering principles and techniques is relevant for solving practical electronic problems in our daily lives (CRDD, 2012). However, Atsumbe, Owodunni, Raymond, and Uduafemhe (2018) observe that instructors of courses like basic electronics struggle to provide students with meaningful classroom activities that promote rapid conceptual change and comprehension. Research has shown that many students struggle with basic concepts of electricity and magnetism (McColgan, Finn, Broder, & Hassel, 2017; Li & Singh, 2017) and that these misunderstandings and challenges are widespread. This shift makes it imperative to examine how much students' future instructors know about integrated science (electronics) from a conceptual standpoint.

The Concept of Balancing Chemical Equations in the Integrated Science

A chemical equation is the symbolic formulation of the proportional amounts of reactants and products. The number of atoms of each element on the left-hand side of the equation (reactants) must be equal to the number of those same atoms on the right-hand side (products) for the chemical equation to be considered balanced (Quaittoo, 1996). Based on the assumption that matter is neither generated nor destroyed during chemical reactions, chemical equations may be characterised as symbolic and quantitative representations of the changes that occur throughout the process of chemical reactions (Ahtee & Varjola, 1998). The substances combined to chemically react are called reactants; the substances formed are the products. In this case, the reactants are A and B, and the products are C and D, as shown by the chemical equation $xA + yB \rightarrow pC + qD$. Stoichiometric coefficients (represented by the subscripts x, y, p, and q) express the proportions of reactants to products in a chemical reaction. The arrow denotes “gives,” “yields,” or “forms,” whereas the plus (+) symbol denotes “and” (Dula, 2018). In a nut shell, Chemical equations consist of symbols of elements and compounds involved in a chemical reaction.

This subject is appropriate for research across all levels of student populations because scientific ideas relating to chemical processes and their symbolic representations have a major position in the chemistry curriculum. Despite the central role that the study of chemical reactions plays in the study of chemistry, students seem to have trouble learning and conceptualising the notion. There are reports of poor performance among students in problems relating to chemical reactions. Numerous research studies have examined students’ misunderstandings and challenges with learning and comprehending chemical topics (Kariper, 2011; Onwu & Randal, 2006; Taber, 2011). Although research has shown that accurately writing chemical equations is not straightforward (Baah & Anthony-Krueger; Baah & Ampiah, 2012; Dula, 2018), it is not impossible. The discovery of misunderstandings among students is concerning. According to research by Savoy (1988) and Hines (1990), science students often struggle to learn and apply the abilities necessary to balance chemical equations. Similar results were found by Johnstone, Morrison, and Sharp (1976) in Scotland, who found that senior high school pupils often avoid writing chemical equations and dealing with calculations using chemical equations. According to research by Anamuah-Mensah and Apafo (1986), senior high school students in Ghana had trouble understanding some scientific concepts, particularly chemical combinations.

About two-thirds of the students in the research said they had a hard time understanding or never understood the chemical combination that was the focus of the investigation. In line with these results, studies by Lazonby, Morris, and Waddington (1982), and Bello (1988) show that students' enduring difficulties in solving stoichiometric problems are related to their incorrect representation of chemical equations. According to available chief examiners' reports from the West African Examinations Council (WAEC, 2018), students do not have sufficient conceptual knowledge in formulating chemical equations throughout high school. According to the chief examiners' report for the SSSCE chemistry paper 2018, most students failed to demonstrate an understanding of how to form balanced chemical equations. The same was true in the 2015 study, reaffirming that many applicants could not write chemical equations correctly. Students in 2016 were found to lack the ability to formulate reaction equations for Bronsted-Lowry base reactions with concentrated HCl. Examining officials noted that applicants struggled with ionic equation drafting in 2018. For the 2021 chemistry theory paper, students were tasked with determining how much dry oxygen gas is produced when KClO3 is heated and writing a balanced chemical equation to describe this process. Candidates had trouble getting the right mole ratio since they could not write the equation correctly, as highlighted by the examiners in the preceding question. Given the above, it is obvious that, although being an essential skill in chemistry, students have historically struggled with and lacked a conceptual grasp of the task of constructing chemical equations. Neither solving nor analysing chemical equations will be possible if pupils fail to write them correctly.

According to WAEC Chief Examiners' report (2013), students who attempted to balance chemical equations exhibited some difficulties. For instance, some candidates copied exactly the skeletal equations as their answers, while others introduced the wrong co-efficient in an attempt to balance the equations. The reports also indicated that candidates who attempted to answer these questions wrote the chemical formula wrongly. For example, some candidates provided Cu_2SO_4 as the chemical formula for Copper (II) tetraoxosulphate (VI) instead of $CuSO_4$. Again, in the same vein, some candidates provided Fe_3O as the chemical formula for Iron (II) oxide instead FeO. However, it should be noted that a proper grasp of the concepts of atoms and atomicity, molecules and molecular formula, atomic structure, and bonding, valency, the use of brackets, radicals, subscripts, and coefficient and Molar ratio is necessary for accurate chemical equation writing (Savoy, 1988).

The three main ways to balance chemical equations are the ion-electron approach, the oxidation number method, and trial and error. The oxidation number approach is ineffective because it encourages students to rely only on concrete reasoning (in the Piagetian sense) by having them utilise a "bookkeeping device" based on internalised algorithms. Herron argued that the ion-electron technique necessitates hypothetico-deductive thinking (in the Piagetian sense) since the meaning of the oxidation process is derived from its place in the larger framework of atomic theory. Aside from students' misconceptions about chemical equations, records of findings also revealed that science students have alternate misconceptions concerning concepts such as burning, physical and chemical changes, dissolving, and solutions (Çalýk et al., 2005; Demircioğlu, 2009).

Teaching chemical reactions implies using three levels of thinking: the macroscopic, the submicroscopic, and the representational (Johnstone, 2000). Many students seem to mix up macroscopic and submicroscopic features of matter, according to the results of previous studies (Bucat, 2004; Chandrasegaran et al., 2007; Meijer, 2011; Treagust et al., 2011). When all three are used simultaneously, people experience an "overload of their working memory space" (Sirhan, 2007). Neglecting the submicroscopic level, on the other hand, may lead to a number of misunderstandings, which is particularly crucial when discussing chemical interactions. The use of metaphorical shortcuts in portraying responses is also crucial. Unfortunately, symbol-based learning of chemical processes is too common, leading students to rely primarily on rote memorisation (Dhindsa & Treagust, 2009; Salame et al., 2011).

The Concept of Infectious and Non-infectious Diseases in Integrated Science

Research has revealed that disease and infections have not seen many studies in educational research; most of the studies of diseases are done in the medical field. According to World Health Organization (WHO, 2020) the term "disease" refers to a specific aberrant state that adversely affects an organism, such as humans or animals, on the whole, or in part but is not instantly caused by external harm (WHO, 2020). Diseases are classified based on the causative organism that causes the disease(pathogens) (Adjibolosoo et al., 2018).

Pathogenic diseases are diseases caused by a living organism that can be transferred to individuals, and non–pathogenic are diseases that are not caused by a living organism; they are mostly caused by genetic and environmental factors (lifestyle). Pathogenic diseases include Cholera, Measles, Typhoid, Polio, Tuberculosis, Tetanus, Yaws, and HIV AIDS. To the biologist, a vector is an organism that transfers the parasite from individual to individual (Baqui et al., 1993) or through air, water, and food. Examples of non-pathogenic disease have varied implications for the life of both children and adults, of which pre-service teachers are not exempted; it needs to be addressed so that the difficulty learners face can be used as a basis to explain the knowledge about the drug may captivate learners who see the treatment of infectious disease for the first time in an Integrated Science lesson or clinic and the skills involved in the diagnosis, and as a result, will pay more attention and engage more deeply.

Relationship between Pre-Service Teachers Interest and Conceptual Understanding

A personal investment in the topic increases the likelihood that a student will return to it and learn more about it over time (Harackiewicz, Durik, Barron, Linnenbrink, & Tauer, 2008). Traditional indicators of academic achievement, such as enrollment and grades, may be predicted by gauging a student’s level of interest in learning.

For learners to conceptualize the Integrated Science concept, the interest of the learners must be considered and developed. It is a fact that interest in a concept will directly affect the performance of the learners that are engaged in these selected concepts.

Among many concepts in Integrated Science, this study teases out Basic Electronics, Balancing Chemical Equations and Diseases to further checks Pre-service teachers conceptual understanding, also verify the relationship that exists between the performance of the learners and the interest they have for the concept understudy, the level at which the learners can perform and the level of conceptual understanding pre-service teachers possess in light of this, the purpose of this research was to examine pre-service teachers' conceptual knowledge of and interest in a particular integrated science subject. The connection between students academic performance and their areas of interest.

Conceptual Framework of the Study

The conceptual framework in Figure 1 was designed to guide the study. It was used as a model for identifying the concepts under study and their relationships. It is realized that when teachers teach the concepts effectively to students, there is a high possibility that students can develop an adequate conceptual understanding (Anim-Eduful & Adu-Gyamfi, 2022b). Conceptual understanding entails students' achievement in the selected concepts, such as basic electronics, balancing of chemical equations and infectious and non-infectious diseases, and their ability to justify their reasoning. However, when these concepts are not well-learned, students develop various conceptual difficulties and alternative conceptions, such as factual misunderstanding and conceptual understanding. No matter how teachers present the concepts to students and even when students read from good textbooks, students still have some level of conceptual difficulties (Nti, et al., 2023). Pre-service Teachers (PST) interest in selected science concepts in integrated science could likely influence their conceptual understanding of those concepts.

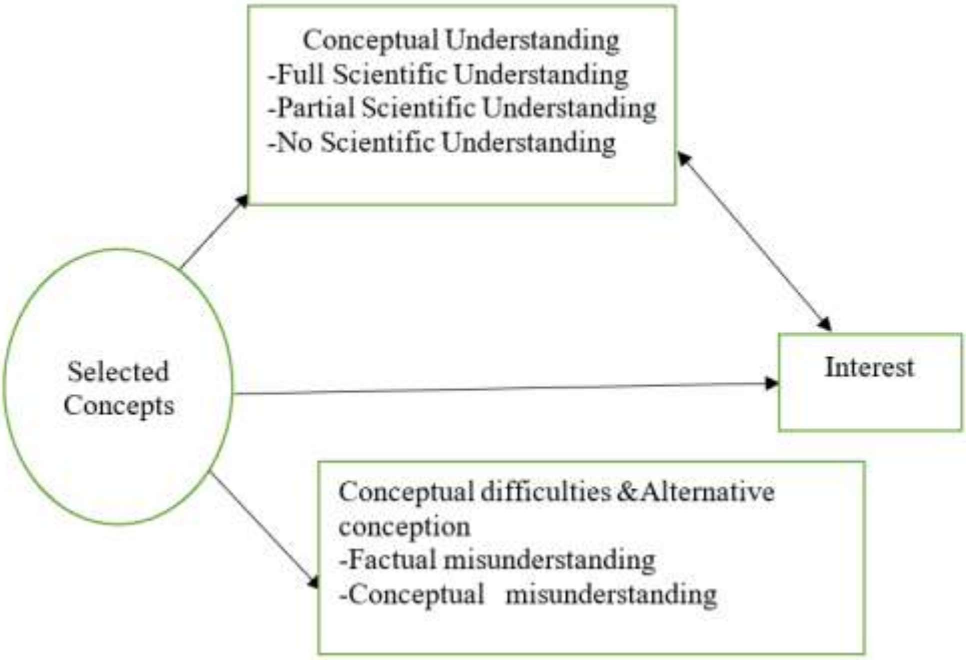

Figure 1: Conceptual framework
Source: Author's construct (Baah-Yanney, 2023)

Chapter Summary

This chapter reviewed the relevant literature which served as a backbone for the study. The literature review was divided into three main sections: theoretical review, empirical review, and conceptual framework of the study. The theoretical review looked at the selected concepts understudy. The empirical review highlighted the conceptual understanding in the integrated science and delimits it to the selected concept under study. Finally, the conceptual framework discussed the model for identifying the concepts under study and their relationships. It is realized that when teachers teach the concepts effectively to students can develop an adequate conceptual understanding.

CHAPTER THREE

RESEARCH METHODS

This chapter describes the methodology that was employed for the study in detail. It comprises the study's design, population, sample, and sampling technique, research instruments, data gathering procedure, data processing and analysis. The chapter also discusses the reliability and validity of the instruments employed in the study and how the instruments were used to collect data to determine the pre-service teachers' conceptual understanding and interest in basic electronics, balancing of chemical equations, and infectious and non-infectious diseases.

Research Design

The research design employed in this study was a convergent parallel mixed methods. This design was used because it allowed for the collection of both quantitative and qualitative data independently to investigate colleges of education pre-service teachers' conceptual understanding and interest in basic electronics, balancing of chemical equations and infectious and non-infectious diseases in Integrated Science at the same time (Creswell & Plano Clark, 2011). The quantitative data was collected using an achievement test and a questionnaire. The achievement was in the form of a two-tier diagnostic test. The first answer tier (A-tier) with four options (one correct option and three distractors) investigated pre-service teachers' achievement of the selected concepts and was used as the quantitative data. The second tier, which was the reason-tier (R-tier), demanded the respondents to provide reasons for their answer tier selected as their answers/explanations to the selected answers for the A-tier. The reasons provided to the answer tier were used as quantitative and qualitative data. The students' interest questionnaire was also used to collect quantitative data. The quantitative data (answer tier) from the diagnostic test and the questionnaires were analysed using means, standard deviations, and percentages. The qualitative data was analysed thematically based on the reasons for the selected concepts to establish any conceptual difficulties as classified by (NRC, 1997). After the analysis, the quantitative results, which yielded conceptual difficulties from the pre-service teachers' conceptual understanding of basic electronics, balancing chemical equations, and infectious and non-infectious diseases, were discussed with the qualitative data from the pre-service teachers' explanations of the same concepts. The findings from students' explanations provided insight and created a better picture of pre-service teachers' conceptual difficulties in learning basic electronics, balancing chemical equations and infectious and non-infectious diseases at the College of Education level. The research design used in this study is seen in Figure 2 below.

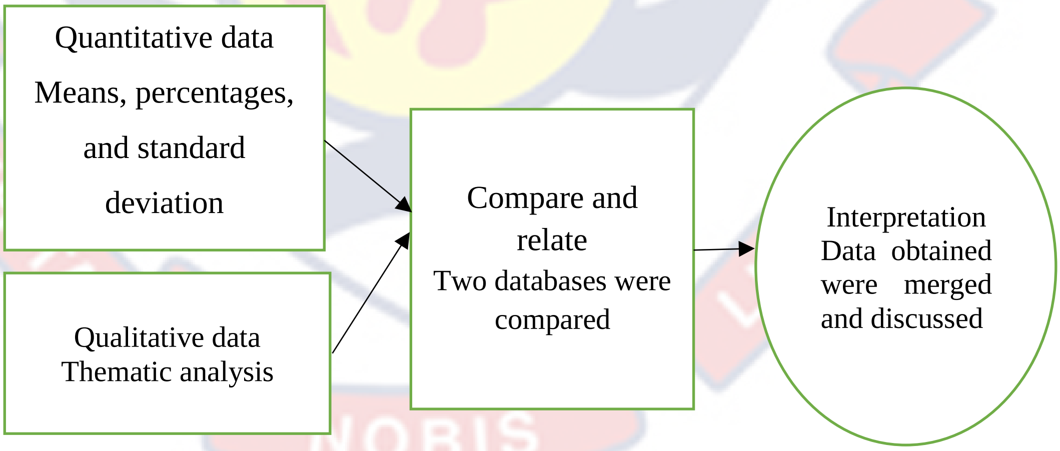

Figure 2: Convergent parallel mixed research design.
Source: (Creswell & Plano Clark, 2011)

Population

There were seven colleges of education in the Eastern Region in the 2020/2021 academic year. Four of the seven colleges of education were affiliated to the University of Education, Winneba, and the other three were affiliated to the University of Cape Coast. The population of the pre-service teachers in the College averagely 200 students in all the four levels making 800 students in each College. In all 3200 pre-service teachers where the population of the study.The target population were the second-years who have study the year one integrated science curriculum. The accessible population were 2400 second year students in the three selected colleges of education affiliated to University of Education Winneba. There were 1,375 females and 1,025 males in all the three colleges of education.

Study Area

The Eastern Region of Ghana, whose headquarters is Koforidua, was the study area. The Ghana Statistical Service (GSS, 2020) estimates that 3,244,834 people live in the region. About 53% of the population works in agriculture; the remaining people are employed in industry and other services. There are 32 Municipal and District Assemblies in the region. There are twenty-nine (29) senior high schools, seven colleges of education, and five universities in the region.

Sample and Sampling Procedure

For this study, purposive sampling technique was used to select three Colleges out of the four Colleges Education in Eastern Region affiliated to the University of Education Winneba. This is because students offering integrated science were selected to participate in the study as the other college of education offered elective science to its students hence, its exclusion from the study. This would have given students in the science-oriented College an upper hand over other students in the three colleges selected.

Second-year pre-service teachers in Colleges of Education participated in the study.This is because, the concepts of basic electronics, balancing of chemical equations and infectious and non-infectious diseases are studied at the first-year hence had fair knowledge about the concepts. To ensure all the second-year pre-service teachers in the three Colleges of Education had equal chance of participating in this study, simple random sampling technique was used through a computer-generated random numbers selection for the 255 pre-service teachers (Krejcie & Morgan, 1970) for the study.

Data Collection Instruments

Achievement tests and questionnaires were the research instruments for the study. These were:

1. Achievement Test on Integrated Science Concepts (ATISC)
2. Questionnaire on Students Interest in Integrated Science Concepts (QSIISC)

Achievement Test on Integrated Science Concepts (ATISC)

ATISC in the form of a diagnostic test was in two sections. Section A, which included six items (items 1-6), sought biodata from respondents: sex, age, level, and programme and Section B was made of 21 two-tier four-option multiple choice test items. Of the 21 two-tier four-option multiple choice test items, eight were on the concepts: basic electronics (items 7-15), seven on balancing of chemical equations (items 16-23), and six on infectious and non-infectious diseases (items 24-30). Pre-service teachers were required to correctly respond to the test items as the answer tier (A-tier) and provide reasons for their selected answer among the four answer options as the reason tier (R-tier). Respondent inability to select the right option, the answer tier, was used a basis to explore the respondents' conceptual understanding level. Again, the reason for selecting a particular option in the answer tier also helped explore respondents' conceptual difficulties.

Validity and reliability of ATISC

After extensive literature review and consultation of different integrated science textbooks and WAEC past examination items, the researcher developed these items on ATISC and compared them to the standard items set by the Institute for Teacher Education and Continuing Professional Development (ITECPD) of the University of Education, Winneba. The test items were compared against standardised items on fundamental electronics, balancing chemical equations, and infectious and non-infectious illnesses established by the University of Education for Colleges of Education year after year for semester exams throughout the test item development process. This was to ensure the instrument's content validity, to ensure the test items measure what it intends to measure. To ensure face validity, the items were shown to three experienced colleague science tutors at the colleges of education to review the items. The science teachers were also experience examiners for the West African Examination Council (WAEC) for over a decade. The items on ATISC were then shown to my supervisor at the Department of Science Education, University of Cape Coast, to critique and make suggestions. Suggestions from these experts helped improve the quality of the instrument.

The ATISC instrument was then pilot-tested with 49 pre-service teachers from a College of Education in the Greater Accra Region. After the pilot test, the difficult item indices were calculated, and this helped to delete less difficult or extremely difficult items. In all, eleven items were deleted (4, 7, 9, 11, 16, 24, 25, 27, 32, 33 and 34) from the initial 32 items and the number of the items was rearranged. This is because they measured the same contents measured by other test items. Of the deleted eleven items, four (4, 7, 9, and 11) were from basic electronics, five (16, 24, 25, 27, and 32) were from balancing of chemical equations, and two (33 and 34) were from infectious and non-infectious diseases. After that, the Kuder-Richardson 21 (KR21) coefficient of reliability was calculated and found to be .79. Twenty(21) items were used for the study with Eight(8) from the concept of basic electronics, Seven(7) from balancing of chemical equation and Six (6) from Infectious and Non-infectious Disease.

Questionnaire on Students Interest in Integrated Science Concepts (QSIISC)

QSIISC was structured on 3-point Likert-type scale questionnaire ranging from 1 Not Interested (NI) to 3 Very Interested (VI) was used to seek pre-service teachers' opinions on their interest in learning of basic electronics, balancing chemical equations and infectious and non-infectious diseases in integrated science (see Appendix B). Sixteen self- developed questionnaire items were on the QSIISC. Of the sixteen items, four items each sought for pre-service teachers' interest in learning of basic electronic devices and balancing of chemical equations, and eight items sought for pre-service teachers' interest in infectious and non-infectious diseases.

Validity and Reliability of QSIISC

There sixteen (16) items on the QSIISC instrument were given to my supervisor in the Department of Science Education, University of Cape Coast to be reviewed to ensure their face and content validity. After which it was pilot-tested in one College of Education in the Greater Accra Region of Ghana. The Cronbach alpha coefficient value of .90 was obtained to determine the internal consistency. This value was obtained after six of the items had been deleted. The value obtained indicated that the questionnaire items were reliable for the study.

Data Collection Procedure

A letter of introduction was obtained from the Department of Science Education, University of Cape Coast. The researcher, with the introductory letter, visited the selected colleges of education to familiarise with the tutors and school authorities to establish a good rapport. This helped to have a smooth data collection process. During the data collection process, the researcher had a brief discussion with tutors teaching integrated science to find out from them if they had covered concepts under investigation, and they responded in the affirmative. After that, the researcher met the respondents (pre-service teachers) and had a brief discussion with them. This helped to explain the relevance of the study and the reasons why they should participate. After the discussion, those willing to participate agreed.

The researcher distributed the achievement test and questionnaire instruments to respondents and ensured they responded independently, as done during the examination. This ensured that independent work was done. Respondents spent 70 minutes responding to the achievement test and 20 minutes responding to the interesting instrument. There was a 100% return rate.

Data Processing and Analysis

Each item on the achievement test for pre-service teachers scored a maximum of 2 marks. This gave a total of 42 marks. That is eight items on the concepts of basic electronics, seven on concepts of balancing chemical equations, and six on infectious and non-infectious diseases, making a total of 21 items. In order to explore the conceptual knowledge of pre-service teachers, a structured level of understanding was used from other research in the field (Anim-Eduful & Adu-Gyamfi, 2021; Anim-Eduful & Adu-Gyamfi, 2022b). Pre-service teachers who replied properly to both levels (content and reason) received 2 marks; those who responded correctly to one tier (content or reason) received 1 mark; and those who responded wrongly to both tiers received 0 mark. The three levels of conceptual understanding were;

1. the first level of Full Scientific Understanding (FSU) goes with correct content and reason responses.
2. the second level Partial Scientific Understanding (PSU), goes with correct responses for either content or reason but not both, and
3. the third level, named No Scientific Understanding (NSU), goes with incorrect responses for both content and reason.

In order to respond to research question one, percentages, means, and standard deviations were employed. For research question two, pre-service teachers conceptual difficulties were classified according to NRC (1997) into five categories. Research question three: students' interest was categorised into; not interested, moderately interested, and very interested, which was adopted from Glaze (2021) employed in the area of evolution. Frequencies, percentages, correlation analysis was used to answer research question three to predict the relationship between pre-service teachers' interest on their conceptual understanding in integrated science.

Chapter Summary

This chapter discussed the methodology that was employed for the study. The research design employed in this study was a convergent parallel mixed methods. This design was used because it allowed for the collection of both quantitative and qualitative data needed for the study. 255 pre-service teachers from seven colleges of education in the Eastern Region constituted the population. Purposive sampling technique was used to select the three colleges affiliated to university of education and simple random sampling was used to selected the pre-service teachers who participated in the study. Finally two tier Achiement tests and questionnaires were the research instruments for the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the study results for the three research questions and discusses all the quantitative and qualitative findings from the colleges of education pre-service teachers' conceptual understanding and interest in the selected concept in integrated science.

Level of Conceptual Understanding of Pre-Service Teachers' in Basic Electronics, Balancing of Chemical Equation, Infectious and Non-infectious Disease in Integrated Science Concepts.

Research question one sought to investigate the level of conceptual understanding of pre-service teachers have in some selected concepts in integrated science. The criteria used for interpreting the levels of pre-service teachers' conceptual understanding in basic electronics, balancing of chemical equations and infectious and non-infectious diseases in integrated science is presented in Table 1. Shows the mean ranges for the three levels of conceptual understanding.

Table 1: Categorisation of Level of Conceptual Understanding

Level	Mean range	Interpretation
1	1.36-2.00	Full Scientific Understanding
2	0.68-1.35	Partial Scientific Understanding
3	0.00-0.67	No Scientific Understanding

To answer the research question, Table 2 provides the frequency, percentages, means, and standard deviations used to answer the level of conceptual understanding in the selected concepts. The maximum mark scored for each question was 2 marks.

To determine the most common material which serves as the main ingredient of sand, Item 7 was used. As shown in Table 2, pre-service teachers demonstrated no scientific understanding that silicon is the most common material which serves as the main ingredient of sand (M = .47, SD = .61). This was evident since 60.0% had no scientific understanding, 21.6% had partial scientific understanding while only 18.4% fully understood the concept. To establish that resistors enable light-emitting Diode (LED) to light up because resistors prevent excess current from flowing through the conductor and thus conserve energy, Item 8 was used. From Table 2, pre-service teachers demonstrated partial scientific understanding (M = .87, SD = .78). This indicates that 43.5% of the students had no scientific understanding, 23.2% exhibited partial scientific understanding, and 33.3% fully understood the concept.

On Item 9, Pre-service teachers were to identify the type of transistor in Fig.2a and 2b, the results from Table 2 show that pre-service teachers demonstrated partial scientific understanding (M=.78, SD=.70). This indicates that PNP and NPN transistors serve as emitter and collector arranged for current from collector flowing through the emitter for PNP and current from emitter to the collector. Since 38.4% had full scientific understanding, 23.1% exhibited partial scientific understanding, and 38.4% had no scientific understanding. To determine why LED bulbs are preferred to other bulbs, Item 10 was used. As seen from Table 2, pre-service teachers demonstrated partial scientific understanding that LED bulbs are energy efficient, they are preferred to other bulbs (M= .98, SD=. 79). This was obvious since 30.6% had no scientific understanding and only 17.6% fully understood and the majority of 51.8% showed partial scientific understanding of the concept.

Table 2: Levels of Pre-service Teachers' Conceptual Understanding in Integrated Science

Item	Full Scientific Understanding		Partial Scientific Understanding		No Scientific Understanding		M	SD
	n	%	n	%	n	%		
Basic electronics								
7	47	18.4	55	21.6	153	60.0	0.47	0.61
8	85	33.3	59	23.1	111	43.5	0.87	0.78
9	98	38.4	59	23.1	98	38.4	0.78	0.70
10	45	17.6	132	51.8	78	30.6	0.98	0.79
11	17	6.7	41	16.1	197	77.3	0.42	0.82
12	18	7.1	57	22.4	93	70.6	0.92	0.61
13	19	7.5	88	34.5	148	58.0	0.45	0.58
14	25	9.8	67	26.3	163	63.9	0.43	0.63
Balancing of equation								
15	13	5.1	36	14.1	206	80.6	0.38	0.79
16	29	11.4	74	29.0	152	59.6	0.47	0.61
17	7	2.7	54	21.2	194	76.1	0.23	0.46
18	18	7.1	102	40.0	135	52.9	0.59	0.70
19	22	8.6	44	17.3	189	74.1	0.25	0.43
20	17	6.7	39	15.3	199	78.0	0.23	0.46
21	7	2.7	21	8.0	227	89	0.24	0.66
Infectious diseases								
22	95	37.3	107	42.0	53	20.8	1.28	0.85
23	59	23.1	104	40.8	92	36.1	1.23	0.90
24	58	22.7	130	51.0	67	26.3	1.14	0.80
25	46	18.0	60	23.5	149	58.4	0.47	0.61
26	59	23.1	125	49.0	71	27.8	1.06	0.82
27	98	38.4	79	31.0	78	30.6	0.98	0.75

Source: Field data (Baah-Yanney, 2023)

To establish why the P-N junction diode is not connected to any current, Item 11 was used. From Table 2, pre-service teachers demonstrated no scientific understanding that if a P-N Junction diode is not connected to any circuit. This is because there is an electric field at the junction directed from the N-type side to the P-type side; hence P-N junction diode is not connected to any current (M=.42, SD=.82). This was evident since 16.1% had partial scientific understanding, 77.3% had no scientific understanding and only 6.7%

fully understood the concept. On item 12, which is related to what is the majority charge carrier in P-type semi-conductor? The results from Table 2 show that pre-service teachers demonstrated partial scientific understanding about what a majority charge carrier in P-type semi-conductor is (M=.92, SD=.61). As a result, 22.4% had partial scientific understanding, 70.6% showed no scientific understanding and only 7.1% fully understood the concepts that majority charge carrier in P-type semi-conductor are holes.

To determine the behavior of the P end of the P-N junction when connected to the negative terminal of the battery and the N end to the positive terminal of the battery the P-N junction behaves like, Item 13 was used. As presented in Table 2, pre-service teachers demonstrated no scientific understanding that the P end of the P-N junction, when connected to the negative terminal of the battery and the N end to the positive terminal of the battery the P-N junction behaves like an insulator (M=.45, SD=.58). This shows that 58.0% had no scientific understanding, 34.5% showed partial scientific understanding, and only 7.5% fully understood the concept. To establish that a capacitor can charge and discharge current, Item 14 was used. From Table 2, pre-service teachers demonstrated no scientific understanding that what can charge and discharge current is a capacitor (M=.43, SD=.63). This is clear since 26.3% had partial understanding, 63.9% exhibited no scientific understanding, and only 9.8% fully understood the concept.

To establish the word equation into a chemical equation that one mole of iron (II) ions (Fe^{2+}) reacts with one mole of an oxide ion (O^{2-}) to form iron (II) oxide (FeO), Item 15 was used. As presented in Table 2, pre-service teachers demonstrated no scientific understanding that one mole of iron(II) ions (Fe^{2+}) reacts with one mole of an oxide ion (O^{2-}) to form iron(II)oxide (FeO) (M=.38, SD=.79). This demonstrates that 14.1% had a limited comprehension of the topic, 80.6% had no scientific understanding, and just 5.1% had a complete understanding. Item 16 was used to determine that, in a balanced chemical equation, one hydrochloric acid reacts with one mole of sodium hydroxide to produce one mole of the salt sodium chloride and one mole of water. Pre-service instructors failed to comprehend the scientific concept that one mole of hydrochloric acid reacts with one mole of sodium hydroxide to produce one mole of the salt sodium chloride and one mole of water as the byproducts (M=.47, SD=.61), as shown in Table 2. This is consistent with 59.0% of respondents had no scientific comprehension, 29.0% had limited scientific awareness, and just 11.4% had complete scientific understanding.

On item 17, students were asked to select a double displacement reaction among four chemical reactions. From Table 2, pre-service teachers demonstrated no scientific understanding that a reaction between one mole of barium chloride and a mole of sodium tetraoxosulphate(VI) to form barium(II) tetraoxosulphate(VI) is a double displacement reaction (M= .23, SD= .46). This implies that 21.2% had partial scientific understanding, 76.1% shows no scientific understanding and only 2.7% fully understood the concepts that a reaction between one mole of barium chloride and a mole of sodium tetraoxosulphate (VI) to form barium (II) tetraoxosulphate(VI) is a double displacement reaction. To establish that the products formed when one mole of calcium hydroxide reacts with ammonium chloride are calcium chloride, ammonia and water, Item 18 was used. As shown in Table 2, pre-service teachers demonstrated no scientific understanding that calcium chloride, ammonia, and water are the products formed when one mole of calcium hydroxide reacts with Ammonium chloride (M=.59, SD=.70). This indicates that 40.0% had partial scientific understanding, 52.9% had no scientific understanding but only 7.1% fully understood the concept.

To determine that hydrogen gas is produced when hydrochloric acid reacts with zinc metal, item 19 was used. As seen from Table 2, pre-service teachers demonstrated no scientific understanding that hydrochloric acid reacts with zinc metal to produce hydrogen gas (M=.25, SD=.43). This shows that 17.3% had partial scientific understanding, 74.1% had no scientific understanding, and only 8.6% fully understood the concept. To establish that the products formed when one mole of aluminum trioxonitrate (V) reacts with three moles of sodium hydroxide to produce aluminium hydroxide and three moles of sodium trioxonitrate (V), Item 20 was used. From Table 2, pre-service teachers demonstrated no scientific understanding that aluminum hydroxide and three moles of sodium trioxonitrate(V) are produced when one mole of aluminium trioxonitrate(V) reacts with three moles of sodium hydroxide (M=.23, SD=.46). This shows that just 2.7% thoroughly comprehended the topic, while the remaining 78.0% simply showed a lack of scientific comprehension.

On item 21, $Al(NO_3)_3 + 3NaOH \rightarrow Al(OH)_3 + 3NaNO_3$.What are the products in the above reaction? The results from Table 2 show that Pre-service teachers demonstrated a partial scientific understanding that a reaction between aluminium metal and copper (II) chloride produces aluminium chloride and copper metal (M=.24, SD=.66). This shows that 8.0% had partial scientific understanding, 89.0% had no scientific understanding and only 2.7% fully understood the concepts that aluminium chloride and copper metal are produced when aluminium metal reacts with copper (II) chloride.

To establish that lifestyle is not a mode of transmission of infectious diseases, Item 22 was used. From Table 2, pre-service teachers demonstrated partial scientific understanding that lifestyle is not a mode of transmission of infectious diseases (M=1.3, SD=.85). This indicates that 42.0% had partial scientific understanding, 20.8% had no scientific understanding, with 37.3% fully understood the concept. On item 23, Diseases are mainly classified into two, namely. The results from Table 2, pre-service teachers demonstrated partial scientific understanding that diseases are mainly classified into pathogenic and non-pathogenic diseases (M=1.2, SD=.90). This is evident that 40.8% had partial scientific understanding, with 36.1% showing no scientific understanding and 23.1% fully understood the concepts that diseases are mainly classified into pathogenic and non-pathogenic diseases. To establish that beriberi is caused by a deficiency of vitamin B1 (thiamine) in the body, Item 24 was used. From Table 2, pre-service teachers demonstrated partial scientific understanding that lack of vitamin B1 (thiamine) in what causes beriberi in the body (M=1.1, SD=.80). This indicates that 51.0% had partial scientific understanding, 26.3% had no scientific understanding and 22.7% fully understood the concept.

To establish that cancer, Leukaemia, hypertension, and arteriosclerosis are non-pathogenic diseases, Item 25 was used. From Table 2, pre-service teachers demonstrated no scientific understanding that cancer, Leukaemia, hypertension and arteriosclerosis are non-pathogenic diseases (M=.50, SD=.61). This indicates that 23.5% had partial scientific understanding, 58.4% had no scientific understanding, and 18.0% fully understood the concept that cancer, Leukaemia, hypertension, and arteriosclerosis are non-pathogenic diseases.

On Item 26, which one of the following is a symptom of Malaria after eight days of infections? From Table 2, pre-service teachers demonstrated partial scientific understanding that malaria is considered an infectious disease because is caused by the Plasmodium spp., which is a parasite (M=1.1, SD=.82). This alludes that 49.0% had partial scientific understanding 27.8% had no scientific understanding and 23.1% fully understood the concepts that malaria is considered an infectious disease because is caused by the Plasmodium which is a parasite. To establish that safe sewage disposal, regular vaccination, and pasteurization of milk help control typhoid disease infection, Item 27 was used. From Table 2, pre-service teachers demonstrate partial scientific understanding that typhoid diseases infection could be prevented by safe disposal of sewage, regular vaccination and pasteurization of milk (M=1.0, SD=.75). This indicates that 31.0% had partial scientific understanding, 30.6% had no scientific understanding and 38.4% fully understood the concept that safe disposal of sewage, regular vaccination and pasteurization of milk help control typhoid diseases infection.

Means from the scores for demonstrating no scientific understanding, partial scientific understanding, and full scientific understanding were calculated to examine the general conceptual understanding of pre-service teachers on basic electronics, balancing chemical equations, and infectious and non-infectious diseases. Pre-service teachers had an average mean of .68

meaning partial scientific understanding in all the areas under study, with the lowest and highest scores being 1 and 37, respectively, out of a possible 42 points. The study's findings show that pre-service teachers have limited comprehension of all three integrated science concepts.

The study key finding is that pre-service teachers had only a partial understanding of the scientific principles underlying infectious and non-infectious diseases with a mean of 1.02 and no grasp of the scientific principles underlying basic electronics .67. Pre-service teachers' demonstrated no scientific understanding of concepts of basic electronics could be due to their perception that basic electronics concepts are abstract and difficult to learn (Kocijanic, 2018; Metioui & Trudel, 2012; Twissel, 2018). Pre-service teachers' demonstration of no scientific understanding of concepts of basic electronics could also be that they hardly spend much time learning on their own but largely depends either on their teachers' information given them during classroom teaching and learning or on available textbooks which they find them difficult to learn on their own for better understanding.

Pre-service teachers' demonstration of no scientific understanding of concepts of balancing chemical equations could be due to the difficult and abstract nature of the concepts (Mensah & Somuah, 2013). Pre-service teachers demonstrate no scientific understanding, possibly because they have difficulty relating symbols and formulas to chemical names and writing full symbolic expressions when identified as abstract (Hanson, 2017). Pre-service teachers who demonstrate no scientific understanding of basic electronics, balancing chemical equations and partial scientific understanding of infectious and non-infectious diseases may find it difficult to teach these concepts at the basic school level. This is because the teachers enact the science concepts in the curriculum have difficulties, and then their students may equally find the concepts difficult to learn (Anim-Eduful & Adu-Gyamfi, 2021) since students are a true reflection of what their teachers teach them. Again, pre-service teachers' demonstration of conceptual difficulties could also be due to difficulties they had while learning the concepts either from the basic school level, at the senior high school level, or even at both levels.

It is, therefore, not strange that concepts in integrated science such as basic electronics, infectious and non-infectious diseases and balancing of chemical equations are difficult for students right from the basic school level to the senior high school (Halim et al., 2014; Santyasa et al., 2018) to learn.

Conceptual Difficulties and Alternative Conceptions of Pre-Service Teachers in Basic Electronics, Balancing of Chemical Equation, Infectious and Non-infectious Disease in Integrated Science.

Research question two sought to determine pre-service teachers' conceptual difficulties and alternative conceptions on basic electronics, balancing chemical equations, and infectious and non-infectious diseases. To achieve this, pre-service teachers who had their conceptual understanding to be partial scientific understanding (PSU) and no scientific understanding (NSU) in their learning basic electronics, balancing chemical equations, and infectious and non-infectious diseases were the focus. Responses of pre-service teachers were used to determine their alternative conceptions by comparing the responses to the NRC's (1997) five types of alternative conceptions/misconceptions (i.e., Preconceived notion, Nonscientific belief, Conceptual misunderstanding, Vernacular misunderstanding, and Factual misunderstanding). Pre-service teachers' explanations classified as conceptual difficulties were open-coded and constantly compared to the NRC (1997) classifications. Frequency counts of coded statements from pre-service teachers were calculated in percentages. This helped to determine the number of the same statements from pre-service teachers to be quantified. Again, pre-service teachers who provided no reasons (NR) to explain their answers or had their space left blank were also calculated (in percentages) to determine the proportion of pre-service teachers with no reasons.

The difficult nature of the test items was determined using the item difficulty index (IDI). That is the proportion of pre-service teachers who answered the item correctly to the total number of pre-service teachers who attempted to answer the item, as shown in Table 3.

Table 3: Categorization of Item Difficulty Indices

Proportions	%	Description
0.0-0.40	0-40	Very difficult
0.50-0.60	50-60	Fairly difficult
0.70-0.80	70-80	Moderately difficult
0.90-1.00	90-100	Very easy

Generally, the achievement test items were very difficult for colleges of education pre-service teachers with a calculated item difficulty index value of .27 and some conceptual difficulties in most instances but not all. Concepts of basic electronics, balancing of chemical equations, and infectious and non-infectious diseases had calculated average item difficult index of .35, .19, and .26, respectively. These values suggest that balancing of chemical equations was the most difficult concept to pre-service teachers, followed by infectious and non-infectious diseases and basic electronics.

It was also found that most of the pre-service teachers had conceptual difficulties with the three concepts under study. It was further found that out of the five 'classifications of alternative conceptions, only two of the classifications that is Conceptual misunderstanding and factual misunderstanding) manifested. Conceptual difficulties and alternative conceptions of pre-service teachers in basic electronics are presented as follows.

Item 7 was very difficult for pre-service teachers, with an index of .40. Of the 208 (81.6%) pre-service teachers with conceptual difficulties, 9(4.33%) of the pre-service teachers' explanations were alternative conceptions. That is 208(81.6%) pre-service teachers, 4(1.9%) explanations were conceptual misunderstandings, 5(2.4%) were of factual misunderstandings category, and 199(95.67%) of the pre-service teachers' provided no explanations could not be classified into any of the alternative conceptions types. The excerpts of conceptual misunderstandings presented on basic electronics and factual misunderstandings are:

Conceptual misunderstandings: (i) silicon is a non-metal hence it cannot be an ingredient of sand. An excerpt is*; "silicon is a non-metal hence it cannot be an ingredient of sand because silicon is a non-metal that is, it easily losses an electron hence cannot be a component of a sand" (Baaba)*

(ii) Graphite most common material which also serves as the main ingredient of sand. An excerpt is*: "graphite is a metal which is obtained from the soil*

hence mostly mixes with the sand hence is most common material which also serves as the main ingredient of sand" (Elorm)

Factual misunderstandings: glass is a component of sand. An excerpt is*: "because glass is obtained from the ground it forms part of sand" (Efua)*

Item 8 was very difficult for pre-service teachers with an index of .43. Of the 170(66.6%) pre-service teachers with conceptual difficulties, 4(2.35%) of the pre-service teachers' explanations were alternative conceptions. Of the 170 pre-service teachers, 2(1.2%) explanations were conceptual misunderstandings and 2(1.2%) were of factual misunderstandings category, and 166(97.65%) of the pre-service teachers' provided no explanations, the excerpts of conceptual misunderstandings presented on basic electronics and factual misunderstandings are:

Conceptual misunderstandings*:* (i) bulbs enable LED to lights up. An excerpt is: *"*presence of bulbs LED to lights up because *bulbs prevent excess current from flowing through the conductor and thus stores up energy.*

(ii) Presence of switch enables LED to lights up. An excerpt is; "enables LED to lights up because *it enables excess current from flowing through the conductor and thus conserve energy" (Kyeremeh).*

Factual misunderstandings: *(i) presence of wires enables LED to lights up. An excerpt is: "presence of wires in LED help to lights up because wires contains and direct current from flowing through them" (Gyasi).*

Item 9 was very difficult for pre-service teachers with an index of 0.40. Of the 157(61.5%) pre-service teachers with conceptual difficulties, 4(2.54%) of the pre-service teachers' explanations were alternative conceptions. Of the 157 pre-service teachers explanations 2(1.27%) were conceptual misunderstandings, and 2(1.27%) were of factual misunderstandings category, and 153(97.45%) of the pre-service teachers provided no explanations. The excerpts of conceptual misunderstandings presented on basic electronics and factual misunderstandings are:

Conceptual misunderstanding*:* (i) only PNP transistors serve as emitter and collector. An excerpt is; "PNP transistors serve as emitter and collector because *it prevents current flow from the emitter to be collected as it is arranged in opposite direction to the current flow" (Kofi)*

Factual misunderstandings: (i) NPN transistors serve as emitter and collector because it cuts current flow during light out because *it is arranged to oppose current flow" (Ama)*

(ii) PNP-only transistors serve as emitter and collector. An excerpt is: "PNP-only transistors serve as emitter and collector because *it can absorb and discharge current as emitters" (Ben).*

Item 10 was very difficult for pre-service teachers, with an index of .38. Of the 210(82.4%) pre-service teachers with conceptual difficulties, 6(2.86%) of the pre-service teachers' explanations were alternative conceptions. Of the 210 pre-service teachers, 3(1.42%) explanations were conceptual misunderstandings, and 3(1.42%) were of factual misunderstandings category, and 204(97.14%) of the pre-service teachers' provided no explanations. The excerpts of conceptual misunderstandings presented on basic electronics and factual misunderstandings are:

Conceptual misunderstanding *i) LED bulbs consume energy. An excerpt is; "LED consumes energy hence preferred to other bulbs because LED bulbs have different colours hence consumes much energy" (Kyeremeh).*

Factual misunderstandings: *(i) all LED bulbs are rechargeable. An excerpt is: "because all LED bulbs are rechargeable, they are preferred to other bulbs" (Adwoa).*

(ii) All LED bulbs are energy inefficient. An excerpt is: "because all LED bulbs are energy inefficient due to its technology they are preferred to other bulbs" (Fiifi).

Item 11 was very difficult for pre-service teachers, with an index of .35. Of the 238(93.4%) pre-service teachers with conceptual difficulties, 7(2.94%) of the pre-service teachers' explanations were alternative conceptions. Of the 238 pre-service teachers, 5(2.1%) explanations were conceptual misunderstandings, and 2(0.84%) were of factual misunderstandings category, and 231(97.14%) of the pre-service teachers' provided no explanations. The excerpts of conceptual misunderstandings presented on basic electronics and factual misunderstandings are:

Conceptual misunderstandings*: (i) the potential is the same everywhere when P-N junction diode is not connected to any current. An excerpt is; "when the P-N junction diode is not connected to any current the electric potential of the system is the same everywhere because P-N junction diode does not have effect whether connected to any current or not" (JB)*

(ii) The P-type has a higher potential than the N-type side flow when the P-N junction diode is not connected to any current" (Gyasi)

Factual misunderstandings: *an electric field at the junction directed from the P-type side to the N-type side. An excerpt is: "There is an electric field at the junction directed from the P-type side to the N-type side when the P-N* *junction diode is not connected to any current because P-type side to the N-type side are connected in series and parallel at the same time" (Okum)*

Item 12 was very difficult for pre-service teachers with an index of .39. Of the 237(93.0%) pre-service teachers with conceptual difficulties, 2(0.84%) of the pre-service teachers' explanations were alternative conceptions. All the two pre-service teachers explanations were of factual misunderstandings category, and 235(99.2%) of the pre-service teachers provided no explanations. The excerpts of factual misunderstandings are:

Factual misunderstandings: *(i) electrons are the majority charge carrier in P-type semi-conductor. An excerpt is; "majority charge carrier in P-type semi-conductor are electrons because electrons carry negative charges and there are numerous amount of electrons in P-type semi-conductor" (Peace). (ii) Equal charge carriers in P-type semi-conductor. An excerpt is: "Equal charge carriers in P-type semi-conductor because of volatility of P-type semi-conductor" (Ama)*

Item 13 was moderately difficult for pre-service teachers with an index of 0.54. Of the 236(92.5%) pre-service teachers who had conceptual difficulties, 2(0.85%) of the pre-service teachers' explanations were alternative conceptions. All the two pre-service teachers explanations were of factual misunderstandings category, and 234(99.2%) of the pre-service teachers provided no explanations. The excerpts of factual misunderstandings are:

Factual misunderstandings: *(i) a conductor character is seen when P end of P-N junction is connected to the battery's negative terminal and the N end to the positive terminal of the P-N junction. An excerpt is; "because a* *conductor carries ions when P end of P-N junction is connected to the negative terminal of the battery and the N end to the positive terminal of the battery the P-N junction it behaves like a conductor" (Papa)*

(ii) a semi-conductor property is seen when P end of P-N junction is connected to the battery's negative terminal and the N end to the positive terminal of the P-N junction. An excerpt is; "because a semis-conductor lacks electrons when P end of P-N junction is connected to the negative terminal of the battery and the N end to the positive terminal of the battery the P-N junction it behaves like a semi-conductor" (Amoasi)

Item 14 was very difficult for pre-service teachers with an index of .28. Of the 230(90.2%) pre-service teachers with conceptual difficulties, 7(3.04%) of the pre-service teachers' explanations were alternative conceptions. Of the 230 pre-service teachers, 5(2.2%) explanations were factual misunderstandings, and 2(0.87%) were of conceptual misunderstandings category, and 227(98.7%) of the pre-service teachers' provided no explanations. The excerpts of conceptual misunderstandings presented on basic electronics and factual misunderstandings are:

***Conceptual misunderstandings**: (i) light emitting diode charges and discharges current. An excerpt is, "Light emitting diode charges and discharges current temporarily due to its emitting properties" (Abbam)*

(ii) Transistor charges and discharges current. An excerpt is: "transistor charges and discharges current due to its ability to store and resist current flow" (Efua)

Factual misunderstandings: *inductor charges and discharges current. An excerpt is: "inductor charges and discharges current due to its ability to stabilize current flow" (BB)*

Item 15 was very difficult for pre-service teachers with an index of .08. Of the 242 (94.7%) pre-service teachers with conceptual difficulties, 4(1.7%) of the pre-service teachers explanations were alternative conceptions. Of the 242 explanations, 2(0.83%) pre-service teachers' explanations were conceptual misunderstandings and factual misunderstandings each category, and 238(98.3%) of the pre-service teachers provided no explanations. The excerpts of conceptual misunderstandings presented on balancing of chemical equations and factual misunderstandings are:

Conceptual misunderstandings: *(i) Fe_3O_2 is formed one mole of iron(II) ions (Fe^{2+}) reacts with one mole of an oxide ion (O^{2-}). An excerpt is; "because one mole of iron (II) ions (Fe^{2+}) has a charge of 2 reacts to form iron (III) ions (Fe^{3+}) before it reacts with one mole of an oxide ion (O^{2-}) with a charge of negative 2 to form iron (III) oxide. This is because iron (II) is reduced to iron (III) hence the product Fe_3O_2" (Baaba)*

Factual misunderstandings: *(i) FeO_2 is formed when one mole of iron (II) ions (Fe^{2+}) reacts with one mole of an oxide ion (O^{2-}). An excerpt is; "because the oxide ion (O^{2-}) gains one more electrons from the Fe to form O^- hence the formation of FeO_2" (Nimo)*

(ii) Fe_3O is formed when one mole of iron (II) ions (Fe^{2+}) reacts with one mole of an oxide ion (O^{2-}). An excerpt is; "because the oxide ion (O^{2-}) losses one electron and the Fe also gains one electron to form O^- and Fe^{3+} hence the formation of Fe_3O" (Essel)

Item 16 was very difficult for pre-service teachers with an index of .18. Of the 226 (88.6%) pre-service teachers with conceptual difficulties, 7(3.1%) of the pre-service teachers explanations were alternative conceptions. Of the 226 pre-service teachers' 2(0.89%) explanations were conceptual misunderstandings and 5(2.21%) factual misunderstandings category, and 219(96.9%) of the pre-service teachers provided no explanations. The excerpts of conceptual misunderstandings presented balancing of chemical equations and factual misunderstandings are:

Conceptual misunderstandings: *(i)* $CH_4 + O_2 \rightarrow H_2O + CO_2$ *is a balanced chemical reaction. An excerpt is; "this is because carbon, hydrogen and oxygen atoms are present in both sides that is, all the atoms are in the reactant side and the product side" (Adu)*

(ii) $HCl + Mg \rightarrow MgCl_2 + H_2$*. An excerpt is: "hydrogen, chlorine and magnesium atoms are present at the reactant and the product sides of the equation" (Ivy)*

Factual misunderstandings: $H_2 + N_2 \rightarrow NH_3$*. An excerpt is: "one mole of hydrogen gas reacts with one mole of nitrogen gas to produce an ammonia gas; hence the reaction is a balanced one" (Regina)*

Item 17 was very difficult for pre-service teachers with an index of .31. Of the 248 (97.3%) pre-service teachers who had conceptual difficulties, 5(2.0%) of the pre-service teachers explanations were alternative conceptions. Of the 248 pre-service teachers', 2(0.81%) explanations were conceptual misunderstandings and 3(1.21%) were of factual misunderstandings category, and 243(98.0%) of the pre-service teachers provided no explanations. The excerpts of conceptual misunderstandings presented balancing of chemical equations and factual misunderstandings are:

Conceptual misunderstandings: *(i) a reaction:* $C_8H_{18}(g) + 25/2O_2(g) \rightarrow 8\ CO_2(g) + 9H_2O(g)$ *is a double displacement reaction. An excerpt is; "*$C_8H_{18}(g) + 25/2O_2(g) \rightarrow 8\ CO_2(g) + 9H_2O(g)$ *is a double displacement reaction because there is a formation of carbon(IV)oxide and water" (fiifi).*

(ii) The reaction: $2HCl(aq) + Mg(s) \rightarrow MgCl_2(aq) + H_2(g)$ *is a double displacement reaction. An excerpt is: magnesium metal displaces hydrogen atom from the hydrochloric acid to form magnesium chloride and hydrogen gas (Efua)*

Factual misunderstandings: *(i) the reaction:* $2N_2O_5\ (g) \rightarrow 2N_{2(g)} + 5O_2(g)$ *is a double displacement reaction. An excerpt is: "because one molecule* N_2O_5 *has decomposed into two molecules; nitrogen gas (*N_2*) and oxygen gas (*O_2*)" (Amoani).*

Item 18 was very difficult to pre-service teachers with an index of 0.25. Of the 237 (93.0%) pre-service teachers who had conceptual difficulties, 4(1.7%) of the pre-service teachers explanations were alternative conceptions. Of the 237 Pre-service teachers explanations were of conceptual misunderstandings and factual misunderstandings category, and 233(98.3%) of the pre-service teachers provided no explanations. The excerpts of conceptual misunderstandings presented on balancing of chemical equations and factual misunderstandings are:

Conceptual misunderstandings: $CaCl_2 + H_2O$*. An excerpt is; "the products formed when one mole of calcium hydroxide reacts with ammonium* *chloride are calcium chloride and water because there is oxygen in calcium hydroxide that produces the water" (Ama)*

Factual misunderstandings: $CaCl_2 + NH_3$. *An excerpt is; "the products formed when one mole of calcium hydroxide reacts with ammonium chloride are calcium chloride and ammonia" (Ben)*

Item 19 was very difficult to pre-service teachers with an index of .24. Of the 233 (91.4%) pre-service teachers who had conceptual difficulties, 2(0.86%) of the pre-service teachers explanations were alternative conceptions. Of the 233 pre-service teachers, 1(0.84%) of each of the pre-service teachers explanations were of conceptual misunderstandings and 1(0.84%) factual misunderstandings, and 231(99.1%) of the pre-service teachers provided no explanations. The excerpts of conceptual misunderstandings presented on balancing of chemical equations and factual misunderstandings are:

Conceptual misunderstandings: *hydrochloric acid reacts with zinc metal to produce carbon dioxide gas. An excerpt is; "this is because Zinc is a very unreactive metal hence reacts with acids to liberate carbon dioxide gas" (Papa)*

Factual misunderstandings: *hydrochloric acid reacts with zinc metal to liberate ammonia gas. An excerpt is; hydrochloric acid reacts with zinc metal to liberate ammonia gas because zinc metals produces react with concentrated hydrochloric acid" (Ebenezer)*

Item 20 was very difficult for pre-service teachers with an index of .25. Of the 238 (93.4%) pre-service teachers with conceptual difficulties, 2(0.84%) of the pre-service teachers explanations were alternative conceptions. Of the

238, 1(0.42%) of pre-service teachers explanations were of conceptual and 1(0.42%) factual misunderstandings category, and 236(99.6%) of the pre-service teachers provided no explanations. The excerpts of conceptual misunderstandings presented on balancing of chemical equations and factual misunderstandings are:

Conceptual misunderstandings: *Al* $(NO_3)_3$ *+ 3NaOH are formed. An excerpt is: aluminium trioxonitrate (V) Al* $(NO_3)_3$ *and sodium hydroxide (NaOH) are formed when aluminium trioxonitrate (V) reacts with t sodium hydroxide" (Erica)*

Factual misunderstandings: *only NaOH is formed. An excerpt is: sodium hydroxide (NaOH) is formed when aluminium trioxonitrate (V) reacts with sodium hydroxide" (Prempeh)*

Item 21 was very difficult for pre-service teachers with an index of .11. Of the 248 (97.3%) pre-service teachers with conceptual difficulties, 2(0.81%) of the pre-service teachers explanations were alternative conceptions. All the 2(0.81%) of pre-service teachers explanations were of factual misunderstandings only, and 246(99.19%) of the pre-service teachers provided no explanations. The excerpts of factual misunderstandings presented on balancing of chemical equations and are:

Factual misunderstandings: *(i) Al* $(NO_3)_3 + 3NaOH \rightarrow Al(OH)_3 + 3NaNO_3$*. An excerpt is: "aluminium metal reacts with copper (II) chloride to yield aluminium chloride and copper metal" (Bernice)*

(ii) $Al + CuCl_2 \rightarrow AlCl_3 + 2Cu$*. An excerpt is: aluminium hydroxide* $Al(OH)_3$ *and sodium trioxonitrate(V) are formed when aluminium metal reacts with copper (II) chloride" (Mathias)*

Item 22 was very difficult for pre-service teachers with an index of .03. Of the 160 (94.7%) pre-service teachers who had conceptual difficulties, none provided explanations to be categorized as alternative conceptions.

Item 23 was very difficult for pre-service teachers with an index of .22. Of the 196 (76.9%) pre-service teachers who had conceptual difficulties, none provided explanations to be categorized as alternative conceptions.

Item 24 was moderately difficult for pre-service teachers with an index of .72. Of the 195 (77.3%) pre-service teachers with conceptual difficulties; none provided explanations to be categorized as alternative conceptions.

Item 25 was very difficult for pre-service teachers with an index of .24. Of the 209 (82.0%) pre-service teachers with conceptual difficulties; none provided explanations to be categorized as alternative conceptions.

Item 26 was very difficult for pre-service teachers with an index of .36. Of the 196 (76.9%) pre-service teachers with conceptual difficulties, 5(2.55%) of the pre-service teachers explanations were alternative conceptions. Of the 196 pre-service teachers, 2(1.0%) explanations were conceptual misunderstandings and 3(1.53%) were of factual misunderstandings category, and 191(97.45%) of the pre-service teachers provided no explanations. The excerpts of conceptual misunderstandings presented on infectious and non-infectious diseases and factual misunderstandings are:

Conceptual misunderstandings: *It is not only protein that lead to kwashiorkor but rather some of the nutrient that contains fats and oils may be added. (Kojo)*

Factual misunderstandings: *(i) Beriberi is a lack of vitamin B2. (Sala)* *(i) Because Beriberi is caused by lack of some nutrients such as folic acid in the body (Kofi)*

Item 27 was very difficult for pre-service teachers with an index of .01. Of the 157(61.6%) pre-service teachers with conceptual difficulties, 3(1.9%) of the pre-service teachers explanations were alternative conceptions. Of the 157 pre-service teachers, 2(1.27%) explanations were of factual misunderstandings and conceptual misunderstandings 1(0.64%) category and 154(98.1%) of the pre-service teachers provided no explanations. The excerpts of conceptual misunderstandings presented on infectious and non-infectious diseases and factual misunderstandings are:

Conceptual misunderstandings: *because treated nets are meant for mosquitoes and not bacteria that causes typhoid.* ***(Abeiku)***

Factual misunderstandings: *(i) safe disposal of sewage such that waste are not dumped into water bodies or around the environment.* ***(Charity)***

The conceptual difficulties exhibited by pre-service teachers could be due to their inability to demonstrate full scientific understanding of the concepts of basic electronics, infectious and non-infectious diseases, and balancing of chemical equations. The findings have shown that not only do pre-service teachers at the university level have difficulties in relating symbols and formulas to chemical names, as well as writing full symbolic of compounds in a chemical reaction (Hanson, 2017), but pre-service teachers at the Colleges of Education also have same difficulties in balancing of chemical equations. Pre-service teachers demonstrate their conceptual difficulties in identifying products of a chemical reactions when the reactants are available, and also state the appropriate stoichiometric powers in a balanced reaction which leads to their inability to balance chemical reactions. The study seems that not only students at the basic school, senior high, and pre-service teachers at the university have difficulties in learning the balancing of chemical equations and basic electronics, but pre-service teachers at the Colleges of Education also seem to have difficulties.

Again, the findings have shown that not only do students have difficulties in balancing of chemical equation and organic functional groups (Anim-Eduful & Adu-Gyamfi, 2022b) but they also exhibit such difficulties in balancing of inorganic chemical reactions. Results of the study also show that pre-service teachers at the College of Education seem to have conceptual difficulties with infectious and non-infectious diseases.

The findings have shown that pre-service teachers exhibited more misconceptions. This is envisaged that majority of those who had conceptual difficulties in all the concepts in integrated science were unable to provide reasons for their options. According to the categories established by NRC (1997), the students' alternative perceptions fell mostly into the realms of conceptual misunderstanding and factual misunderstanding.

Generally, colleges of education pre-service teachers' harboured 75 alternative conceptions in concepts of basic electronics, balancing of chemical equations and infectious and non-infectious diseases in integrated science. Forty-one (41) out of the 75 alternative conceptions came from basic electronics concepts, twenty-six (26) came from balancing chemical equations, and eight came from infectious and non-infectious diseases.

Even though all three concepts in integrated science were very difficult for pre-service teachers, the results seem to suggest that pre-service teachers exhibited more conceptual difficulties in basic electronics than in balancing chemical equations and infectious and non-infectious diseases. Pre-service teachers' alternative conceptions were much of factual, 45(60.0%) than conceptual 30(40.0%) out of the 75 alternative conceptions revealed in this study.

For basic electronics, pre-service teachers exhibited 41 alternative conceptions of which 23(56.1%) were factual and that of conceptual misconceptions was 18(43.9%). Pre-service teachers harboured 26 alternative conceptions in balancing chemical equations concepts, of which 17(65.4%) were factual misconceptions, and 9(34.6%) were conceptual misconceptions. Pre-service teachers exhibited eight alternative conceptions in infectious and non-infectious diseases concepts, with (62.5%) factual misconceptions and 37.5% conceptual misconceptions. Consequently, pre-service teachers' exhibition of more factual misconceptions in basic electronics and balancing of chemical equations seems to suggest that they have difficulties in understanding these concepts in physics and chemistry, respectively, compared to concepts of infectious and non-infectious diseases in biology.

Level of Interest of Pre-service Teachers' in Basic Electronics, Balancing Chemical Equation, Infectious and Non-infectious Disease in Integrated Science.

Research question three sought to determine the level of pre-service teachers' interest in basic electronics, balancing of chemical equations, and infectious and non-infectious diseases; data obtained from the level of pre-service teachers interest were analysed using descriptive (frequency, percentage, mean and standard deviations) and further categorised into three levels each.

To start with data analysis for research question three, the level of interest of pre-service teachers was determined. Table 4 presents the criteria for interpreting the level of interest.

Table 4: Format for Interpreting Students Level of Interest in Integrated Science

Level	Range	Description
1	1.00 to 1.7	Not interested
2	1.71 to 2.4	Moderately interested
3	2.41 to 3.00	Very interested

Adapted from Glaze (2021).

Table 5: Pre-service Teachers Level of Interest in Studying Concepts in Integrated Science (N=255)

S/N	Item	Not Interested		Moderately Interested		Very Interested		M	SD
		n	%	n	%	n	%		
1	I am interested in understanding the relevance of Basic Electronic appliances as commonly use at homes	176	69.0	54	21.2	25	9.8	1.41	0.66
2	I am interested in reading about uses of Electronic appliance at home	151	59.2	80	31.4	24	9.4	1.50	0.63
3	I am interested in Basic Electronic components connection in class	166	65.1	70	27.5	19	7.5	1.42	0.49
4	I am interested in knowing how electronic devices are used in vehicle	199	78.0	49	19.2	7	2.7	1.25	0.49
5	Balancing chemical equation of reaction is a concept that is very interesting to study	50	19.6	63	24.7	142	55.7	2.39	0.99
6	Understanding Balancing chemical equations arouse my interest in learning chemical compounds	54	21.2	72	28.2	129	50.6	2.29	0.79
7	Basic idea in Balancing chemical equation interest me to learn more of chemical equation	65	25.5	82	32.2	108	42.4	2.16	0.80
8	It is interesting to know the importance of balancing chemical equation.	71	27.8	81	31.8	103	40.4	2.12	0.81
9	It is interesting to know the spread of infectious and non-infectious disease within the community	60	23.5	89	34.9	106	41.6	2.25	0.48
10	I am interested to know that malaria is an infectious disease	48	18.8	86	33.7	121	47.5	2.29	0.76
11	I am interested to know that personal hygiene reduces infectious diseases	44	17.3	211	82.7	0	00.0	1.83	0.38
12	I am interested to know that protozoa, bacteria, fungi, virus and yeast causes infectious diseases	46	18.0	88	34.5	121	47.5	2.29	0.76
13	It is interesting to know that health does not mean absence of diseases only	49	19.2	91	35.7	115	45.1	2.26	0.76
14	It is interesting to know that antibacterial products do not affect disease caused by a virus	54	21.2	102	40.0	99	38.8	2.18	0.76
15	It is interesting to know that deficiency diseases are caused by a lack of nutrients in the body	43	16.9	84	32.9	128	50.2	2.33	0.75
16	Interesting facts about disease make me read more about health and hygiene	47	18.4	89	31.4	128	50.2	2.32	0.77

Source: Field data (Baah-Yanney, 2023)

For the statement, knowledge in Basic Electronics help one to understand the relevance of electronic appliances at home, Item 1 was used. Results from Table 5 show that pre-service teachers perceived they had no interest in the relevance of basic electronic appliances commonly used at home. (M=1.41, SD=.66). This is evident since 69% were not interested, 21.2% were moderately interested, and 9.8% only were very interested in the relevance of basic electronic appliances commonly used at homes. The second item understanding basic electronics, enables one to recognise their uses at our homes. As seen from Table 5, pre-service teachers were not interested in reading about the uses of an electronic appliance at home (M=1.5, SD=.60). This was clear since 59.2% did not show interest, 31.4% showed moderate interest, and only 9.4% of the pre-service teachers were very interested that they mostly read about the uses of an electronic appliance at home.

Again, for knowledge of basic electronics, one knows the various functions of the components of electronic devices. Item 3 was used. As seen from Table 5, pre-service teachers were not interested (M=1.42, SD=.49). This was so because 65.1% were not interested, 27.5% were moderately interested, and only 7.5% of the pre-service teachers were very interested that basic electronic components connection in classrooms. Also, basic electronics concepts are complex, abstract and difficult to learn; Item 4 was used. As shown in Table 5, pre-service teachers were not interested in knowing how electronic devices are used in the vehicle (M=1.25, SD=.49). It was obvious that 78% showed no interest, 19.2% of the pre-service teachers were moderately interested, and only 2.7% of the pre-service teachers were very interested of knowing how electronic devices are used in the vehicle.

In addition, balancing the chemical equation of a reaction is a concept one can understand through various methods. Item 5 was used, and pre-service teachers were moderately interested in the chemical concept of balancing chemical equations (M=2.39, SD=.99). This was made possible since 19% were not 63 (24.7%) were moderately interested, and 142(55.7%) of the pre-service teachers were very interested of the chemical concept of balancing of chemical equations. Also, Understanding Balancing Chemical equations aroused my interest in learning chemistry. Item 6 was used. As indicated in Table 5, pre-service teachers were moderately interested that understanding balancing chemical equations aroused my interest in learning chemical compounds (M=2.29, SD=.79). This was identified in that 21.2% showed no interest, 28.2% demonstrated partial interest, and more than half 50.6% of the pre-service teachers were very interested that understanding of balancing chemical equations arouse my interest in learning chemical compounds.

Continuing with Good knowledge in Balancing Chemical Equations motivates me to learn more about Chemical compounds, Item 7 was used. As seen from Table 5, pre-service teachers were moderately interested in basic ideas in balancing chemical equations interest me to learn more chemical equations (M=2.16, SD=.80). This was evident since 25.5% were not interested, 32.2% were moderately interested, 42.4% of the pre-service teachers were very interested that basic ideas in balancing chemical equation interest me to learn more of a chemical equation.

Also, it is interesting to know the importance of balancing chemical equations; Item 8 was used, as seen from Table 5. Pre-service teachers were moderately interested to know the importance of balancing chemical equations

(M=2.12, SD=.81). The percentages show that 27.8 were not interested, 31.8 were moderately interested, and 40.4% of the pre-service teachers were very interested to know the importance of balancing a chemical equation.

Furthermore, for the statement it is interesting to know the spread of infectious and non-infectious diseases within the community; item 7 was used, as seen from Table 5. Pre-service teachers were moderately interested to know the spread of infectious and non-infectious diseases within the community (M=2.25, SD=.48). This allude to the fact that 23.5% were not interested, 34.9% were moderately interested, and 41.6% of the pre-service teachers were very interested that it is interesting to know the spread of infectious and non-infectious disease within the community. Also, I am interested to know that malaria is an infectious disease; item 10 was used. As seen from Table 5, pre-service teachers were moderately interested to know that malaria is an infectious disease (M=2.29, SD=.76). This is clear since 18.8% were not interested, 33.7% were moderately interested, and 47.5% of the pre-service teachers were very interested to know that malaria is an infectious disease.

For the statement 'I am interested to know that personal hygiene reduces infectious diseases', Item 11 was used. As seen from Table 5, pre-service teachers were not interested to know that personal hygiene reduces infectious diseases (M=1.83, SD=.38). This indicates that 17.3% were not interested and the rest 82.7% were moderately interested, and none of the pre-service teachers been very interested to know that personal hygiene reduces infectious diseases. Also, I am interested to know that protozoa, bacteria, fungi, virus, and yeast causes infectious diseases; item 12 was used; as shown in Table 5, pre-service teachers were not interested to know that protozoa, bacteria, fungi, virus, and yeast causes infectious diseases (M=2.29, SD=.76). This was obvious since 18% were not interested, 34.5% were moderately interested, and 47.5% of the pre-service teachers were very interested to know that protozoa, bacteria, fungi, virus, and yeast cause infectious diseases.

It is interesting to know that health does not mean the absence of diseases only; Item 13 was used. Results from Table 5 show that pre-service teachers) were not interested to know that health does not mean the absence of diseases only (M= 2.26, SD=.76). This is evident since 19.2% were not interested, 35.7% were moderately interested, and 45.1% of the pre-service teachers were very interested to know that health does not mean an absence of diseases only. Also, It is interesting to know that antibacterial products do not affect disease caused by viruses, item 14 was used. As presented in Table 5. Pre-service teachers were moderately interested to know that antibacterial products do not affect disease caused by viruses (M=2.18, SD=.76). It was not a surprise 21.2% were not interested, 40% were moderately interested and 38.8% of the pre-service teachers were very interested to know that antibacterial products do not affect disease cause by virus.

Furthermore, It is interesting to know that deficiency diseases are caused by a lack of nutrients in the body; item 15 was used; from Table 5, pre-service teachers were moderately interested to know that deficiency diseases are caused by lack of nutrients in the body (M=2.23, SD=.75). This shows that 16.9% were not interested, 32.9% were moderately interested, and 50.2% of the pre-service teachers were very interested to know that deficiency diseases are caused by lack of nutrients in the body. The last item, Interesting facts about disease, makes me read more on health and hygiene. As presented in

Table 5, pre-service teachers were moderately interested in the facts about disease makes one read more on health and hygiene (M=2.32, SD=.77). This is evident since 18.4% were not interested, 31.4% were moderately interested, and 50.2% of the pre-service teachers were very interested in the facts about disease makes them read more on health and hygiene.

Generally, pre-service teachers' exhibited moderate interest in basic electronics, balancing of chemical equations, and infectious and non-infectious diseases. This could be due to the abstract nature of the concepts (M=2.02, SD=.70), (Hanson, 2017) and how the students were taught at the junior and senior high school level. That is, their teachers' level of understanding of the concepts and the kind of instructional teaching strategies employed does not give pre-service teachers the kind of interest needed to interact with the concept introduced in the classroom. It was clear that pre-service teachers did not show interest in the concept of basic electronics (M=1.4, SD=.60), this statement is in agreement to Harackiewicz, Durik, Barron, Linnenbrink, and Tauer, 2008 that traditional indicators of academic achievement, such as enrollment and grades, may be predicted by gauging a student's level of interest in learning basic electronics. This mean of pre-service teachers showing no interest in basic electronics is also confirmed by Adeyemo (2010) who said that the low interst is as a result of the challenging character of the topic, whereas others (Oladejo, Olosunde, Ojebisi, & Isola, 2011) linked it to the inadequate teaching pedagogies used by physics professors. According to Atsumbe, Owodunni, Raymond, and Uduafemhe (2018), electronics is the discipline of science that examines the flow and control of electrons (electricity) as well as their behaviour and effects in vacuums, gases, and semiconductors. For the concept of balancing of chemical equation and infectious and non-infectious disease, pre-service teachers showed moderate interest in these selected area (M=2.2, SD=.85; M=2.2, SD=.68). pre-service teachers who showed no scientific understanding in the concept of balancing of chemical equation, however by infering from the mean above indicate moderate interest in balancing of chemical equation. This findings support the assertion by WAEC Chief Examiners' report (2013), which explains students who attempted to balance chemical equations exhibited some difficulties but have moderate interest in the concept of balancing chemical equation. The reports further indicated that candidates who attempted to answer these questions wrote the chemical formula wrongly. For example, some candidates provided Cu_2SO_4 as the chemical formula for Copper (II) tetraoxosulphate (VI) instead of $CuSO_4$. Pre-service teachers demonstration of interest in the concept of infectious and non-infectious was in line with the first research question as their conceptual understanding level is at the partial scientific level and also

Relationship between Pre-Service Teachers' Interest and Conceptual Understanding On Basic Electronics, Balancing of Chemical Equation, Infectious and Non-infectious Disease in integrated science.

Research question four sought to examine the relationship between students' interest and their conceptual understanding in basic electronics, balancing of chemical equations and infectious and non-infectious diseases, data obtained from students' interest and understanding were analysed by the use of Pearson's correlation coefficient to determine the relationship between students' interest and their academic achievement (performance).

The data obtained were explored to determine whether it showed normal distribution in order to decide which appropriate test statistic to implement. This helped to take into consideration assumptions regarding parametric tests. The scale data's central tendency measures, skewness and kurtosis, were tested, as seen in Table 6, to determine whether it showed normal distribution. When a scale data's mean, median, and peak values are equal or close, the data shows normal distribution. Again, Tabachnick and Fidell (2013) indicated that the data is normally distributed when skewness and kurtosis coefficient values are between ± 1.5.

Table 6: Measures of Central Distribution, Skewness, and Coefficients

Dimension	Mean	Median	Skewness	Kurtosis
Test Items	14.72	14.49	.44	.304

The data was explored further to ensure the test of normality using Kolmogorov-Smirnov. As seen from Table 6, the data can now be confirmed to be normally distributed as values of either Kolmogorov-Smirnov (Tabachnick & Fidell, 2013) were below .05. With the significant value of .001 (being less than p<.05), Table 7 is the result of Kolmogorov-Smirnov statistics that were further considered. Hence, the information obtained indicates that the data were normally distributed.

Table 7: Tests of Normality

	Tests of Normality		
Dimension	Kolmogorov-Smirnov		
	Statistic	Df	Sig
Students' scores	.068	255	.008

The relationship between pre-service teachers' interest and conceptual understanding in basic electronics, balancing of chemical equation and infectious and non-infectious diseases was investigated using the Pearson-product-moment correlation coefficient. After the preliminary analyses were performed to ensure assumptions of normality, linearity and homoscedasticity were not violated, As shown in Table 7, there was no correlation between the two variables (interest and performance), r = .087, n = 255, p = .165. as shown in table 8.

Table 8: Correlation of Interest and Conceptual Understanding

		Interest	Sig.	N
Pearson Correlation	Performance	.087	.165	255

This means that students' interest is not a predictor of their conceptual understanding in basic electronics, balancing chemical equations and infectious and non-infectious diseases, but other variables rather contribute to students' performance.

In conclusion, the current research contributes to a new perspective of the literature on pre-service teachers' conceptual understanding that interest does not predicts pre-service teachers' conceptual understanding in basic electronics, balancing of chemical equations and infectious and non-infectious in integrated science.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter summarises the key findings, conclusion, and recommendations on the pre-service teachers' interest and their conceptual understanding of basic electronics, balancing of chemical equations, and infectious and non-infectious disease concepts in Integrated Science at the Colleges of Education in Eastern region affiliated University of Education Winneba.

Summary

This study investigated the interest of pre-service teachers on their conceptual understanding of basic electronics, balancing chemical equations, and infectious and non-infectious diseases in the Colleges of Education in the Eastern Region of Ghana. To answer the research questions raised, diagnostic test items and a questionnaire on a 3-point Likert scale were pilot tested to ascertain their validity and reliability. The sample used was 255 level 200 Pre-service teachers for the 2020/2021 academic year drawn from three Colleges of Education in the Eastern region of Ghana. A convergent parallel mixed method design was used to collect quantitative data on their performance and a questionnaire on students' interests. The diagnostic test's second tier (reason tier) was extracted and used for the qualitative aspect of the study for the three integrated science concepts under study.

Key findings

The key findings from the study based on the results from research questions are presented as:

1. The findings from the exploration of pre-service teachers' level of conceptual understanding of basic electronics, balancing chemical equations, infectious and non-infectious diseases are:
   a. Pre-service teachers were at the partial scientific understanding level of learning basic electronics, balancing chemical equations, and infectious and non-infectious diseases. The average of the means of all three concepts was within the partial scientific understanding.
   b. Pre-service teachers demonstrated no scientific understanding of the concepts of basic electronics. Such as resistors that enable LED to light up; PNP and NPN transistors serve as emitters and collectors arranged for current from the collector flowing through the emitter for PNP and current from emitter to the collect; because LED bulbs are energy efficient, they are preferred to other bulbs; majority charge carrier in P-type semi-conductor are holes;
   c. Pre-service teachers demonstrated no scientific understanding of the concept of balancing chemical equations.
   d. However, pre-service teachers demonstrated a partial scientific understanding of infectious and non-infectious diseases.
2. It was found that most pre-service teachers had conceptual difficulties in basic electronics, balancing chemical equations, and Infectious and non-infectious diseases. Pre-service teachers had conceptual and factual misunderstandings out of the five classifications of alternative conceptions of the three concepts under study.

3. The findings from the exploration of the relationship between pre-service teachers' interest and their conceptual understanding in basic electronics, balancing of chemical equations and infectious and non-infectious diseases is that generally, pre-service teachers' exhibited a moderate interest in basic electronics, balancing chemical equations and infectious and non-infectious diseases.

Conclusions

The study has shown that pre-service teachers' conceptual understanding is at partial scientific understanding; however, pre-service teachers demonstrated no scientific understanding of basic electronics and balancing chemical equation concepts but partial scientific understanding of infectious and non-infectious disease concepts. Results from this research support the difficulty level of the idea as described by Mensah and Somuah (2013) in their integrated science curriculum and add to the body of information that pre-service teachers usually experienced challenges with the three chosen concepts under consideration.

The study also revealed that pre-service teachers had conceptual difficulties and alternative conceptions in all the concepts under study. The conceptual difficulties manifested in that many pre-service teachers could not write or respond to the given reason tier option selected. The alternative conceptions expressed by pre-service teachers were classified into five categories (NRC, 1997). Only two alternative conceptions were expressed (i.e., conceptual misunderstanding and factual misunderstanding). This could be because pre-service teachers have false ideas learnt while growing up that they did not get any opportunity to unlearn till adulthood, i.e., from wrong approaches to teaching, alternative conception transferred from teachers to learners, or learners' experiences of untrue or incomplete observations. There is an obvious favourable non-significant association between the enthusiasm of pre-service teachers and student achievement. This manifested when Pearson correlation analysis was tested, and further linear regression was used to confirm the results. It also clearly showed that interest did not relate to pre-service teachers' academic performance.

Recommendations

Based on the key findings of the study, the following recommendations are made:

a. As pre-service teachers demonstrated partial scientific conceptual understanding of basic electronics, balancing of chemical equations and infectious and non-infectious diseases, Tutors at the Colleges of Education should use conceptual change strategies to help improve pre-service teachers understanding of integrated science concepts.

b. Science Tutors at the Colleges of Education should design and develop teaching strategies that challenge pre-service teachers' conceptual construction of knowledge.

c. Tutors at the Colleges of Education should employ well-tailored innovative teaching methods to help stimulate pre-service teachers' interest in learning integrated science concepts.

Suggestions for Future Research

1. The study examined pre-service teachers conceptual understanding of basic electronics, balancing of chemical equations, and infectious and non-infectious diseases at the Colleges of Education. The study,

however, did not intervene with any treatment to help pre-service teachers develop scientific conceptions on basic electronics, balancing of chemical equations and infectious and non-infectious diseases with ease. Therefore, it is suggested that future studies include treatments to improve pre-service teachers' conceptual understanding of fundamental electronics, chemical equation balance, and contagious and non-infectious diseases.

2. The study examined pre-service teachers conceptual understanding of basic electronics, balancing chemical equations and infectious and non-infectious diseases. The research did not, however, look into the conceptual knowledge of the teachers of integrated science at the colleges of education. Therefore, it is suggested that future studies consider investigating the conceptual knowledge of teachers who teach integrated science at colleges of education.
3. Also, the study examined the relationship between pre-service teachers' interests and academic performance. However, the study did not examine the relationship between other variables, such as pre-service teachers' perception and self-efficacy belief and their academic performance.

REFERENCES

Abdi, S., & Rahmania, D. (2023). The effect of learning interest and self-efficacy on junior high school students' learning achievement. *ProGCouns: Journal of Professionals in Guidance and Counseling*, *4*(1), 20-28.

Abell, S.K., & Smith, D.C. (1994). What is science?: Preservice elementary teachers' conceptions of the nature of science. *International Journal of Science Education*, *16*(4), 475-487.

Adeyemo, S.A. (2010). Background and classroom correlate of students in physics. *International Journal of Educational Research and Technology*, *1*(1), 25-34.

Adjibolosoo, S. V., Annan, S. T., Adarkwah, F., Frimpong, B., Ampofo, J. A., & Santaigo, P. K. (2018). Assessment of bacteriological quality of sources of drinking water in some selected communities in the Akuapem South District of the Eastern Region, Ghana. *Appl Ecol Environ Sci*, *6*(4), 153-159.

Adu-Gyamfi, K. (2013). Lack of interest in school science among non-science students at the senior high school level. *Problems of Education in the 21st Century*, *53*(1), 7-21.

Adu-Gyamfi, K. (2014). Challenges face by science teachers in the teaching of integrated science in Ghanaian Junior High schools. *Journal of Science and Mathematics Education*, *6*(2), 59-80.

Adu-Gyamfi, K., & Ampiah, J.A (2016). The junior high school integrated science: The actual teaching process in the perspective of an ethnographer. *European Journal of Science and Mathematics Education*, *4* (2), 268-282.

Ahtee M., & Varjola, I. (1998). Students' understanding of chemical reaction, *International Journal of Science Education*, *20*(3), 305-316, DOI: 10.1080/0950069980200304

Aina, K. J. (2013). Instructional materials and improvisation in physics class: Implications for teaching and learning. *Journal of Research & Method in Education*, *2*(5), 38-42.

Ainley, M. (2012). Students' interest and engagement in classroom activities. *In Handbook of Research on Student Engagement* (pp. 283-302). Springer, Boston, MA.

Aiyelabegan, T, A (2003). Effect of physics practical on students' academic performance in senior school certificate examination in Kwara state. *Lafiagi Journal of Science Education*. *1*(1), 1-6.

Akanbi, A.O. (2003). An investigation into students' performance in senior secondary school physics. *Journal of Teacher education trends 1*, (1), 58-64.

Amadi, J.N. (2021). Analyses of students' interest and mathematical ability as correlates of chemistry students' academic achievement in secondary schools in Rivers State. *Rivers State University Journal of Education*, *24* (2), 113-119.

Anamuah-Mensah, J., & Apafo, N.T. (1986). Students perceived difficulties with ordinary level chemistry topics. *Chemistry and Industry Proceedings*, *1*(1), 38-39.

Anderson, L. W., Krathwohl, D. R., & Bloom, B. S. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Boston: Allyn & Bacon.

Anim-Eduful, B., & Adu-Gyamfi, K. (2022b). Chemistry students' conceptual understanding of organic qualitative analysis. *Pedagogical Research, 7*(4), 1-13. https://doi.org/10.29333/pr/12307

Anim-Eduful, B., &Adu-Gyamfi, K. (2021). Functional groups detection: Do chemistry teachers demonstrate conceptual difficulties in teaching? *Global Journal of Human Social Science-G Linguistics & Education, 21*(7), 47-60. https://doi.org/10.34257/GJHSSGVOL21IS7PG470

Anim-Eduful, B., &Adu-Gyamfi, K. (2022a). Factors influencing high school chemistry teachers' and students' teaching and learning of organic qualitative analysis: A qualitative study. *European Journal of Education Studies*, *9*(7), 194-219.

Ansah, F. O., Amoah, C. A., & Baah, K. A.(2018). Assessing pre-service teachers conceptual understanding on "Amount of substance and the Mole" in Ghana. *International Journal of science and research*, *7*(4), 2319-7064.

Antwi, V. (2013). *Interactive teaching of mechanics in a Ghanaian university context*. Faculteit Bètawetenschappen FIsme, Utrecht University.

Appleton, K. (2006). Science pedagogical content knowledge and elementary school teachers. In K. Appleton (Ed.), Elementary science teacher education: *International Perspectives on Contemporary Issues and Practice* (pp. 31–54). Mahwah, NJ: Erlbaum.

Arends, R. (2012). *Learning to teach* (6th ed.). McGraw-Hill. https://doi.org/10.1088/1751-8113/44/8/085201

Arokoyu, A. A. (2012). Elements of contemporary integrated science curriculum: Impacts on science education. *Global Journal of Educational Research*, *11*(1), 49-55.

Asoko, H. (2002). Developing conceptual understanding in primary science. *Cambridge Journal of Education*, *32*(2), 153-164.

Atsumbe, B., Owodunni, S., Raymond, E., & Uduafemhe, M. (2018). Students' achievement in basic electronics: Effects of scaffolding and collaborative instructional approaches. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(8), em1563. https://doi.org/10.29333/ejmste/91898.

Azure, J. A. (2015). Senior High School students' views on the teaching of Integrated Science in Ghana. *Journal of Science Education and Research*, *1*(2), 49-61.

Baah R. & Anthony-krueger; C. (2012). An investigation into senior high school student's understanding and difficulties in writing chemical formulae of inorganic compounds. *International Journal of Research Studies in Educational Technology*, *1*(2), 31-39.

Baah, R. & Ampiah, J.G. (2012). Senior high school students' understanding and difficulties in writing chemical equations. *International Journal of Scientific Research in Education*,*5*(3), 162-170.

Baqui, A. H., Black, R. E., Sack, R. B., Chowdhury, H. R., Yunus, M., & Siddique, A. K. (1993). Malnutrition, cell-mediated immune deficiency, and diarrhea: A community-based longitudinal study in rural Bangladeshi children. *American journal of epidemiology*, *137*(3), 355-365.

Barke, H., Hazari, A. & Yitbarek, S. (2009). Misconceptions in chemistry: Addressing perceptions in chemical education. 10.1007/978-3-540-70989-3.

Bell, R. L., Blair, L. M., Crawford, B. A., & Lederman, N. G. (2003). Just do it? Impact of a science apprenticeship program on high school students' understandings of the nature of science and scientific inquiry. *Journal of Research in Science Teaching*, *40*(5), 487–509. https://doi.org/10.1002/tea.10086

Bello, O. (1988). An analysis of students' error in stoichiometric problems. *Nigerian Education Forum 1*(2), 181-186.

Brown, G. 9. (2007). The average impulse response of a rough surface and its applications. *IEEE transactions on antennas and propagation*, *25*(1), 67-74.

Brown, G. L. (1977). The average impulse response of a rough surface and its applications. *IEEE transactions on antennas and propagation*, *25*(1), 67-74.

Bucat, R. (2004). Pedagogical content knowledge as a way forward: Applied research in chemistry education. *Chemistry Education: Research and Practice*, *5*(3), 215 -228.

Bybee, R. W. (2010). The teaching of science: 21st century perspectives. NSTA press.

Çalýk, M., Ayas, A., & Ebenezer, J. V. (2005). A review of solution chemistry studies: Insights into students' conceptions. *Journal of Science Education and Technology*, *14*, 29-50.

Carey, S. (1985). Conceptual change in childhood. (1st edition). Cambridge. Mass. MIT Press.

Carey, S. (2000). Science Education as Conceptual Change. *Journal of Applied Developmental Psychology*, *21*(1), 13–19. https://doi.org/ https://doi.org/10.1016/S0193-3973(99)00046-5

Chandrasegaran, A. L., Treagust, D. F., & Mocerino, M. (2007). Enhancing students' use of multiple levels of representation to describe and explain chemical reactions. *School Science Review*, *88*(325), 115.

Cresswell, J.W., & Piano-Clarke, V.L. (2011). Designing and conducting mixed methods research (2nd ed.). Thousand Oaks: Sage

Curriculum Research Development Division (CRDD) (2012). Teaching syllabus for science (junior high school). Ghana, Accra: Ministry of Education.

Dahsah, C., & Coll, R. K. (2008). Thai grade 10 and 11 students' understanding of stoichiometry and related concepts. *International Journal of Science and Mathematics Education*, *6*(3), 573-600.

Dass, P., & Yager, R. (2009). Professional development of science teachers: History of reform and contributions of the STS-Based Iowa Chautauqua program. *Science Education Review*.

Demircioğlu, G. (2009). Comparison of the effect of conceptual change texts implemented after and before instruction on secondary school students' understanding of acid-base concepts. *Asia-Pacific Forum on Science Learning and Teaching*, *10*, Article ID: 5.

Dhindsa, H. S., & Treagust, D. F. (2009). Conceptual understanding of Bruneian tertiary students: Chemical bonding and structure. *Brunei International Journal of Science & Mathematics Education*, *1*(1), 33-51.

DiSessa, A. A. (2002). Why conceptual ecology is a good idea. In M. Limon & L. Mason (Eds.). Reconsidering conceptual change: Issues in theory and practice (pp. 29-60). Dordrecht: Kluwer.

Dula, D. E. (2018). Improving the problems of writing chemical symbols, formulae and chemical equations an action research. *Annals of Reviews and Research.* 2018; *4*(3), 51-59.

Etobro, A.B., & Banjoko, S.O. (2017). Misconception of Genetics Concept Among Pre-Service Teachers.*16*(3), 121-128. https://doi.org/http://dx.doi.org/10.4314/gjedr.v1612.6.

Ghana Statistical Service (2020). Population by region 2019:Eastern, Retrived from https://www.statsghana.gov.gh

Glaze, A. L. (2021). Acceptance, confidence, and time: Exploring dynamics of middle and secondary science teacher autonomy in teaching evolution in the Southeastern United States. *Eurasian Journal of Science and*

Environmental Education, *10*(2), 63-75. https://doi.org/10.30935/ejsee /11872

Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2015). A review and comparison of diagnostic instruments to identify students' misconceptions in science. *Eurasia Journal of Mathematics, Science & Technology Education, 11* (5) 989-1008.

Halim, L., & Yong, T., & Meeran, S. (2014). Overcoming Students' misconceptions on forces in equilibrium: An action research study. *Creative Education*. 5, 1032-1042. 10.4236/ce.2014.511117.

Hanson, R. (2016). Ghanaian teacher trainees' conceptual understanding of stoichiometry. *Journal of Education and e-Learning Research.* 3, 1-8. 10.20448/journal.509/2016.3.1/509.1.1.8.

Hanson, R. (2017). Enhancing students' performance in organic chemistry through context-based learning and micro activities–A case study. *European Journal of Research and Reflection in Educational Sciences*, *5*(6), 7-20.

Harackiewicz, J. M., Durik, A. M., Barron, K. E., Linnenbrink-Garcia, L., & Tauer, J. M. (2008). The role of achievement goals in the development of interest: Reciprocal relations between achievement goals, interest, and performance. *Journal of Educational Psychology*, *100*(1), 105–122. https://doi.org/10.1037/0022-0663.100.1.105

Häussler, P., & Hoffmann, L. (2000). A curricular frame for physics education: Development, comparison with students' interests, and impact on students' achievement and self-concept. *Science education*, *84*(6), 689-705.

Herr, N. (2021). Elements of critical thinking. *The Sourcebook for Teaching Science*. John Wiley Publishers.

Hewson, P. W. (1981). A conceptual change approach to learning science. *European Journal of Science Education, 3*(4), 383-396.

Hewson, P. W., Zeichner, K. M., Tabachnick, B. R., Blomker, K. B., & Toolin, R. (1992). A conceptual change approach to science teacher education at the University of Wisconsin-Madison. Paper presented at the Annual Meeting of the American Education Research Association, San Francisco, CA

Hines, C. (1990). Students' understanding of chemical equations in secondary schools in Botswana. *School Science Review, 72*(285), 138-140.

Hussain, N. H., Latiff, L. A., & Yahaya, N. (2012). Alternative conception about open and short circuit concepts. *Procedia - Social and Behavioral Sciences, 56*, 466- 473.

Jaoude, S. B., & Barakat, H. (2000). Secondary school students' difficulties with stoichiometry. *School science review*, *81*(296), 91-98.

Johnstone H, Morrison T. I., Sharp, D. W. A. (1976). Topic difficulties in chemistry. *Education in Chemistry ,20*(1), 212-218.

Johnstone, A. (2000). Teaching of chemistry-logical or psychological. Chemistry Education: *Research and Practice in Europe*, *1*(1), 9-15.

Kariper, I. A. (2011). An Investigation into the misconceptions, erroneous ideas and limited conception of the pH concept in pre-service science teacher education. *The Chemical Education Journal*, *14*(1), 105-122.

Kitchenham, A. (2008). The evolution of John Mezirow's transformative learning theory. *Journal of Transformative Education*. *6* (2), 104–123. doi:10.1177/1541344608322678.

Kocijancic, S. (2018). Contemporary challenges in teaching electronics to stem teachers. In *AIP Conference Proceedings*, 2043(1). AIP Publishing.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*,*30*(3), 607-610.

Kuczmann, I., & Budapest, N.F.G, (2017). The Structure of knowledge and students' misconceptions in physics. *AIP Conference Proceedings* 1916, 050001.

Lazonby, J.N., Morris, J.E., & Waddington, D.J. (1982). The muddle some mole. *Education in Chemistry*, 19, 109-111.

Leischow, S. J., Best, A., Trochim, W. M., Clark, P. I., Gallagher, R. S., Marcus, S. E., & Matthews, E. (2008). Systems thinking to improve the public's health. *American Journal of Preventive Medicine*, *35*(2), 196-203.

Li, J., & Singh, C. (2017). Investigating and improving introductory physics students' understanding of the electric field and the superposition principle. *European Journal of Physics*, *38*(5), 1-28

Lin, J. W., Yen, M. H., Liang, J. C., Chiu, M. H., & Guo, C. J. (2016). Examining the factors that Influence student's science learning processes and their learning outcomes: 30 Years of conceptual change years. *Eurasia Journal of Mathematics, Science, & Technology Education*, *12* (9), 2617-2646.

Lo, C. K. (2023). How can flipped learning continue in a fully online environment? Lessons learned during the COVID-19 pandemic. *Primus*, *33*(2), 175-185.

Mayer, R.E. (2002). Cognitive theory and the design of multimedia instruction: An example of the two-way street between cognition and instruction. New Directions For Teaching and Learning.

Mazur, E. (1997). Peer instruction: a user's manual. Upper Saddle River: Prentice Hall.

McColgan, M. W., Finn, R. A., Broder, D. L., & Hassel, G. E. (2017). Assessing students' Conceptual knowledge of electricity and magnetism. *Physical Review Physics Education Research*, *13*(2), 020121-1-020121-19.

McDermott, L., & Shaffer, P. (1992). Research as a guide for curriculum development: An example from introductory electricity. Part I: Investigation of student understanding. *American Journal of Physics*, *60*, 994-1003.

Meijer, M. R. (2011). Macro-meso-micro thinking with structure- property relations for chemistry education. An explorative design- based study. Ph.D. Thesis, Utrecht: Utrecht University.

Mensah, F., & Somuah, A. B. (2013). The teaching of Science: Challenges and Prescription. *Journal of Education and Practice*, *4*(22) 24-35.

Metioui, A., & Trudel, L. (2012). Acquiring knowledge in learning concepts from electrical circuits: The Use of multiple representations in technology-based learning environments. *Systemics, Cybernetics and Informatics*, *10*(2), 24-35.

Ministry of Education (2010). Teaching syllabus for integrated science (senior high school). Curriculum Research and Development Division (CRDD), Ghana Education Service (GES).

Morgan, M. A., & Aboagye, G. K. (2022). Teachers Classroom Management Practices: Predictors of Students Interest in Physics. *International Journal of Research and Innovation in Social Science*, *6*(9), 643-655.

NRC. (1997). Misconceptions as barriers to understanding science. In C.o. Education, *Science teaching reconsidered: A handbook*. Washington, D.C: National Academy Press.

Nti, D., Appiah-Twumasi, E., Ameyaw, F., Agyemang, C., Asare, A. H. Y., & Issah, B. (2023). Analyzing Gender Differences in Misconception in Linear Momentum Using Two-tier Diagnostic Test Instrument. *JournalofEducationandPractice*. *14*(1), 175-185.

Ofori-Appiah, C., Safo-Adu, G., Quansah, R. E., & Ngman-Wara, E.(2018) Competency level of senior high school biology teachers' and their attitudes toward organising practical work in eastern region of Ghana. *International Research Journal of curriculum and Pedagogy*.*6*(1), 112 -124.

Oladejo, M. A, Olosunde, G. R, Ojebisi, A. O., & Isola, O. M. (2011). Instructional materials and students' academic achievement in physics: some policy implications. *European Journal of Humanities and Social Sciences*, *2*(1), 226-239.

Omosewo, E. O. (2009). Views of physics teachers on the need to train and retrain physics teachers in Nigeria. *African Research Review*, *3*(1). 10.4314/afrrev.v3i1.43577.

Onwu, G. O. M., & Randal, E. (2006). Some aspects of students' understanding of representational model of the particulate nature of matter in chemistry in three different countries. *Chemistry Education Research and Practice*, *7*, 226-239. doi:10.1039/b6rp90012g

Ormrod, J. E. (1999). Human learning. New Jersey: Merrill-Prentice Hall.

Osei-Himah, V., Amoah, C. A., & Parker, J.(2018). Effects of Using Practical Activities in Teaching Electronics Concept to Pre-service Teachers. *International Journal of Science Research and Management*, *6*(6), 423-427.

Otarigho, M. D., & Djabo, D. D. (2013). Problems and prospects of teaching Integrated Science in secondary schools in Warri, Delta State, Nigeria. *Techno Learn: An International Journal of Educational Technology*, *3*(1), 19-26.

Ozdemir, G., & Clarke, D. B. (2007). An Overview of Conceptual Change Theories. www.ejmste.com/v3n4/EJMSTE-v3n4-ozd.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of scientific conception: Toward a theory of conceptual change. *Science Education, 66*(2), 211-227. http://dx.doi.org/10.1002/sce.3730660207

Quaittoo, W. A. (1996). The ultimate Chemistry for West African Senior Secondary Schools (kov's series). Pixelimage Ltd.

Roschelle, J. (1995). Learning by collaborating: Convergent conceptual change. *The Journal of the Learning Sciences*, 2(3), 235—276.

Sakpaku, D. (2016). *Exploring the perception of junior high school teachers and students on topics in the integrated science syllabus* (Unpublished Doctoral dissertation, University of Cape Coast).

Salame, I.I., Sarowar, S., Begum, S. & Krauss, D. (2011). Students' alternative conceptions about atomic properties and the periodic table. *Chem. Educator, 16,* 190–194

Sanger, M. J. (2005). Evaluating students' conceptual understanding of balanced equations and stoichiometric ratios using a particulate drawing. *Journal of Chemical Education, 82*(1), 131-134.

Santosh, D. (2021). Electronics definition: Definition of electronics and difference between electronics and electrical. Available on https://www.electronicsandyou.com/electronics-definition.html

Santyasa, W., Warpala, W. S., & Tegeh, M. (2018). The effect of conceptual change model in the senior high school students' understanding and character in learning physics. *SHS Web of Conferences, 42,* 00058 DOI:https://doi.org/10.1051/shsconf/20184200058.

Savoy, L.G. (1988). Balancing chemical equations. *School Science Review, 69*(249), 713-720.

Scace, R. I. (2023). Electronics. Encyclopedia Britannica. Available on https://www.britannica.com/technology/electronics

Schiefele, U. (1991). Interest, learning, and motivation. *Educational psychologist*, *26*(3-4), 299-323.

Schmidt, H., & Jigneus, C. (2003). Students´ strategies in solving algorithmic stoichiometry problems. *Chemistry. Education. Research and Practice, 4*(3):305-317. DOI: 4. 305-317. 10.1039/B3RP90018E.

Sel, B., & Sözer, M. A. (2019). The Effect of Conceptual Change Texts on the Level of Conceptual Understanding of Students. *International Electronic Journal of Elementary Education*, *11*(4), 383-391.

Sirhan, G. (2007). Learning difficulties in chemistry: an overview. *J. Turkish Sci. Educ.*, *4*(2), 2–20.

Stein, M., Larrabee T. G., & Barman, C. R. (2008). A Study of common beliefs and misconceptions in physical science. *Journal of Elementary Science Education*, *20* (2), 1-11.

Steinberg, J., Andrews-Todd, J., Forsyth, C., Chamberlain, J., Horwitz, P., Al Koon, Rupp, A., & McCulla, L. (2020). The development of a content assessment of basic electronics knowledge. Educational Testing Service, Princeton, NJ

Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2013). *Using multivariate statistics* (Vol. 6, pp. 497-516). Boston, MA: pearson.

Taber, K. S. (2011). Models, molecules and misconceptions: A commentary on “Secondary school students’ misconceptions of covalent bonding”. *Journal of Turkish Science Education, 8*, 3-18

Talabi, J.K. & R. Hanson, (2004). A comparative evaluation of the science resource centres of Ghana and Nigeria. *Ghana Journal of Education and Teaching, 1*(3): 59-63.

Tam, M. (2000). Constructivism, instructional design, and technology: Implications for transforming distance learning. *Journal of Educational Technology & Society, 3*(2), 50-60.

Treagust, D.F., Chandrasesaran, A.L., Zain, A.N.M., Ong, E.T., Karpudewan, M. & Halim, L. (2011). Evaluation of an intervention instructional program to facilitate understanding of basic particle concepts among students enrolled in several levels of study. *Chemistry Education: Research & Practice, 12*, 251–261.

Trundle, K., Atwood, R., & Christopher, J. (2007). Fourth-grade elementary students' conceptions of standards-based lunar concepts. *International Journal of Science Education, 29*(5). 595-616. 10.1080/ 095006906 00779932.

Turgut, Ü., Gürbüz, F., & Turgut, G. (2011). An investigation 10th-grade students’ misconceptions about electric current. *Procedia Social and Behavioral Sciences, 15*, 1965–1971.

Twissell, A. (2018). Modelling and simulating electronics knowledge: Conceptual understanding and learning through active agency. *Educational Technology & Society, 21* (2), 111–123.

Üce, M., & Ceyhan, I. (2019). Misconception in chemistry education and practices to eliminate hem: Literature Analysis. *Journal of Education and Training Studies*, *7* (3).

Von Korff, J., Archibeque, B., Gomez, K. A., Heckendorf, T., McKagan, S. B., C. Sayre, E. & Sorell, L. (2016). Secondary analysis of teaching methods in introductory physics: A 50 k-student study. *American Journal of Physics*, *84*(12), 969-974.

Vosniadou, S. (2014). Examining cognitive development from a conceptual change point of view: The framework theory approach. *European Journal of Developmental Psychology*. *11*, 645-661.

WAEC. (2013). *West Africa senior secondary certificate examination (school candidates*). *Chief examiners' report science, May/June.*

WAEC. (2014). *West Africa senior secondary certificate examination (school candidates). Chief examiners' report science, May/June.*

WAEC. (2015). *West Africa senior secondary certificate examination (school candidates). Chief examiners' report science, May/June.*

WAEC. (2016). *West Africa senior secondary certificate examination (school candidates). Chief examiners' report science, May/June.*

WAEC. (2017). *West Africa senior secondary certificate examination (school candidates). Chief examiners' report science, May/June.*

WAEC. (2018). *West Africa senior secondary certificate examination (school candidates). Chief examiners' report science, May/June.*

WAEC. (2019). *West Africa senior secondary certificate examination (school candidates). Chief examiners' report science, May/June.*

Wanbugu, P. W, Changeiywo, J. M. and Ndirit. F. G (2013). Investigations of experimental cooperative Concept mapping instructional approach on secondary school girls' achievement in physics in Nyeri county, Kenya. Journal of Education and Practice, 4(6), 120-130.

Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1994). Research on alternative conceptions in science. In D. L. Gabel (Ed.), Handbook of research on science teaching and learning (pp. 177-210). New York: Simon & Schuster and Prentice Hall International.

Wang, T. L., & Berlin, D. (2010). Construction and validation of an instrument to measure Taiwanese elementary students' attitudes toward their science class. *International Journal of Science Education*, *32*(18), 2413-2428.

West African Examination Council. (2018). *Chief Examiners Report on Secondary School Certificate Examination*. WAEC Press.

Western Governors University (2020). What is the transformative learning theory? Retrieved from https://www.wgu.edu/blog/what-transformative-learning-theory2007.html#close

World Health Organization. Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19) 16-24 February 2020 [Internet]. Geneva: World Health Organization; 2020.

APPENDICES

APPENDIX A

PRE-SERVICE TEACHERS' CONCEPTUAL UNDERSTANDING AND INTEREST IN BASIC ELECTRONICS, BALANCING OF CHEMICAL EQUATIONT, INFECTIOUS AND NON-INFECTIOUS DISEASES IN INTEGRATED SCIENCE

Questionnaire for Pre-Service Teachers

Dear respondents

Thank you for your interest in this questionnaire. This questionnaire is intended to investigate pre-service teacher's conceptual understanding and interest in some selected topics in Integrated Science. The study seeks to gain insight into the following topics; Basic Electronics, Balancing Chemical Equation, Infectious and Non-infectious Diseases. The questionnaire should take approximately 45 minutes to complete. The study will enable pre-service teachers and tutors to come out with issues and suggestions concerning these challenging concepts in the Colleges of Education Science Curriculum. Results will be shared with practitioners and researchers across the world to improve teaching and learning. Responses provided will be confidential. The information you provide will be de-identified for any publication or dissemination. To participate in the questionnaire, kindly answer the questions at the end of this page. By indicating "Yes" and participating in the questionnaire, you are giving your consent for your responses to be used in this study. Should you require more information about the questionnaire, please send a mail to any of these emails: kofibaahyanney@gmail.com | aduaboagye@ucc.edu.gh

Kindly fill the space provided by ticking (√) the box following the options

I am ready to proceed Yes [ ] No [ ]

Part I: Demographic Characteristics of Pre-Service Teachers: This *section seeks personal information about you.*.

1. Sex: Male [ ] Female [ ]
2. Age:16-20 [ ] 21-25 [ ] 26-30 [ ] 31 and above [ ]
3. Educational Level: 100 [ ] 200 [ ] 300 [ ]
4. Region of your college…………………………………………
5. Program Offering in the College……………………………..……
6. Highest academic qualification at start of training:

GCE "O" Level [ ]

GCE "A" Level [ ]

SSSCE/WASSCE [ ]

DBE [ ]

Part II: Conceptual understanding in Basic Electronics.

7. The most common material which also serves as the main ingredient of sand is refer to as………………………………………………………………

A. Graphite
B. Germanium
C. Glass
D. Silicon

Give reason for your response?

……………………………………………………………………………………
……………………………………………………………………………………
…………………………………………

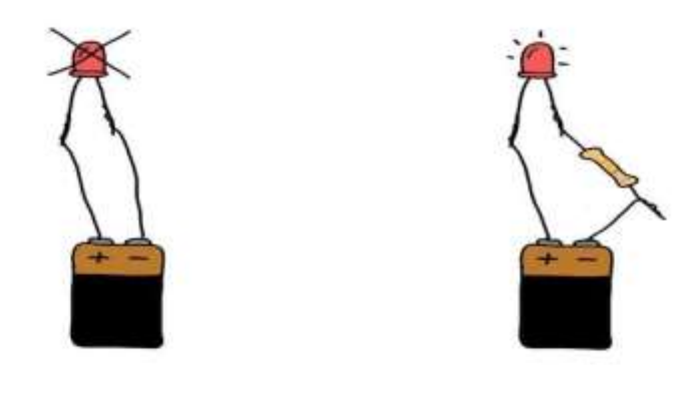

Figure 1a Figure 1b

8. In figure, **1a** the LED does not lights up but in figure **1b** the LED lights up. What is the cause of the observation in figure **1b**?
    A. Presence of Resistor
    B. Presence of Switch
    C. Presence of Wire
    D. Presence of Bulb

    Give reason for your response?

    ………………………………………………………………………………

    ………………………………………………………………………………

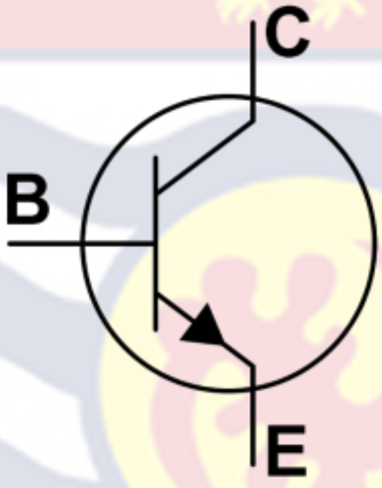

Fig. 2a

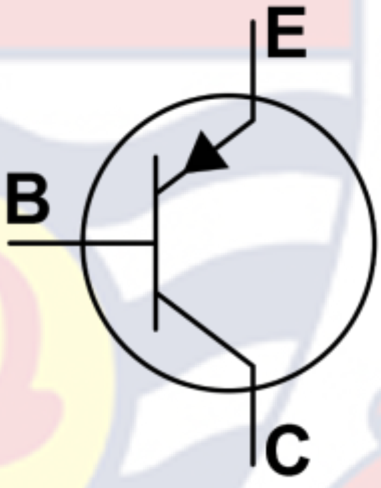
Fig. 2b

The Figure below is made up of two types of Transistors.

9. Identify the type of transistor in **Fig.2a** and **2b**.
    A. PNP only
    B. NPN only
    C. PNP and NPN
    D. None of the above

    Give reason for the response?

    ………………………………………………………………………

    ………………………………………………………………………

10. Why would you prefer LED bulbs to other bulbs in the market?
    A. It consumes energy
    B. It is energy efficient
    C. New technology
    D. Rechargeable

Give reason for the response?

……………………………………………………………………………

……………………………………………………………………………

11. If a P-N Junction, diode is not connected to any circuit…………………………..
    A. The potential is the same everywhere.
    B. The P-type has a higher potential than the N-types side.
    C. There is an electric field at the junction directed from the N-type side to the P-type side.
    D. There is an electric field at the junction directed from the P-type side to the N-type side.

    Give reason for your response?

    ……………………………………………………………………

    ……………………………………………………………………

12. What is the majority charge carrier in P-type semi-conductor?
    A. Holes.
    B. Electrons.
    C. Both equal.
    D. None of the above.

Give reason for response?

……………………………………………………………………………

……………………………………………………………………………

13. When the P end of P-N junction is connected to the negative terminal of the battery and the N end to the positive terminal of the battery the P-N junction behaves likes……………………………
    A. A conductor
    B. An insulator

C. A super-conductor
D. A semi-conductor

Give reason for the response?

…………………………………………………………………
…………………………………………………………………

14. One of the following electronic components can charge and discharge current.
    A. Light emitting diode.
    B. Transistor.
    C. Capacitor.
    D. Inductor.

Give reason for your response?

……………………………………………………………………………
……………………………………………………………………………

PART III: Conceptual understanding in Balancing Chemical Equations

15. Represent the word equation below into a chemical equation:

    Iron (II) react with Oxygen gas to produce Iron (II) oxide.

    A. $Fe_2 + O_2 \rightarrow FeO_2$
    B. $Fe^{2+} + O_2 \rightarrow Fe_2O_3$
    C. $Fe + O \rightarrow Fe3O$
    D. $2Fe + O_2 \rightarrow 2FeO$

    Give reason for your response?

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

16. All the following are unbalanced chemical equations **except**?
    A. $CH_4 + O_2 \rightarrow H_2O + CO_2$
    B. $H_2 + N_2 \rightarrow NH_3$
    C. $HCl + Mg \rightarrow MgCl_2 + H_2$
    D. $HCl + NaOH \rightarrow NaCl + H_2O$

Give reason for your response?

……………………………………………………………………………

……………………………………………………………………………

……………………………....................

17. Select a double displacement reaction among the following.

A. $C_8H_{18}(g) + 25/2O_2(g) \rightarrow 8\ CO_2(g) + 9H_2O(g)$

B. $BaCl_{2(S)} + Na_2SO_{4(aq)} \rightarrow BaSO_{4(aq)} + 2NaCl$

C. $2HCl(aq) + Mg(s) \rightarrow MgCl_2(aq) + H_2(g)$

D. $2N_2O_5\ (g) \rightarrow 2N_{2(g)} + 5O_2(g)$

Give reason for your response?

……………………………………………………………………

……………………………………………………………………

…………………………………………

18. What are the possible products that will be formed if Ca $(OH)_2$ reacts with

NH4Cl→………………………………….?

A. $CaCl_2 + H_2O$

B. $H_2O + NH_3$

C. $CaCl_2 + NH_3$

D. $CaCl_2 + NH_3 + H_2O$

Give reason for your response?

……………………………………………………………………………

……………………………………………………………………………

…………………………

19. The gas produced when hydrochloric acid reacts with zinc metal is…………………………………………………………………………

……?

A. Hydrogen gas.

B. Carbon dioxide gas.

C. Nitrogen oxide gas.

D. Ammonia gas.

Give reason for your response?

…………………………………………………………………………

…………………………………………………………………………

Answer questions 20 -22 using the chemical equation shown below:

$Al\ (NO_3)_3 + 3NaOH \rightarrow Al\ (OH)_3 + 3NaNO_3$

20. What are the reactants in the above chemical equation?
    A. $Al\ (NO_3)_3 + 3NaOH$
    B. $Al\ (OH)_3 + 3NaNO_3$
    C. $Al\ (NO_3)_3$
    D. 3NaOH

    Give reason for your response?

    …………………………………………………………………

    …………………………………………………………………

21. What are the products in the above reaction?
    A. $Al\ (NO_3)_3 + 3NaOH$
    B. $Al\ (OH)_3 + 3NaNO_3$
    C. $Al\ (NO_3)_3$
    D. 3NaOH

    Give reason for your response?

    ……………………………………………………………………

    ……………………………………………………………………

    Select a **balanced chemical equations** for each of the following descriptions of a chemical reaction, include the phases of the reactants and products.

22. Aluminium metal ***reacts with*** copper (II) chloride ***to produce*** aluminium chloride and copper metal.
    A. $Al + Cu^{2+}Cl \rightarrow Al\ Cl_3 + Cu$
    B. $Al\ (NO_3)_3 + 3NaOH \rightarrow Al\ (OH)_3 + 3NaNO_3$
    C. $2Al + 3CuCl_2 \rightarrow 2Al\ Cl_3 + 3Cu$
    D. $3Al + 3CuCl2 \rightarrow Al\ Cl_3 + 3Cu$

    Give reason for your response?

    …………………………………………………………………

    …………………………………………………………………

PART IV: Conceptual understanding in infectious and non-infectious Diseases.

23. One of the following is not a mode of transmission of Infectious diseases.
    A. Air.
    B. Water.
    C. Food.
    D. Lifestyle.

    Give reason for your response?

……………………………………………………………………………
……………………………………………………………………………

24. Diseases are mainly classified into two namely
    A. Infectious and communicable disease.
    B. Non-infectious and Non-communicable.
    C. Pathogenic and Non-pathogenic diseases.
    D. Genetic and environmental diseases.

Give reason for your response?

……………………………………………………………………
……………………………………………………………………

25. Which of the following diseases does not match with the right deficiency nutrient?
    I. Night blindness----------------------Lack of vitamin A.
    II. Beriberi ------------------------Deficiency of Vitamin D.
    III. Goiter ---------------------------Deficiency of iodine.
    IV. Kwashiorkor----------------------Deficiency of Protein.
    A. I only
    B. II only
    C. III only
    D. IV only

Give reason for your response?

……………………………………………………………………

……………………………………………………………………

26. These are list of non-pathogenic diseases, select the **ODD** one?

I. Beriberi, Scurvy

II.Cholera, Chickenpox

III.Cancer, Leukaemia

IV.Hypertension, Arteriosclerosis

A.I only

B.I and II only

C.II only

D.III and IV only

Give reason for your response?

……………………………………………………………………

……………………………………………………………………

27. Which one of the following is a symptom of Malaria after eight days of infections?

A. Prolonged cough with blood-tinged sputum.
B. Chest pain, severe abdominal sensation.
C. Fever, shaking chills, severe headache.
D. Weight loss, fatigue, finger clubbing.

Give reason for your response?

……………………………………………………………………

……………………………………………………………………

28. Which of the following is not caused by non-infectious diseases?

A. Malnutrition.
B. Genetic.
C. Virus.
D. Environment.

Give reason for your response?

…………………………………………………………………………

…………………………………………………………………………

29. Why should you consider malaria as an infectious disease?

    A. The presence of Plasmodium Spp.
    B. The presence Human blood
    C. The presence of litter
    D. The presence of Virus

Give reason for your response?

…………………………………………………………………………

…………………………………………………………………………

30. Which of the following is not a Control measure for the typhoid diseases.

    A. Safe disposal of sewage.
    B. Regular vaccination.
    C. Pasteurization of milk.
    D. Sleeping under treated nets.

Give reason for your response?

…………………………………………………………………………

…………………………………………………………………………

……………………………………

APPENDIX B

This part of the questionnaire seeks to find out the level of interest pre-service teachers have in Basic Electronics, Balancing Chemical Equation, Infectious and Non-infectious Diseases.

It comprises of a five likert scale questionnaire. Tick (√) Not Interested (NI), Slightly Interested (SI), Moderately Interested (MI), Very Interested (VI) and Highly Interested (HI)

S/N	Items	NI	MI	VI
1	Knowledge in Basic Electronics help us to understand the relevance of electronic appliances at home.			
2	Understanding Basic Electronics enable us recognize their uses at our homes.			
3	Knowledge of Basic Electronics makes us know the various functions of the components of electronic devices.			
4	Basic Electronics concepts are complex, abstract and difficult to learn.			
5	Balancing chemical equation of reaction is a concept one can understand through applying variety of methods.			
6	Understanding Balancing Chemical equations arouse my interest in learning chemistry.			
7	Good knowledge in Balancing Chemical Equations motivates me to learn more of Chemical compounds.			
8	Understanding causes and effects of diseases help me live a very healthy lifestyles.			
9	My knowledge and interest in learning diseases help me practice good hygiene.			
10	Good knowledge in diseases help me prevent the spread of infectious and non-infectious diseases within my locality.			
11	I am interested to know that personal hygiene reduces infectious diseases			
12	I am interested to know that protozoa, bacteria, fungi, virus and yeast causes infectious diseases			
13	It is interesting to know that health does not mean absence of diseases only			
14	It is interesting to know that antibacterial products do not affect disease caused by a virus			
15	It is interesting to know that deficiency diseases are caused by a lack of nutrients in the body			
16	Interesting facts about disease make me read more about health and hygiene			

APPENDIX C

PRE-SERVICE TEACHERS' CONCEPTUAL UNDERSTANDING AND INTEREST IN BASIC ELECTRONICS, BALANCING OF CHEMICAL EQUATIONT, INFECTIOUS AND NON-INFECTIOUS DISEASES IN INTEGRATED SCIENCE.

MARKING SCHEME

Part II: Conceptual understanding in Basic Electronics.

7. The most common material which also serves as the main ingredient of sand is refer to as…………………………………………………………………

A. Graphite

A. Germanium

B. Glass

C. Silicon

Give reason for your response?

Silicon is a component of sand with chemical formula of sand as SiO_2.

Misconception: Because it gives semiconductor in transistor as it is used. (**39**)

Glass is a product from sand mix with other elements. (**56**).

The breakdown of particles (smaller) make up sand. (**33**)

Graphite are made out of carbon and since carbon are found deep down the earth, it is the main ingredient of sand. (216)

Because after Glass has been broken down it can grand up to be sand. (232)

Because silicon…… **(252)**

Glass is made from natural and abundant raw materials (sand, soda ash and limestone) **(250)**

Graphite is a type of rock and rocks weathers to form soil. (231)

Because is germanium is a bad conductor of electricity **(222)**

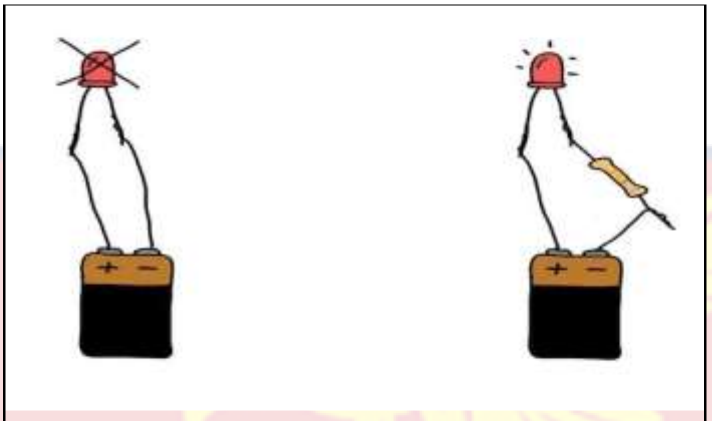

Figure 1a Figure 1b

8. In figure, **1a** the LED does not lights up but in figure **1b** the LED lights up. What is the cause of the observation in figure **1b**?
   A. Presence of Resistor
   B. Presence of Switch
   C. Presence of Wire
   D. Presence of Bulb

Give reason for your response?

The function of the resistor is to prevent excess current from flowing through the conductor and thus conserve energy.

Misconception: The LED will emit light when small current passes or flows through it.

The cell (battery) is working well. (**33**)

Figure 1a. has no switch Figure 1b has a switch. (**20**).

LED Bulds has high and power voltage (221)

Because it is connected to a capacitor, is the capacitor that helps the LED to lighting. **(250)**

For the fig. 1a LED together with the connected wire and battery cannot lights up but for the 1b is together with the transistor so it can light up. **(222)**

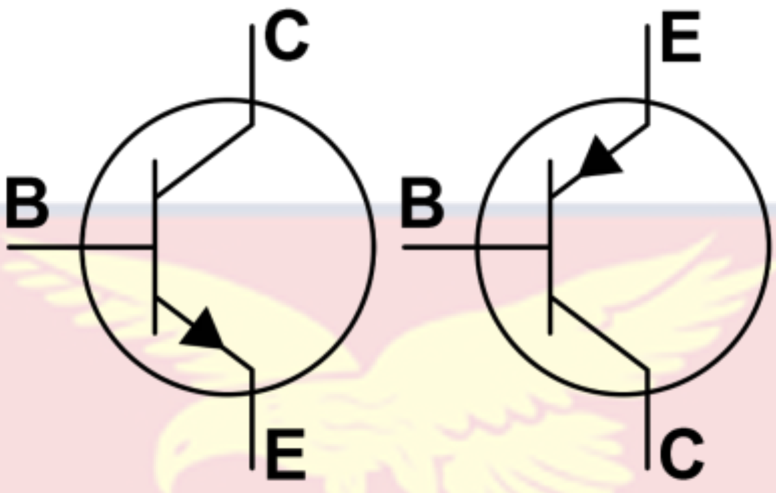

Fig. 2a Fig. 2b

The Figure below is made up of two types of Transistors.

9. Identify the type of transistor in **Fig.2a** and **2b**.
   A. PNP only
   B. NPN only
   C. PNP and NPN
   D. None of the above

Give reason for the response?

The diagram has emitter and collector arranged for current from collector flowing through the emitter for PNP and current from emitter to the collect in the case of NPN transistor.

Misconception: Fig 2A is an NPN and Fig. 2b is a PNP transistor.

Chemical energy is stored in the battery hence for that energy to be converted into light energy, it requires a medium which is the conducting wire needs not only to be connected but also be properly and carefully connected. **(61)**

LED bulds are good in current (**33**)

Negative goes with negative and positive goes with positive.(211)

9. Why would you prefer LED bulbs to other bulbs in the market?
   A. It consumes energy
   B. It is energy efficient
   C. New technology
   D. Rechargeable

Give reason for the response?

In Light Emitting Diode small current is able to power high load.

Misconception: Because the lighting is very high as compare to the others.

LED bulb are low conductors of current. (216)

LED Bulbs has high and powerful low voltage flow. **(240)**

Because it is the quality and also durable. **(253)**

10. If a P-N Junction, diode is not connected to any current…………….
    A. The potential is the same everywhere.
    B. The P-type has a higher potential than the N-types side.
    C. There is an electric field at the junction directed from the N-type side to the P-type side.
    D. There is an electric field at the junction directed from the P-type side to the N-type side.

Give reason for your response?

After joining p-type and n-type semiconductors, electrons from the n-region near the p-n interface tend to diffuse into the p-region. As electrons diffuse, they leave positively charged ions (donors) in the n-region. Likewise, holes from the p-type region near the p-n interface begin to diffuse into the n-type region, leaving fixed ions (acceptors) with negative charge.

Thus, an electric field is established at the junction directed from the n-type side to the p-type side.

Misconception: The p-type is the hole or proton which has a higher voltage.

Both can be directed by its side (**33**)

Because the P-type has a higher potential than the N-types (221)

An electric field is established at the junction directed from the n-type side to the p-type side. (235)

Because there is not diode in present with the connection. (240).

There is no any current flow through it, so is potential. **(253)**

If the P-N diode does not connect to any current, it affect its same potential. (230)

11. The conductivity of a semi-conductor……………………

A. Increases with an increase in temperature.

B. Decreases with an increase in temperature.

C. Is independent on temperature.

D. Increases up to certain temperature and remains constant

Give reason for your response?

When temperature is increased in case of a semiconductor the free electron get more energy to cross the energy gap to the conduction band from the valance band. So more electrons can go easily to the conduction band so resistance decreases with temperature.

Misconception: Because it control high current flow.

Semi-conductors have the tendency to conduct more electrons at this stage as the bend between their particles decreases creating more free ions. (39)

The changes of current can increase to a certain temperature and remains constant. (33)

Because it increase up to certain temperature and remains constant. (221)

Semi-conductor decrease the current flow of (216)

12. What is the majority charge carrier in P-type semi-conductor?

A. **Holes.**

B. Electrons.

C. Both equal.

D. None of the above.

Give reason for response?

In p-type semiconductor, large number of holes is present. Hence, holes are the majority charge carriers in the p-types semiconductor. The holes (majority charge carriers) carry most of the electric charge or electric current in the p-type semiconductor.

Misconception: P-type and semiconductors can both charge and discharge.

13. When the P end of P-N junction is connected to the negative terminal of the battery and the N end to the positive terminal of the battery the P-N junction behaves likes……………………………………………
    A. A conductor
    B. An insulator
    C. A super-conductor
    D. A semi-conductor

    Give reason for the response?

    In this condition **P − N junction** is reverse biased that's why **when the P end** of **P − N junction is connected to the negative terminal of battery and the N end to the positive** terminals **of the battery**, then the **P − N junction behaves** like an insulator. Current does not flow through the circuit.

    Misconception: To allow the partial flow of current in a circuit.

14. One of the following electronic components can charge and discharge current.
    A. Light emitting diode.
    B. Transistor.
    C. **Capacitor.**
    D. Inductor.

Give reason for your response?

The function of the capacitor is to store electric charge temporarily. It is measured in microfarads (uF).

Misconception: Because it can be used to amplify electronic signals, switching, etc.

The transistor is used for amplification and switching and as such, if the transistor is switching and as such, if the transistor is switched on electric charges flows through the circuit but when it is switched off, electric charges are unable to do so. (61).

Inductors can charge on current and discharge current. (20)

Because when you add it the negative and positive side of the transistor, it does not allow the light to light up. (223)

Transistor when connect to a source of energy light come and when disconnect it goes off. (216)

Answer(Transistor)

PART III: Conceptual understanding in Balancing Chemical Equations

15. Represent the word equation below into a chemical equation:

Iron metal react with Oxygen gas to produce Iron (II) oxide.

A. $Fe_2 + O_2 \rightarrow FeO_2$

B. $Fe^{2+} + O_2 \rightarrow Fe_2O_3$

C. $Fe + O \rightarrow Fe3O$

D. **$Fe + O_2 \rightarrow FeO$**

Give reason for your response?

In the formation of FeO, the reactant Fe^{2+}combining with one $O^{2-}$to produce the compound FeO.

Misconception: Because the chemical symbol of iron is Fe and Oxgyen is O. (223)

Because iron react with oxygen gas **(221)**

Because the law of chemical equation say when the is two attach both iron and oxygen in chemical equation the two ie. Multiplying both iron and oxide to give FeO_2. **(253).**

16. All the following are unbalanced chemical equations **except**?

A. $CH_4 + O_2 \rightarrow H_2O + CO_2$

B. $H_2 + N_2 \rightarrow NH_3$

C. $HCl + Mg \rightarrow MgCl_2 + H_2$

D. **$HCl + NaOH \rightarrow NaCl + H_2O$**

Give reason for your response?

In balancing chemical equation, the number of atoms at the reactant side must be equal to the number of atoms at the product side, there should be balance of positive and negative charges on the atoms.

Misconception: There are two atoms of hydrogen, one atom of sodium, chlorine and Oxygen at the reactant side and the same at the product side. Thus, an acid and a base produces salt and water only. **(39).**

Because is a balanced chemical equation **(221)**

Because any balance chemical equation have no any addition sign between. (44).

Because in chemical equation there is any additional sign between the equation been given. **(253)**

Sodium chloride and water **(231)**

The answer is A because it is the right chemical equation and how to arrange it the right chemical equation and how to arrange it. **(230)**

17. Select a double displacement reaction among the following.

A. $C_8H_{18}(g) + 25/2O_2(g) \rightarrow 8\ CO_2(g) + 9H_2O(g)$

B. $\mathbf{BaCl_{2(S)} + Na_2SO_{4(aq)} \rightarrow BaSO_{4(aq)} + 2NaCl}$

C. $2HCl\ (aq) + Mg(s) \rightarrow MgCl_2(aq) + H_2(g)$

D. $2N_2O_5\ (g) \rightarrow 2N_{2(g)} + 5O_2(g)$

Give reason for your response?

The reaction between sodium sulphate solution and barium chloride solution, Sodium sulphate chemically reacts with barium chloride in the form of their aqueous solution to form a white precipitate of barium sulphate.

Misconception: When a hydrochloric acid reacts with magnesium it produces magnesium chloride and hydrogen gas. (39)

Because it has a double displacement. (221).

Because there is no any chemical equation been arrange in that form. **(253)**

18. What are the possible products that will be formed if Ca $(OH)_2$ reacts with

NH4Cl→…………………………………?

A. $CaCl_2 + H_2O$

B. $H_2O + NH_3$

C. $CaCl_2 + NH_3$

D. $CaCl_2 + NH_3 + H_2O$

Give reason for your response?

It is the property of an alkali that when an alkali reacts with ammonium salts it produces ammonia gas, Calcium chloride (salt) and water.

Misconception: When Calcium hydroxide react with Ammonium Chloride it produces calcium chloride, ammonia gas and water only. (39)

Because the gas produced hydrochloric acid reacts. (221)

19. The gas produced when hydrochloric acid reacts with zinc metal is……………………………………………………………?

A. **Hydrogen gas**.

B. Carbon dioxide gas.

C. Nitrogen oxide gas.

D. Ammonia gas.

Give reason for your response?

"Zinc has the tendency to react with hydrochloric acid by its nature. Zinc is an **electropositive element.** It is easily oxidized by hydrogen. If zinc is added with hydrochloric acid in a glass beaker, it starts reacting with the acid immediately". Generally metals which are above in the reactivity series displace hydrogen from dilute acids except Copper, Gold and Silver which are below the series.

Answer questions 21 -23 using the chemical equation shown below:

$Al\ (NO_3)_3 + 3NaOH \rightarrow Al\ (OH)_3 + 3NaNO_3$

20. What are the reactants in the above chemical equation?

A. $Al\ (NO_3)_3 + 3NaOH$

B. $Al\ (OH)_3 + 3NaNO_3$

C. $Al\ (NO_3)_3$

D. 3NaOH

Give reason for your response?

Reactant are the starting material in a chemical equation and they are represented at the left side of the equation. In this case $Al\ (NO_3)_3 + 3NaOH$

Misconception: Sodium chloride is also known as common salt

21. What are the products in the above reaction?

A. $Al\ (NO_3)_3 + 3NaOH$

B. $Al\ (OH)_3 + 3NaNO_3$

C. $Al\ (NO_3)_3$

D. 3NaOH

Give reason for your response?

The **chemical formula of the products which is also refer to as the substances formed in the chemical reaction are placed at the at the right side of the equation, in this case** $Al\ (OH)_3 + 3NaNO_3$

Select a **balanced chemical equation** for each of the following descriptions of a chemical reaction, include the phases of the reactants and products.

22. Aluminium metal ***reacts with*** copper (II) chloride ***to produce*** aluminium chloride and copper metal.

A. $Al + Cu^{2+}Cl \rightarrow Al\ Cl_3 + Cu$

B. $Al\ (NO_3)_3 + 3NaOH \rightarrow Al\ (OH)_3 + 3NaNO_3$

C. $2Al + 3CuCl_2 \rightarrow 2Al\ Cl_3 + 3Cu$

D. $3Al + 3CuCl2 \rightarrow Al\ Cl_3 + 3Cu$

Give reason for your response?

The aluminum metal reacts with copper chloride (ions) that is **sprinkled over the foil**. When the copper chloride (ion) powder reacts with the aluminum metal, the ions and the metal change form. The aluminum metal now becomes the ion, which dissolves away, weakening the foil.

Misconception: Because the chemical symbol for Aluminium is Al Chlorde is Cl (223)

23. At high temperatures during baking, Sodium hydrogen tri-oxo-carbonate (IV) (baking soda) decomposes (reacts) to produce sodium carbonate, carbon dioxide, and dihydrogen monoxide (water).

   A. $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

   B. $NaHCO_2 \rightarrow NaCO_3 + CO_3 + H_2O$

   C. $NaCO_3 \rightarrow NaCO_3 + CO_3 + H_2O$

   D. $4NaHCO_3 \rightarrow Na_2CO_3 + 2\,CO_2 + H_2O$

Give reason for your response?

The explanation is that the sodium bicarbonate decomposes into sodium carbonate (Na2CO3), carbon dioxide (CO2), and water when it is heated. The balanced chemical equation for this reaction is

$2NaHCO_3\ (s) \leftrightarrow Na_2CO_3\ (s) + CO_2\ (g) + H_2O\ (g)$

Sodium hydrogen carbonate is a white solid at room temperature. It is a crystalline compound, but it can also be found in the form of fine powder. Its other physical characteristics include the fact that it is odorless and soluble in water. **Sodium bicarbonate** has a slightly bitter taste owing to its alkaline nature.

PART IV: Conceptual understanding in infectious and non-infectious Diseases.

26. One of the following is not a mode of transmission of Infectious diseases.

   A. Air.

   B. Water.

   C. Food.

D. **Lifestyle.**

Give reason for your response?

All the first three options are mode or medium of transmission of infectious diseases but Non-infectious diseases are not caused by pathogens and therefore cannot be spread from one person to another. Instead, non-infectious diseases are caused by factors such as **genetics, malnutrition, environment and lifestyle**.

Misconception:

Infectious diseases can not be transmitted through food.

27. Diseases are mainly classified into two namely

A. Infectious and communicable disease.
B. Non-infectious and Non-communicable.
C. **Pathogenic and Non-pathogenic diseases.**
D. Genetic and environmental diseases.

Give reason for your response?

Diseases are mainly classified on whether it was caused by organism or not caused by organism. Pathogenic and non-pathogenic diseases.

Misconception: some people get their diseases from their parent and the community they found themselves. (23)

Diseases can be contracted genetically or environmentally. (64)

When one lacks vitamin D, the person gets rickets. (51)

28. Which of the following diseases does not match with the right deficiency nutrient?

I. Night blindness-----------------------Lack of vitamin A.
II. Beriberi -------------------------Deficiency of Vitamin D.
III. Goiter -----------------------Deficiency of iodine.
IV. Kwashiorkor --------------Deficiency of Protein.

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

Give reason for your response?

Beri-beri is caused by deficiency of Vitamin B1(thiamine)in the body and not Vitamin D.

Misconception:

Pathogenic are from (223)

Beriberi is a lack of vitamin B2. (253)

Because BI is caused by lack of some nutrients in the body (64)

It is not only protein that lead to kwashiorkor but rather some of the nutrient may be added. (78)

It is not only protein that lead to kwashiorkor but rather some of the nutrient may be added. (78)

29. These are list of non-pathogenic diseases, select the **ODD** one?

I. Beriberi, Scurvy
II.Cholera, Chickenpox
III.Cancer, Leukaemia
IV.Hypertension, Arteriosclerosis

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

Give reason for your response?

Cancer, Leukemia, Hypertension and Arteriosclerosis are caused by either once lifestyle, genetic or not exercising and these can all grouped under non-infectious diseases.

Misconception: They are cause by external

Cholera, chickenpox has causative organism. (48)

It is caused by lack of balance diet.

30. Which one of the following is a symptom of Malaria after eight days of infections?

A. Prolonged cough with blood-tinged sputum.
B. Chest pain, severe abdominal sensation.
C. **Fever, shaking chills, severe headache.**
D. Weight loss, fatigue, finger clubbing.

Give reason for your response?

Literature from mayo clinic .org confirms the symptoms of malaria after eight days of infections as Fever, shaking chills and severe headache.

32. Which of the following is not caused by non-infectious diseases?

A. Malnutrition.
B. Genetic.
C. **Virus.**
D. Environment.

Give reason for your response?

The statement is referring to the cause of infectious disease among the option. It is clear among the option viral diseases can be transmitted from one to another.

Misconception: The environment has nothing to do with infectious diseases and non-infectious but its habit and the causes that matters. (57)

Environment is not a disease but our surrounding (20).

Malnutrition is when the amount of nutrient required by the body is less, therefore, it is a non-infectious disease. (51)

Because malnutrition disease cause by malnutrition cannot be transfer to another person. (74)

Genetic is not caused by non-infectious disease because we inherit from our parents but non-infectious disease is caused through air-borne, water born and food borne. **(205)**

It is caused by in balanced diet. It caused by non-infectious diseases **(249)**

Because it cannot be transmitted from one person to the other. **(239)**

33. Why should you consider malaria as an infectious disease?

    A. **The presence of Plasmodium Spp**.
    B. The presence Human blood
    C. The presence of litter
    D. The presence of Virus

Give reason for your response?

This is because the Plasmodium spp (p. falciparum, P. vivax, P. ovale, P. malariae) is the parasite that caused the disease Malaria.

Misconception: it considered as infectious because it caused by the female Anopheles Mosquitoes. (64)

Because it is not spread through the food we eat but rather from the environment. (51)

As the name implies, infectious (being affected). Malaria is an environmental cause disease and hence an infectious disease. **(79)**

Because the mosquitoes that bit are in the community and transfers sickness through the bite. **(184)**

34. Which of the following is not a Control measure for the typhoid diseases.

    A. Safe disposal of sewage.
    B. Regular vaccination.
    C. Pasteurization of milk.
    D. **Sleeping under treated nets.**

Give reason for your response?

The organism Salmolena typhi can be control by all the option above with exception of **Sleeping under treated nets.**

Misconception: safe disposal of sewage such that waste are not dumped into water bodies or around the environment. **(64)**

All the above can control typhoid except that **(184)**

Because treated nets are meant for mosquitoes and not bacteria s that causes typhoid. **(186)**

35. What is the name of the vector that causes Malaria?

A. Male Anopheles Mosquito

B. Female Anopheles Mosquito

C. Male Tsetse fly

D. Female Black fly

Give reason for your response?

It is the vector that carries the plasmodium parasite, in this instance the female Anopheles Mosquito.

APPENDIX D

	DEPARTMENT OF SCIENCE EDUCATION	
	E-mail:dse@ucc.edu.gh *TELEGRAMS* & CABLE UNIVERSITY, CAPE COAST *TELEPHONE.* *OFFICE: +2333321-34890*	COLLEGE OF EDUCATION STUDIES UNIVERSITY OF CAPE COAST CAPE COAST, GHANA

Your Ref.: 0022	Our Ref.: DSEE/R.2/V.1/295	Date:14th June, 2021

TO WHOM IT MAY CONCERN

Dear Sir/Madam

LETTER OF INTRODUCTION

We write on behalf of **Obed Baah-Yanney**, an M.Phil. (Science Education) student with registration number **ET/SED/19/0012** who has been assigned to collect data at your institution.

Mr. Baah-Yanney is conducting a research on the topic: " **PRE-SERVICE TEACHERS' CONCEPTUAL UNDERSTANDING AND INTEREST IN BASIC ELECTRONICS, BALANCING OF CHEMICAL EQUATIONT, INFECTIOUS AND NON-INFECTIOUS DISEASES IN INTEGRATED SCIENCE."**

We therefore write to introduce and request that you grant him the needed assistance.

Counting on your usual cooperation.

Thank you.

Yours faithfully,

Godwin Kwame Aboagye (PhD)

SUPERVISOR