

**AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND
ENTREPRENEURIAL DEVELOPMENT**

**DIGITAL TRANSFORMATION EDUCATION: CHALLENGES,
EFFECTIVENESS AND PERCEPTION OF COMPUTER-ASSISTED
INSTRUCTIONS APPLICATION IN PHYSICS CLASSROOM**

EMMANUEL OPPONG

NOVEMBER, 2023

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BY

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**A thesis submitted to the School of Graduate Studies, Akenten Appiah-Menka
University of Skills Training and Entrepreneurial Development in partial fulfilment
of the requirements for the award of a Master of Philosophy in Science Education**

NOVEMBER, 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.

Emmanuel Oppong

Signature: **Date:**.....

Supervisors' Declaration

We hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines on supervision of thesis as laid down by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development.

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ABSTRACT

The study examined the challenges, effectiveness and perceptions of students on CAI in colleges of education physics' classroom. To address these, mixed-method research design, involving 12 Physics tutors and 254 Physics students from selected CoEs in the Sekyere South District and the Mampong Municipality were used. Data was collected through interviews and questionnaires, and analyzed using descriptive statistics, thematic, and correlational analysis. Results from the quantitative analysis revealed that Physics tutors encountered significant challenges, primarily stemming from inadequate technological resources and limited financial support. In response, tutors employed various strategies, such as personal investment in internet bundles and advocating for institutional intervention. Factors that contributed to students' positive perceptions of CAI effectiveness included perceived learning outcomes, relevance of content, learning style, teacher's pedagogical approach, and interactivity. Pearson product-moment correlation analysis indicated a significant positive correlation between CAI usage and attitude towards Physics learning, suggesting that nearly 43.69 % of the variation in students' attitude scores can be explained by the use of CAI. Integration of quantitative and qualitative findings revealed convergence and agreement between the two sets of data. In conclusion, while Physics tutors encounter challenges, students perceive its use positively, indicating a need to strengthen the integration of CAI in Physics education within CoE. The study recommends further support and investment in CAI infrastructure and training for Physics tutors to enhance teaching and learning outcomes in Physics education.

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DEDICATION

This thesis is dedicated to Kwaku Gyedu-Okumanyin-Karikari Oppong, Ella Ama-Nyarko-Abronomah Oppong, and Keren Ena Akua-Kaakyire Oppong.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

The introduction provides an overview of the research topic and establishes the context and rationale for the study. Specifically, it provides background information, states the research problem, research objectives, research questions, and discusses the significance of the study. It then discusses the delimitation and limitations to the study and gives operational definitions of key terms in the study. It ends with a summary of the organization of the rest of the study.

1.1 Background to the Study

The field of education has been profoundly impacted by the advent of digital technology, and this transformation has led to the emergence of digital transformation in education. The relevance of trained individuals as knowledge creators as well as users is growing, which imposes new obligations on scientific educators (Rahm, 2023). Physics is the most basic science which deals with the study of nature and natural phenomenon; thus, a knowledge of Physics is the basis for understanding science (Nwanne & Agommuoh, 2017). The utilization and exploration of Physics play a crucial role in driving the progress and development of societies and nations in the realms of science, industry, technology, and social evolution (Nwanne & Agommuoh). Therefore, Physics Education should aim at developing the skills required for proper understanding of Physics principles governing the behaviours of natural phenomena and their applications.

Physics Education Research (PER) has been dedicated to examining ways to enhance students' learning for many years (Rosali, 2020). Typically, researchers in the field of Physics Education Research (PER) focus their studies on various aspects that aim to facilitate learning. These aspects include conceptual comprehension, epistemology, problem-solving skills, attitudes, social dynamics, technological applications, assessment of particular teaching methods, and the creation of educational materials (Bao & Koenig, 2019; Beichner, 2011). As reported earlier by May (2002), despite formal instruction, there is still a gap between what has been taught and what is learnt in the classroom. Other researchers ascribe the problem to the use of conventional direct instruction instead of active learning (Fraser *et al.*, 2014; Rotgans & Schmidt, 2011). Therefore, it is worth investigating alternative teaching methods and approaches, such as the incorporation of technology into classroom teaching, to determine their capacity to promote active and self-directed learning (Rosali, 2020).

Digital transformation in education, characterized by integration of digital tools and technologies to enhance teaching and learning processes, with the ultimate goal of improving educational outcomes, has gained significant attention. Using a computer as a medium of instruction has been described variously as Computer-Based Learning (CBL), Computer-Enhanced Learning (CEL), Computer-Based Instruction (CBI), Computer-Aided Instruction (CAI), Computer-Aided Learning (CAL) and Computer-Assisted Instruction (CAI) (Suleman *et al.*). Among these, CAI has proven to be an effective and advantageous instructional strategy for increasing interest, uplifting mindset, enhancing students' capacity for retention, and improving students' performance (Dwivide *et al.*, 2022;

Park & Son, 2022; Ezeh *et al.*, 2021; Nwanne & Agommuoh, 2017; Suleman *et al.*, 2017), and with significant impact to facilitate and augment traditional classroom teaching, especially in STEM subjects like physics (Barakabitze *et al.*, 2019; Kaputa *et al.*, 2022; Ghavifekr & Rosdy, 2015).

CAI in physics classrooms has been increasingly adopted by educators in recent years. The implementation of digital tools and educational software has the potential to make physics instruction more engaging, interactive, and personalized. It uses a blend of graphs, texts, words, sounds, and movies for the learning process (Bakri *et al.*, 2022), including word processors, models, instructional exercises, supplemental exercises, training schemes, database creation, and programming (Lestari & Thresia, 2021). It can also help bridge gaps in learning, provide immediate feedback, and offer access to a vast array of resources, thus aligning with the principles of digital transformation in education (Bates, 2019; Cox, 2018).

CAI is activity-focused and student-centered though its optimization has been a serious challenge (Byusa *et al.*, 2022). In a wide range of subjects, from literature to the social sciences and beyond, Computer-Assisted Learning can encourage active learning (Heilporn *et al.*, 2022) and has the potential benefit for managing the instructional strategy and enhancing education (Beardsley *et al.*, 2021). When handled correctly, it can also remove students' fear and embarrassment and result in constructive learning and academic success (Lepper & Malone, 2021). Research indicates that students who use computers to learn exhibit high levels of self-assurance and confidence and are more effective and motivated to learn than students who learn in a more conventional setting (Olson *et al.*,

2021). Also, to fully comprehend a theory, learners can focus on the physical meaning of its abstract notions with the aid of CAI (Bouchée *et al.*, 2022).

Although Physics teachers are constantly searching for effective ways to enhance student learning outcomes and engagement in the classroom (McMillan, 2012), the use of CAI in colleges of education Physics' classrooms present unique challenges, such as the need for adequate technological infrastructure, training of instructors and students, and the availability of appropriate educational materials (Usman & Madudili, 2020). Therefore, this study was aimed to explore and analyze the challenges, effectiveness and perceptions of students regarding computer-assisted instruction in CoE physics' classroom in the context of digital transformation education. By conducting a comprehensive study into the challenges, effectiveness students' views and experiences, we can better tailor the integration of CAI to meet the needs of both learners and tutors and optimize the educational process.

1.2 Statement of the Problem

Research indicates that many students find Physics difficult and boring (Erinosho, 2013; Rohandi, 2017; Shirazi, 2017). It is worrying that a large number of students do not seem to understand basic concepts in Physics at the college level, and find it difficult to answer questions on areas such as optics and basic electronics (UCC Chief Examiner's Report for EBS 227 General Physics, 2021; 2022; 2023). Learning tends to be rote and memorization and students find learning of Physics difficult, which in turn affects their academic achievements (Jegade, 2012; Maduwesi, & Onyechu, 2014). Although the use of

Computer-Aided Instruction (CAI) in colleges of education Physics classrooms has the potential to enhance student engagement, motivation and learning outcomes (Julius et al., 2018), implementation of CAI programs in Physics' Education faces several challenges, such as instructors unfamiliarity with the technology (Willis, 1993) and cost of implementing and maintaining CAI programs (Masenya, 2020).

Computer-Assisted Instruction (CAI) in teaching in the colleges of education in Ghana became prominent when the Ministry of Education, backed by the Act of Parliament (ACT 847, 2012), changed all diploma courses in the colleges of education to degree programs. Since then, instructors have integrated various pedagogical modules involving CAI strategies such as the use of laptops, projectors and smart boards in their teachings. Students, on the other hand, are allowed to use smart phones and laptops during instructional hours where the instructor can share videos, YouTube links, power points and other electronic content packages. Moreover, students are central to the success of digital transformation in education, and their perceptions of CAI in the physics classroom are pivotal. Understanding how students perceive and interact with computer-assisted instruction is essential in gauging the effectiveness of this approach and in refining its implementation. Students' attitudes, preferences, and experiences can shed light on the challenges and opportunities presented by digital transformation in the context of physics education (Prensky, 2010; Selwyn, 2011). While some studies have shown positive effects, others have been inconclusive or have demonstrated no significant difference between traditional teaching methods and CAI programs (Liu *et al.*, 2023).

However, over the past five years, CAI integration in teaching in the Colleges of education in Ghana has not been fully assessed with reference to its effectiveness, challenges and students' perceptions associated with its implementation. Therefore, this current research examined the challenges, effectiveness and perceptions of students regarding computer-assisted instruction in CoE physics' classrooms in the context of digital transformation education.

1.3 Objectives of the Study

The objective of the study was to examine the challenges, effectiveness and perceptions of students on CAI in colleges of education Physics' classrooms.

Specifically, the study sought to:

1. Identify the challenges Physics tutors face when integrating CAI in Physics classrooms in the college of education and how they address these challenges
2. Find out students' perception on the effectiveness of CAI in Physics classrooms in CoE and what factors contribute to their perception.
3. Determine the corroboration between the quantitative findings on CoE Physics tutors' challenges in integrating CAI and CoE Physics students' perceptions on the effectiveness of CAI, with the qualitative findings on CoE Physics tutors' challenges in integrating CAI and CoE Physics students' perceptions on the effectiveness of CAI.
4. Assess the relationship between the use of CAI and students' attitudes towards Physics.

1.4 Research Questions

The study sought to address the following research questions:

1. What challenges do Physics tutors face when integrating Computer-Assisted Instruction (CAI) in Physics classrooms in colleges of education, and how do they address these challenges?
2. How do students perceive the effectiveness of Computer-Assisted Instruction in Physics classrooms in colleges of education, and what factors contribute to their perceptions?
3. To what extent do the quantitative findings on CoE Physics tutors' challenges in integrating CAI and CoE Physics students' perceptions on the effectiveness of CAI corroborate with the qualitative findings on CoE Physics tutors' challenges in integrating CAI and CoE Physics students' perceptions on the effectiveness of CAI?
4. What is the relationship between the use of Computer-Assisted Instruction in Physics classrooms in colleges of education and students' attitudes towards Physics?

1.6 Justification for the Study

Despite the challenges and variations in needs, the use of CAI in colleges of education Physics' classrooms represents a promising approach to enhancing student learning outcomes and contributing to the advancement of Physics Education (Cai *et al.*, 2017). Several studies have reported positive results such as improved conceptual understanding, increased motivation and enhanced problem-solving skills on the use of CAI in Physics Education (Prahani *et al.*, 2022).

The justification for this research lies in its potential to provide valuable insights and evidence regarding the effectiveness of CAI in the teaching of Physics. By examining the impact of CAI on student-centered learning, students' participation and motivation as well as comprehension of concepts, this study will contribute to the existing body of knowledge on educational technology in the Ghanaian context. It will provide empirical data to validate the perceived advantages of CAI and shed light on the extent to which it facilitates the understanding of complex scientific concepts.

Additionally, this research aims to identify the challenges faced in the implementation of CAI strategies. Understanding the barriers encountered by instructors and students is crucial for developing targeted interventions and support systems. By addressing these challenges, the findings of this study will contribute to the improvement of instructional practices and the successful integration of CAI in Physics Education within the colleges of education in Ghana.

The outcomes of this research will be of interest to educators, policymakers, and educational institutions. The insights gained from this study will inform decision-making processes regarding the alignment of CAI programs with the curriculum, and the incorporation of high levels of interactivity and adaptability into the programs (Barakabitze *et al.*, 2019; Eom & Ashill, 2016). Ultimately, the findings will support efforts to enhance the quality of Physics Education in the colleges of education in Ghana and optimize the use of CAI strategies for improved teaching and learning outcomes.

1.7 Significance of the Study

The study will provide insights into the effectiveness of using CAI in colleges of education Physics' classrooms, and its potential to enhance students' academic performance. This can contribute to the improvement of teaching and learning outcomes in Physics Education. Moreover, the study will identify the implementation challenges that colleges of education Physics' classrooms face when using CAI, which can inform the development of strategies and interventions to address these challenges. This practical implication can help to improve the integration of technology in education and enhance the quality of Physics Education.

Besides, the study will contribute to the existing body of knowledge on the use of CAI in Physics Education, particularly in the colleges of education, an area that has received limited research attention. This can stimulate further research and innovation in the use of technology in Physics Education. Finally, the study will provide evidence-based information that can inform policy decisions on the use of CAI in Physics Education, particularly in colleges of education in Ghana. This can lead to the development of policies that support the integration of technology in education and enhance the quality of Physics Education.

1.8 Delimitations of the Study

The study focuses exclusively on the field of Physics Education. This limitation is important because it ensures that the research is specific and in-depth, allowing for a more detailed analysis of the subject matter. However, it also means that the findings may not be

directly applicable to other educational disciplines. Research by Hake (1998) and Laws (1997) highlighted the unique challenges and characteristics of Physics Education and emphasized the need for specialized investigations within the field.

The study employs both quantitative and qualitative research methods to gather data from students and instructors. This mixed-methods approach allows for a comprehensive exploration of the topic, capturing both quantitative data for statistical analysis and qualitative insights for a deeper understanding of the phenomenon (Johnson and Onwuegbuzie, 2004). Data is primarily collected from students and instructors in colleges of education Physics' classrooms. This limitation ensures that the study directly investigates the experiences and perspectives of those directly involved in CAI in Physics Education, which is significant for evaluating the effectiveness of instructional methods and technology integration (Frey and Schmitt, 2010; Keengwe *et al.*, 2013).

The study does not extensively explore the perspectives of administrators, policymakers, and other stakeholders in the education system. This limitation may restrict the examination of broader systemic influences on the adoption and implementation of CAI. Studies by Cuban (2001) and Anderson and Dexter (2005) stress the importance of considering administrative and policy-level perspectives in educational technology research to understand the broader context of implementation. The findings of this study are intended to be directly applicable to colleges of education Physics' classrooms in Ghana. The study's context is specific to the Ghanaian educational system, and its findings may not be directly generalizable to tertiary institutions in other countries. Research by UNESCO (2019)

highlights the need for localized educational research to address context-specific challenges and solutions in different regions.

1.9 Limitations of the Study

The study is specifically focused on colleges of education and the subject of Physics. This narrow focus may limit the generalizability of the findings to other educational settings or different subject areas. Research by Ertmer (1999) highlights the importance of considering context-specific factors when studying technology integration in education, as the effectiveness of CAI can vary significantly across subjects and educational levels. The assessment tools used in the study to measure the effectiveness of CAI may not comprehensively capture the full range of learning outcomes or align perfectly with the specific content and skills targeted by Computer-Assisted Instruction.

Studies by Chiu (2017) emphasized the need for valid and reliable assessment methods when evaluating educational interventions, as inadequate assessment tools can lead to incomplete conclusions about instructional effectiveness. The study might not adequately address challenges related to the availability and reliability of technological resources in colleges of education Physics' classrooms as reported by Ely and Plomp (2016) to be a critical factor in technology integration in education, as it can act as a barrier to effective implementation. The study does not consider external factors such as the influence of other teaching methodologies, curriculum constraints, or institutional policies, which could affect the effectiveness of CAI. These external factors may interact with CAI and shape its

impact, hence, should be considered when studying instructional methods in Science Education, like Physics (Hodson, 1996).

1.10 Operational Definition of Terms

Computer-Assisted Instruction (CAI)/Computer-Aided Instruction (CAI) - CAI involves employing the computer as a tool to enhance and facilitate instruction.

Computer-Aided Learning (CAL) – Computer-Aided Learning describes an educational environment where a computer program, or an application, as they are commonly known, is used to assist the user in learning a particular subject.

Computer-Based Learning (CBL) - Computer-Based Learning (CBL) is the term applied to any form of learning that relies on the use of computers. CBL leverages the interactive features of computer applications and software, along with the capability to deliver various types of media to users.

Computer-Based Instruction (CBI) - Computer-Based Instruction is an educational framework that utilizes computer technology to provide training or educational content to individuals.

Computer-Enhanced Learning (CEL) - Computer-Enhanced Language Learning is essentially the improvement of language learning achieved through the integration of computers.

Information and Communication Technology (ICT) - Information and communication technology (ICT) can be described as a wide range of technological instruments and assets employed for the transmission, storage, generation, distribution, or interchange of information.

Physics Education Research (PER) - Physics Education Research (PER) is a specialized field of education research that concentrates on the examination of how Physics is taught and learned.

Problem-Based Learning (PBL) - Problem-Based Learning (PBL) is an education method that centers on students taking an active role in their learning by collaborating in groups to solve complex, open-ended problems related to a particular subject.

Inquiry-Based Learning (IBL) - Inquiry-Based Learning (IBL) is an educational method that prioritizes student involvement, with the teacher providing guidance as students generate their own questions, devise research methodologies, and analyze data.

Science, Technology, Engineering and Mathematics (STEM) - STEM is a collective term used to categorize the separate yet interconnected technical fields of science, technology, engineering, and mathematics.

1.11 Organization of the Study

The study unfolds across five chapters, each serving a distinct purpose. The initial chapter introduces the research with a background and statement of the problem, outlines objectives, delineates justification and significance, defines the scope, and highlights operational terminologies used in the study. Chapter two undertakes an extensive review of pertinent literature, establishing a theoretical framework and contextual backdrop on challenges and effectiveness, benefits, delimitations and limitations on CAI integration in education, instructional methods for teaching Physics, knowledge gap on CAI integration in teaching and learning, and ends with summary on literature review. Following this, chapter three expounds on the research methodology, encompassing the study areas,

research paradigm, research design, population, sampling procedures, data collection instruments, and analytical methods. The subsequent chapter, four, unveils the results and engages in a comprehensive discussion, presenting data through tables, thematic analysis and descriptive statistics, and interpreting findings in light of the research questions. Finally, chapter five summarizes the study, provides conclusive statements, offers practical recommendations, and identifies potential avenues for future research, thus culminating the research journey.

;

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

The literature review section provides a comprehensive summary and evaluation of the existing literature on Computer-Assisted Instruction and its effectiveness and implementation challenges in colleges of education Physics classrooms. The literature review typically includes the following sub-topics: Theoretical and Conceptual Frameworks, Definition of Computer-Assisted Instruction, Benefits of Computer-Assisted Instruction, Effectiveness of Computer-Assisted Instruction, Challenges of Computer-Assisted Instruction, Empirical Studies on CAI, Effects of CAI on Students Learning Domains, Implementation Challenges of CAI, Physics Education and CAI, Teaching Strategies/Methods for Teaching Physics, and Gaps in the Existing Literature Highlighting the Need for Further Research in the Area.

2.1 Theoretical Background

In learning through computers, computers either take over or assist the teacher with various functions of instruction (Owusu *et al.*, 2010). According to Soe *et al.* (2000), learning from computers encompasses approaches to Computer-Assisted Instruction in which the computer is used as a means for transmitting specific subject matter. In this approach, the flow of information is basically from the computer to the student. The use of Computer-Assisted Instruction (CAI) in education has gained popularity in recent years. CAI refers to the use of computers to deliver instructional content and provide interactive learning

experiences. This study draws on several theoretical perspectives, including the cognitive load theory, the social learning theory, and the technology acceptance model.

2.1.1 Cognitive Load Theory

Cognitive load is a critical factor that can affect students' learning outcomes when using CAI in colleges of education Physics' classrooms. Cognitive load can be classified into three categories: intrinsic, extraneous, and germane. Intrinsic cognitive load refers to the inherent complexity of the learning material, whereas Extraneous cognitive load refers to the unnecessary cognitive load imposed by the design of the learning materials. Germane cognitive load refers to the cognitive processing that contributes to learning and understanding (Liu *et al.*, 2021).

The Cognitive Load Theory (CLT) is a learning theory that focuses on how the cognitive load imposed by instructional materials can affect the learning process. According to the CLT, learners have a limited working memory capacity, and when instructional materials exceed this capacity, learning can be impaired. The theory posits that instructional materials should be designed to minimize Extraneous cognitive load and maximize Germane cognitive load. Extraneous cognitive load refers to the cognitive load imposed by irrelevant information or poorly designed instructional materials. In contrast, Germane cognitive load refers to the cognitive load imposed by instructional materials that are directly relevant to the learning goal (Plass & Kalyuga, 2019).

The CLT is relevant to this study because it highlights the importance of designing CAI materials that minimize Extraneous cognitive load and maximize Germane cognitive load. The study can investigate how the design of CAI materials in colleges of Education Physics' classrooms can affect the cognitive load of learners and influence their learning outcomes.

2.1.2 Social Learning Theory

The Social Learning Theory suggests that learning can occur through social interactions and observational learning. Social interactions can facilitate the exchange of ideas and information among learners and teachers, thereby enhancing learning (Carcea & Froemke, 2019). Observational learning refers to the learning that occurs through observing the behaviour of others. The use of CAI in Colleges of education Physics classrooms can facilitate social interactions and observational learning. For example, CAI materials include discussion forums and collaborative learning activities that allow learners to interact with each other and exchange ideas as well as simulations and animations that demonstrate physical phenomena and experiments to facilitate observational learning.

The Social Learning Theory (SLT) is a learning theory that emphasizes the role of social interactions and observational learning in the learning process. According to SLT, learners can acquire knowledge and skills by observing the behaviour of others and the consequences of their actions (Pinho et al., 2020). The theory posits that learning is influenced by the cognitive processes of attention, retention, reproduction and motivation. The SLT is relevant because it highlights the importance of social interactions and

observational learning in the use of CAI. This makes it suitable for this study which investigates how the use of CAI can facilitate social interactions and observational learning in Physics Education in the colleges of education in Ghana.

2.1.3 Technology Acceptance Model

The attitudes of teachers and students towards technology adoption can significantly influence the effectiveness of using CAI in colleges of education Physics' classrooms. The Technology Acceptance Model suggests that the perceived usefulness and ease of use of technology are critical factors that influence attitudes towards technology adoption (Najib & Fahma, 2020). The Technology Acceptance Model (TAM) is a theoretical framework that explains how users perceive and adopt new technologies. According to the TAM, users' attitudes towards technology are influenced by two main factors: perceived usefulness and perceived ease of use (Cai *et al.*, 2019). Perceived usefulness refers to the extent to which users perceive that a technology can enhance their performance and achieve their goals. Perceived ease of use refers to the extent to which users perceive that a technology is easy to use and learn.

The TAM is relevant to this study because it can explain the factors that influence the acceptance and adoption of CAI in colleges of education Physics' classrooms. The study can investigate how teachers and students perceive the usefulness and ease of use of CAI and how these perceptions can influence their attitudes towards its adoption. The study draws on the theory of the Cognitive Load Theory, the Social Learning Theory, and the technology acceptance model. These theoretical perspectives provide the guiding

assumptions for investigating the challenges and effectiveness of using CAI in colleges of education Physics classrooms.

2.2 Conceptual Framework

The conceptual framework in Figure 2.1 illustrates the relationships between the variables of the study. It suggests that the implementation of CAI in colleges of education Physics' classrooms can lead to increased effectiveness (improved learning outcomes) and positive student perception (Bizimana *et al.*, 2022). However, these outcomes may be influenced by mediating variables, such as the challenges faced by teachers and the strategies to address them. Additionally, moderating variables, such as technological infrastructure and teacher competence can either facilitate or hinder the effectiveness and challenges associated with CAI implementation (Major *et al.*, 2021).

This conceptual framework provides a visual representation of the interconnections among the variables guiding the investigation of the study's research questions and hypotheses. It helps to identify key factors and their potential impacts on the effectiveness and challenges of implementing CAI in colleges of education Physics' classrooms.

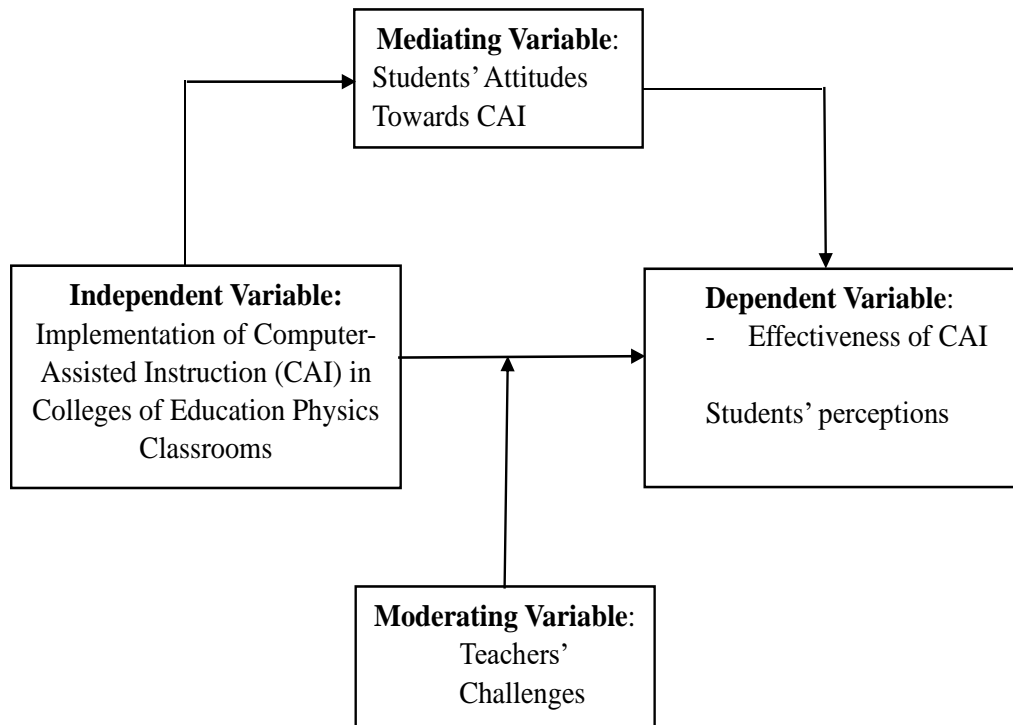


Figure 2.1: Conceptual Framework for CAI in Colleges of education Physics' Classrooms

2.2.1 Explanation of the Conceptual Framework:

Independent Variable: Implementation of Computer-Assisted Instruction (CAI)

This variable represents the use of Computer-Assisted Instruction in COE Physics' classrooms. It encompasses the integration of technology tools, software, and other resources to support teaching and learning in the context of Physics Education (Ellermeijer & Tran, 2019).

Dependent Variable:

Effectiveness of CAI: This variable measures the extent to which CAI positively impacts student learning outcomes in Physics. It includes academic achievement, knowledge

acquisition, and skill development (Li *et al.*, 2022). In this study, the effectiveness of CAI was determined from CoE Physics students' perceptions, which includes students' attitudes, beliefs, and opinions regarding how CAI impact their learning experiences, engagement, motivation, and interest in Physics (Cai *et al.*, 2022; Yang & Heh, 2007).

Moderating Variable:

Teachers' Challenges: This variable represent the difficulties and obstacles faced by teachers when integrating CAI in Physics classrooms. The moderating variable is one that acts upon the relationship between the independent and dependent variables, and changes its direction or strength. They encompass factors such as limited technological infrastructure, lack of training, time constraints, pedagogical adaptation challenges and curriculum provisions (Hennessy, 2006; Romiszowski & Mason, 2013).

Mediating Variable:

Students' Attitudes Towards CAI: This variable represents CoE Physics students' attitudes towards the use of CAI in the teaching and learning of Physics. This variable is part of the causal pathway between the dependent variable and independent variable, which is caused by the independent variable and directly influences the dependent variable. By so doing, a correlation was established between students' attitude towards CAI and the use of CAI (Gil-Flores *et al.*, 2017; Susanto *et al.*, 2020; Petko *et al.*, 2018).

2.3 Computer-Assisted Instruction

Computer-Assisted Instruction (CAI) is a form of educational technology that utilizes computers to deliver instruction and facilitate learning. CAI involves the use of software programs designed to provide interactive educational content and assessment to learners, often customized to individual learning needs and styles (Bouhnik et al., 2019; Tello-Rozas et al., 2017). CAI has been around since the 1950s and it has evolved over the years as technology has advanced. The early forms of CAI were based on drill-and-practice exercises that provided students with repeated opportunities to master specific skills. However, with the development of more sophisticated software and multimedia tools, CAI has expanded to include simulations, virtual environments and games that provide engaging and immersive learning experiences.

The effectiveness of CAI has been widely studied and the results have been generally positive. One meta-analysis of 232 studies on CAI found that it had a moderate to large effect on student learning outcomes (Cheung & Slavin, 2013). Another review of 67 studies found that CAI had a positive effect on students' academic achievement, particularly in Science, Mathematics, and Language Learning (Hwang *et al.*, 2015). According to Vidal-Carreras et al. (2019), CAI has several advantages, including flexibility in terms of pacing and delivery, the ability to provide immediate feedback and assessment and the potential to personalize instruction based on individual student needs. Research has shown that CAI can improve student learning outcomes in a variety of subjects, including Mathematics, Science, and Language Learning (Bouhnik *et al.*, 2019; Tello-Rozas *et al.*, 2017). However, some studies have also noted potential drawbacks of CAI, including a lack of

face-to-face interaction with instructors, the tendency for students to become overly reliant on the technology and the need for adequate hardware and software resources (Lepper & Woolverton, 2018; Liu *et al.*, 2019).

Despite these limitations, the use of CAI has become increasingly common in educational settings with many schools and universities integrating technology-based instruction into their curricula. As such, further research is needed to better understand the effectiveness of CAI and to identify best practices for its implementation in educational contexts. However, it is important to ensure that CAI is used in a way that is evidence-based and aligned with best practices in pedagogy.

2.4 Physics Education and Computer-Assisted Instruction (CAI)

Physics is the cornerstone of scientific and technical progress as well as a nation's human resource development, and it will be hard to have a thorough understanding of the topic if it is not effectively taught and learnt in the country's secondary schools (Suleman *et al.*, 2017). Moreover, speaking about the significance of Physics, Suleman *et al.* (2017) asserted that each nation's technological growth depends on the study and investigation of science and this advancement would not be feasible without advancement in Physics. To them, Physics, the "spirit of science," plays a crucial part in all human endeavors and is a requirement for courses in Geology, Medicine, Forestry, Computer Engineering, Agricultural Science, Space Navigation, Pharmacy, and other fields. In order to comprehend natural phenomena, we need to rely on Physics as a discipline that makes use

of numerical measurements and experimental observations and can, therefore, quantitatively explain natural occurrences and connect them to regular occurrences.

CAI has been empirically proven to be an excellent teaching approach that enhances students' achievement, accelerates their interest and reduces the exhausting and abstract nature of Physics (Clowes *et al.*, 2021). CAI provides learners with flexibility and functionality which the traditional methods and processes sometimes lack. As CAI includes drill-and-practice, lesson or simulation activities, it may be quite effective. When compared to conventional techniques, Computer-Assisted Instruction (CAI) can significantly more strongly influence students' learning. Computer programming offers many educational benefits. For instance, researchers have found that CAI enhances learning proportion; that is, it enables students to acquire the same amount of material in less time than kids who get traditional instruction.

Additionally, CAI significantly improves student retention (Léon, 2021). The development of students' analytical and decision-making abilities, data processing capabilities and communication skills can be supported by CAI. Students can access various learning resources and increase their exposure to a variety of people and viewpoints by using computers (Asad *et al.*, 2021). The practices that aid students in visualizing abstract ideas will aid in conceptual understanding. These activities may be actual physical workouts or computer simulations and animations, and they would be congruent with and complementary to traditional instruction (Shyamala, 2021). In computer simulations, a variety of Physics visual representations that are often invisible to learners become visible

(Saudelli *et al.*, 2021). Through the use of simulations, educators have the opportunity to give students a teaching tool that will help them convert their alternative scientific ideas into accurate ones. Students could adjust and detach from parameters to better understand the connections between physical concepts, variables and phenomena (Moşteanu, 2021).

The use of CAI in science disciplines would increase students' exposure to and capacity for developing talents, learning and access to information in the technological world. Such skill development will enhance the nation's social, economic, and mechanical relevance (Chevalère *et al.*, 2021). Technology advancements have opened up several doors for Physics teaching. Students have a wide range of alternatives when using computer-based learning in Physics, such as the ability to visualize abstract ideas to aid in comprehension (Jenkins, 2022).

The study of matter and energy in connection to each other is the focus of the physical science known as Physics (Imanova, 2022). It has several subfields, including plasma Physics, nuclear Physics, solar energy, heat, electricity, optics, mechanics, and optics (Chandrappa & Das, 2021). The four fundamental human needs of food, housing, health care, and security are closely related to Physics (Boehnlein *et al.*, 2022). Physics is the science that students have the most trouble understanding since the majority of physical concepts are abstract. Additionally, in contrast to previous courses, even if there are numerous connections between the primary topics and the number of subjects to be mastered, merely understanding definitions are not sufficient to understand the subject.

Additionally, theories and numerical expressions make it challenging to comprehend Physics and draw connections between the topics.

According to Jenkins (2022), instructors who switch to new learning environments encourage active learning, higher order thinking, peer instruction, and multisensory stimulation. Multiple intelligence, constructivism, and cooperative learning are all supported in these settings. On the part of Bouchée *et al.* (2022), conventional education and the current educational resources did not aid in the formation of conceptual learning nor help learners to overcome any difficulties that were already present in the learning process. A learning environment where the degree of the students' past knowledge is known, real-life events are discussed, students are both intellectually and physically ready, and cognitive transformation is offered are all necessary for managing effective learning in Physics.

Additionally, these learning settings should give students the chance to reinforce the concepts they have just acquired (Miller *et al.*, 2021). Instead of employing conventional approaches, alternative student-centered education strategies should be used to teach Physics to improve students' problem-solving abilities and cognitive learning (al Ghouti, 2022). According to Ude and Onah, (2022), Computer-Assisted Instruction al materials are more effective in fostering a positive attitude and Physics learning enthusiasm. Ekundayo (2022) study showed increased students' performance in Physics with the use of CAI, although few teachers are willing to use it. To him, teachers employ the lecture approach but it is necessary to try an alternative teaching style in line with global trends of

adopting CAI, particularly for scientific instruction. When Omeh and Olelewe (2021) looked at how CAI affected students' academic performance, they discovered, through the test results, that the experimental group outperformed the controlled group. Further, it was discovered that age and gender disparities did not significantly affect the experimental group's mean accomplishment.

2.5 Empirical Studies on Computer-Assisted Instruction

Several empirical studies have examined the effectiveness of Computer-Assisted Instruction (CAI) in enhancing student learning outcomes in Physics Education. These studies have yielded mixed results, highlighting the need for further research to explore the potential benefits and challenges associated with CAI.

A study conducted by Abimbade *et al.* (2017) examined the impact of CAI on the academic performance of senior secondary school students in Nigeria. The study found that the use of CAI significantly improved students' performance in Physics, particularly in the areas of problem-solving and critical thinking. The study also highlighted the importance of incorporating interactive and collaborative learning activities into CAI materials to enhance students' engagement and motivation. On the other hand, a study conducted by Usman and Madudili (2020) examined the challenges and limitations of implementing CAI in Nigerian schools. The study identified factors such as inadequate technology infrastructure, limited access to resources, and inadequate teacher training as significant barriers to the effective implementation of CAI. The study also emphasized the importance

of addressing these challenges to ensure equitable access to technology and effective utilization of CAI in the learning process.

Another study conducted by Antonis *et al.* (2010) examined the effectiveness of a web-based CAI system in promoting student learning outcomes in Physics Education. The study found that the use of the web-based system significantly improved students' understanding of Physics concepts, enhanced their problem-solving skills, and increased their motivation to learn. The study also highlighted the importance of considering students' individual differences and learning styles when designing and implementing CAI materials. Again, Ozmen (2008) conducted a study which examined the impact of CAI on students' conceptual understanding and problem-solving skills in Physics Education. The study found that the use of CAI significantly improved students' performance in both areas, with the effect being more prominent among low-achieving students. The study also highlighted the importance of providing adequate technical support and resources to teachers to facilitate effective implementation of CAI.

In a similar vein, a study conducted by Thomas *et al.* (2019) examined the impact of CAI on students' engagement and motivation in Physics Education. The study found that the use of CAI led to increased student engagement and motivation, as evidenced by higher attendance rates, increased participation in class discussions, and higher levels of student satisfaction with the learning experience. The study also emphasized the importance of considering the needs and preferences of students when designing and implementing CAI materials. Furthermore, a study conducted by Udoh and Udo (2020) examined the impact

of a blended learning approach that incorporated CAI on students' learning outcomes in Physics Education. The study found that the blended learning approach resulted in higher levels of student engagement and motivation, as well as improved performance in Physics assessments. The study also highlighted the importance of providing opportunities for students to interact with their peers and teachers in both online and face-to-face settings to optimize the effectiveness of CAI.

Besides, a study conducted by Tlili *et al.* (2016) examined the impact of a personalized CAI system on students' learning outcomes in Physics Education. The study found that the personalized approach resulted in higher levels of students' engagement, motivation and achievement, particularly among low-achieving students. The study also highlighted the importance of incorporating adaptive learning technologies that can tailor the learning experience to individual student's needs and preferences.

In addition to the studies mentioned above, several other studies have examined the effectiveness of CAI in Physics Education. For example, a study conducted by Crouch *et al.* (2018) explored the impact of a CAI program on students' attitudes toward Physics. The study found that the use of CAI was associated with a significant increase in positive attitudes toward Physics among students. The study also found that students who used the CAI program scored higher on Physics achievement tests than those who did not. More so, McMillan (2012) investigated the impact of a CAI program on students' achievement and motivation in Physics Education. The study found that students who used the CAI program

performed better on Physics achievement tests and reported higher levels of motivation and engagement in learning Physics than those who did not use the program.

Moreover, research has investigated the impact of personalized and adaptive CAI programmes on student learning outcomes. Personalized and adaptive CAI programmes use machine learning algorithms to tailor the learning experience to each student's individual needs, preferences and learning styles. By adapting the content, pace and difficulty of instruction, these programmes aim to optimize student learning outcomes and engagement. For example, a study conducted by Major *et al.* (2021) explored the effectiveness of a personalized and adaptive CAI program in Physics Education. The study found that the personalized and adaptive programme was associated with significant higher learning gains, greater engagement, and more positive attitudes toward Physics compared to a non-adaptive programme. On personalized and adaptive CAI programme on students learning outcomes in Physics Education, Zhu *et al.* (2018) reported significantly higher association on academic performance, greater motivation and engagement, and more positive attitudes toward Physics compared to a non-adaptive programme.

CAI programmes have been associated with a significant improvement in students' self-efficacy beliefs, particularly among low-achieving students. Studies indicate that students who had higher self-efficacy beliefs had better academic performance and more positive attitudes toward Physics (Cai *et al.*, 2021; Han *et al.*, 2021). In addition to its impact on self-efficacy beliefs and academic performance, CAI has also been shown to be effective in promoting conceptual understanding and problem-solving skills in Physics Education.

Notwithstanding, studies have also investigated the impact of different types of CAI programmes on students' learning outcomes in Physics Education. For example, a study by Zacharia and Anderson (2003) investigated the impact of interactive multimedia simulations on students' conceptual understanding in Physics. The study found that the use of interactive multimedia simulations was associated with a significant improvement in students' conceptual understanding compared to traditional teaching methods. The study also found that students who had low prior knowledge and skills in Physics benefited the most from the use of interactive multimedia simulations. Additionally, Hurtado-Bermúdez & Romero-Abrio (2023) investigated the impact of a CAI programme that used virtual and real experiments on students' conceptual understanding and motivation in Physics Education. The study found that the use of the CAI programme was associated with a significant improvement in students' conceptual understanding and motivation compared to traditional teaching methods. The study also found that the use of virtual and real experiments in the CAI program was particularly effective in promoting students' conceptual understanding and motivation.

2.6 Benefits of Computer-Assisted Instruction

Computer-Assisted Instruction (CAI) has been found to have several benefits for learners, educators and educational institutions. CAI provides learners with personalized and adaptive learning experiences. According to Kim and Baylor (2015), CAI programmes can adapt to learners' individual needs and pace of learning, providing them with customized instruction and feedback. This helps learners to stay engaged and motivated, and to achieve better learning outcomes (Kwon & Lee, 2018). CAI programmes can adapt to individual

student needs and provide immediate feedback on performance, enabling students to identify areas where they need to improve (Cuomo & Roffi, 2022).

CAI can improve the efficiency and effectiveness of teaching. Teachers can use CAI to deliver instruction more efficiently, allowing them to reach a larger number of students at once (Gibson & Farris, 2014). Additionally, CAI can provide teachers with data on students' progress and performance, enabling teachers to make informed decisions about instruction and assessment (VanLehn, 2011). More so, CAI provides opportunities for multimedia learning, which can be engaging and effective for learners. This according to Mayer (2014), multimedia materials such as videos, animations, and interactive graphics, can enhance learning by providing visual and auditory cues that help to improve comprehension and retention.

Additionally, CAI can help to bridge educational gaps by providing access to high-quality educational resources to learners in remote or underserved areas (Kumar & Kumar, 2012). CAI can also provide learners with opportunities to learn at their own pace, enabling them to catch up with their peers or to accelerate their learning as needed. Besides, CAI can be used to facilitate collaborative learning which promotes interaction and cooperation among students, leading to increased motivation and better learning outcomes (Alqahtani, 2015; Huang & Liang, 2018).

Notwithstanding, CAI can be a cost-effective solution for educators, and can lead to cost savings in areas such as instructional materials, teacher salaries, and classroom space, and personnel required for traditional classroom instruction (Gibson & Farris, 2014).

2.7 Effectiveness of Computer-Assisted Instruction

Computer-Assisted Instruction (CAI) has been widely studied for its effectiveness in improving students' learning outcomes. According to a meta-analysis conducted by Kulik and Kulik (1991), CAI has a positive effect on students' learning outcomes. The study found that the average student in a CAI environment scored higher on achievement tests than 70 % of students in traditional classroom settings. Furthermore, CAI can be an effective tool for promoting active learning. In a study by Garcia and Cinque (2019), students who used CAI showed higher levels of engagement and participation compared to those who received traditional classroom instruction. This is because CAI can provide interactive and engaging learning activities, such as simulations and games that can motivate students and increase their interest in the subject matter. Similarly, a study by Wang *et al.* (2018) found that students who received CAI had higher achievement scores than those who received traditional classroom instruction. The study also found that CAI was particularly effective for low-achieving students.

In addition, CAI has been shown to be effective in improving students' motivation and engagement. According to a study by Koohang *et al.* (2013), students who received CAI were more motivated and engaged in the learning process than those in traditional classroom settings. Further, CAI can provide individualized instruction which can be

particularly effective for students who have diverse learning needs. This as reported by studies can be used to provide accommodations for students with disabilities, leading to improved learning outcomes and greater access to educational opportunities (Reed *et al.*, 2015; Wang *et al.*, 2018). CAI has also been found to be effective in teaching specific subjects. For instance, a study by Wang and Chen (2019) found that CAI was effective in improving students' English Language proficiency.

Similarly, a study by Ni and Cheng (2019) found that CAI was effective in improving students' mathematical problem-solving skills. However, it is important to note that the effectiveness of CAI depends on various factors, such as the quality of the instructional materials, the level of students' engagement and the level of teacher's support. According to a study by VanLehn (2011), the effectiveness of CAI is influenced by the quality of the instructional materials, the ability of the CAI programme to provide immediate feedback, and the level of teacher's support. Nonetheless, there are some limitations to the effectiveness of CAI. For instance, CAI may not be effective for all types of learners. According to a meta-analysis by Sitzmann *et al.* (2006), the effectiveness of CAI varied depending on the characteristics of the learners and the instructional context.

2.8 Factors Contributing to the Effectiveness of CAI in Physics Education

Several factors contribute to the effectiveness of using CAI in Physics Education. One factor is the level of interactivity provided by the CAI programme. Programmes that provide high levels of interactivity, such as interactive simulations and videos, have been shown to be more effective in enhancing student learning outcomes (Zhang *et al.*, 2019).

Another factor is the adaptability of the CAI programme. Programmes that can adapt to individual student's needs and provide personalized feedback have been shown to be more effective in enhancing students' learning outcomes (Tetzlaff *et al.*, 2021).

The quality of the educational materials provided by the CAI programme is also a crucial factor. Programmes that provide accurate and relevant educational materials that align with the curriculum have been shown to be more effective in enhancing students' learning outcomes (Kasneci *et al.*, 2023). Additionally, the level of support provided to instructors and students is an important factor. Instructors who receive adequate training and support in the use of CAI are better equipped to integrate it into their teaching practices and use it effectively in the classroom (Li, 2014).

2.9 Implementation Challenges of Computer-Assisted Instruction

While Computer-Assisted Instruction (CAI) has many advantages, it also presents several challenges that need to be addressed. One of the main challenges of CAI is the need for technical support. From the studies by Al-Azawei *et al.* (2017) and Chen and Liang (2015), technical difficulties can hinder the effectiveness of CAI. Technical support is needed to ensure that the software and hardware are working properly and to troubleshoot any issues that may arise. Similarly, a study by Wang *et al.* (2022) found that inadequate technical infrastructure can limit the availability and accessibility of CAI programmes, particularly in rural or low-income areas. Besides, technological malfunctions can be a significant barrier to effective CAI as this can cause delays in instruction, decrease in students' motivation, and increase in frustration levels (Khalil & Ebner, 2013; Orey *et al.*, 2008).

Additionally, there is the need for teachers to be trained in the use of CAI. Several studies have indicated that teachers who lack training and support in using CAI may not be able to effectively integrate it into their teaching practices (Becker *et al.*, 2018; Karabulut-Ilgu *et al.*, 2018; Castillo *et al.*, 2022). This can lead to poor outcomes for students and decrease the effectiveness of CAI as an instructional tool. Meanwhile, there is the potential for students to become distracted or disengaged than they would be in a traditional classroom setting. This can lead to a decrease in learning outcomes (Bayraktar & Goktas, 2015; Rakoczy & Schneider, 2014). Again, CAI has the potential for learners to become too reliant on the technology. Studies have shown that learners may become too dependent on CAI programmes. The effect of this is that it can limit their ability to think critically and solve problems independently, thereby decreasing the development of their social and emotional skills (Anderson *et al.*, 2016; Mavroudi *et al.*, 2015; DiCerbo & Behrens, 2014). This can be particularly problematic in situations where technology is not available or reliable. That notwithstanding, there is the potential for low students' motivation and engagement. Similarly, a study by Yilmaz (2017) found that students' motivation was a significant predictor of the effectiveness of CAI.

Furthermore, there may be a learning curve associated with using CAI, particularly for students who are not comfortable with technology. Hargis and Wood (2014) in their study reported that students may need additional support and training to use CAI effectively. In a different setting, there is the potential for CAI to be used as a replacement for human interaction and instruction, but the overreliance on CAI can limit opportunities for student-teacher interaction and personalized instruction, which can have negative consequences on

students' learning outcomes (Kirschner & van Merriënboer, 2013). Nonetheless, CAI programmes may present challenges for students with disabilities. According to a study by Yılmaz & Melekoğlu (2023), CAI programmes may not be accessible to all students with disabilities, particularly those with visual or hearing impairments. Similar, a study by Cmar (2019) indicated that students with learning disabilities may require additional support and accommodations to fully benefit from CAI programmes.

There may also be concerns about the quality of the content in CAI programmes. If the content is not accurate or engaging, students may not learn as effectively as they should. Also, CAI presents challenges for the assessment of students' learning. According to a study by Roitblat *et al.* (2002), the lack of standardization in CAI can make it difficult to accurately assess students' learning outcomes and compare results across different programs. Finally, there may be concerns about the cost of implementing CAI. According to a study by Bachmair and Pachler (2015), the cost of technology and technical support can be a barrier to implementing CAI in some educational settings.

2.10 Empirical Review on the Challenges of Computer-Assisted Instruction

Computer-Assisted Instruction (CAI) encompasses a broad range of educational strategies that incorporate technology to enhance teaching and learning processes (Chaudhari, 2013). While CAI holds tremendous potential, it is not without its challenges. This empirical review aims to provide an in-depth analysis of the prevailing challenges faced by educators in implementing CAI, drawing on recent empirical studies.

2.10.1 Technological Barriers

One of the foremost challenges in CAI implementation revolves around technological constraints (Shahid *et al.*, 2019). Insufficient access to hardware, software, and reliable internet connectivity can impede the seamless integration of CAI in educational settings. Additionally, varying levels of technological proficiency among educators and students pose a significant hurdle. Research indicates that bridging the digital divide remains a pressing concern in the widespread adoption of CAI.

2.10.2 Pedagogical Considerations

Effective CAI requires a pedagogical shift from traditional instructional methods (Triola *et al.*, 2012). Ensuring alignment between CAI content and learning objectives, as well as the incorporation of interactive and engaging activities, demands careful planning and design. Recent studies highlight the need for comprehensive training for educators to leverage CAI effectively, and to adapt their teaching strategies to accommodate a technology-driven learning environment.

2.10.3 Learner Characteristics

The diverse profiles of learners present a multifaceted challenge in CAI implementation (Drgoňa *et al.*, 2018). Individual differences in learning styles, preferences, and abilities necessitate personalized approaches to CAI. Moreover, research suggests that some students may struggle with self-directed learning in a digital environment, underscoring the importance of scaffolding and providing adequate support structures.

2.10.3 Evaluation and Assessment

Evaluating the efficacy of CAI tools and methods poses a significant challenge for educators (Cai *et al.*, 2017). Establishing reliable metrics and assessment strategies that align with the goals of CAI is crucial. Recent research emphasizes the importance of formative assessment practices, real-time feedback mechanisms, and the integration of data-driven insights to monitor learner progress effectively.

2.11 Management of CAI Integration in Teaching

The challenge that may arise from using CAI in colleges of education Physics' classrooms is the potential for technology-related issues, such as hardware or software failures, internet connectivity problems, or incompatibility with different devices. These issues can disrupt the learning process and may require additional time and resources to resolve (Leoste *et al.*, 2021). To mitigate these challenges, it is important to have a plan in place to address potential technology-related issues, including providing technical support and backup plans in case of failures.

Furthermore, the design and implementation of CAI programmes should take into consideration the diversity of students in terms of culture, language, and background (Eisenstein *et al.*, 2022). For example, the use of language and examples in CAI programmes should be appropriate and inclusive of different cultures and students who are non-native speakers of the language of instruction should be provided with adequate support to ensure that they can benefit from the program. The effectiveness of using CAI in colleges of education Physics' classrooms may also depend on the institutional support

for the implementation of these programmes. Institutional support can take many forms, such as providing adequate resources for the design and implementation of CAI programmes, supporting the training and professional development of instructors, and providing incentives for the use of these programs (Cai & Lönnqvist (2022).

Moreover, the institution should ensure that the use of CAI programmes is aligned with the overall mission and goals of the institution and that it is integrated into the overall curriculum in a coherent and meaningful way. Educational materials in CAI programmes should be designed to align with the learning objectives of the course and the needs of the students. They should be engaging, interactive, and challenging enough to motivate students to learn and explore the subject matter. The materials should also be up-to-date, accurate and based on the latest research and scientific discoveries in Physics. The educational materials should be accessible and easy to use with clear instructions and a user-friendly interface (Ramsey *et al.*, 2020). This is especially important for students who may not have prior experience using technology or who may be unfamiliar with the language of instruction.

Another important aspect of educational materials in CAI programmes is their level of interactivity (Hamdan *et al.*, 2021). Interactivity can enhance student engagement, motivation and learning outcomes by allowing students to actively participate in the learning process. Interactivity can take many forms, such as simulations, animations, quizzes, and interactive exercises. The level of interactivity should be appropriate for the level of the course and the needs of the students. For example, introductory courses may

require more interactive exercises and simulations to help students grasp complex concepts while advanced courses may require more complex simulations and problem-solving exercises to challenge students and encourage them to apply their knowledge to real-world situations. The use of adaptive learning technologies in educational materials can also enhance the effectiveness of CAI programmes. Adaptive learning technologies use algorithms to personalize the learning experience for each student, taking into consideration their learning preferences, strengths and weaknesses (Truong, 2016).

Notwithstanding, instructors should be encouraged to experiment with different approaches and strategies for using CAI programmes in their teaching practices (Reynolds *et al.*, 2020). This can help to identify best practices and to refine the design and implementation of the programme to better align with the needs of the students and the learning objectives of the course. To address this challenge, institutions should provide adequate training and support to instructors and emphasize the benefits of using technology in teaching practices. Institutions should also consider implementing incentives and rewards for instructors who demonstrate excellence in their use of CAI programmes.

2.12 Current State of Research on Using CAI in Colleges of education Physics Classrooms

There has been a significant amount of research conducted on the effectiveness of using CAI in Physics Education, including studies focused specifically on colleges of education Physics' classrooms. Several studies have shown that the use of CAI can enhance students' learning outcomes, engagement, and motivation in the classroom.

One study conducted by Abdullah et al. (2023) found that the use of a CAI programme in a college of education Physics classroom led to significant improvements in student learning outcomes as well as higher levels of engagement and motivation among students. The study also found that the use of the CAI programme led to a higher level of retention of Physics concepts among students.

2.13 Effect of CAI on Students Learning Domains

Several studies have investigated the effects of Computer-Assisted Instruction (CAI) on students' learning in both lower-order and higher-order cognitive domains. These domains encompass different levels of thinking and cognitive processes. In this section, we will examine the effects of CAI on both lower-order and higher-order learning domains in the context of Physics Education.

2.13.1 Lower-Order Learning Domain

The lower-order learning domain primarily focuses on the acquisition and application of basic knowledge and skills. It includes tasks such as remembering, understanding, and applying factual information. CAI can be effective in facilitating learning in the lower-order domain through various instructional strategies and interactive features (Mastrolembo *et al.*, 2022).

One of the key advantages of CAI is its ability to provide immediate feedback to students. This feedback helps students identify and correct their misconceptions or errors in real-time, thereby promoting better understanding and retention of factual information. Studies

have shown that CAI programmes that offer immediate feedback can significantly improve students' performance in recalling and applying factual knowledge in Physics (Yeung *et al.*, 2021).

Additionally, CAI programmes often incorporate interactive simulations, virtual experiments, and multimedia presentations to enhance students' understanding of abstract concepts and phenomena. These visual and interactive representations allow students to manipulate variables, observe cause-and-effect relationships and engage in hands-on learning experiences. Research has indicated that these features of CAI can improve students' comprehension and application of basic Physics concepts (Usman, 2021). For instance, a study by Lee (2022) explored the effects of a CAI programme on students' lower-order cognitive skills in Physics. The study found that the use of CAI significantly improved students' knowledge acquisition, understanding of basic concepts, and ability to solve Physics problems. Another study by Kara (2008) investigated the effects of CAI on students' retention of Physics knowledge and found that students who used the CAI programme demonstrated higher levels of knowledge retention compared to those who received traditional instruction.

These findings indicate that CAI can effectively support learning in the lower-order cognitive domain by facilitating the acquisition, understanding and application of basic knowledge and skills in Physics Education.

2.13.2 Higher-Order Learning Domain

The higher-order learning domain involves complex cognitive processes such as analysis, synthesis, evaluation and problem-solving. It focuses on developing students' critical thinking skills, creativity and the ability to apply knowledge to solve complex problems. CAI has also shown promising effects on students' learning outcomes in the higher-order cognitive domain.

One of the advantages of CAI is its ability to provide personalized and adaptive learning experiences. CAI programmes can tailor the instructional content and activities to match students' individual needs, preferences and proficiency levels. This adaptivity allows students to engage in challenging tasks that promote higher-order thinking skills. Several studies have reported the positive effects of personalized and adaptive CAI on students' higher-order cognitive skills in Physics Education. For example, a study by Geban *et al.* (1992) investigated the effects of a personalized CAI programme on students' problem-solving skills in Physics. The study found that the use of personalized CAI significantly improved students' problem-solving abilities and their ability to transfer their knowledge to new situations. Similarly, a study by Cornejo *et al.* (2022) examined the effects of a personalized and adaptive CAI programme on students' critical thinking skills in Physics. The study found that students who used the personalized and adaptive CAI programme demonstrated significantly higher levels of critical thinking compared to those who received traditional instruction.

Further, Ameyaw-Baah *et al.* (2018) investigated the effects of a CAI programme that incorporated inquiry-based learning on students' higher-order cognitive skills in Physics. The study found that the use of the CAI programme significantly improved students' abilities to analyze and synthesize information, make connections between concepts and solve complex problems. Another study by Adolphus *et al.*, (2013) examined the effects of a collaborative CAI programme on students' collaborative problem-solving skills in Physics. The study found that students who engaged in collaborative problem-solving activities using the CAI programme demonstrated higher levels of collaborative problem-solving abilities compared to those who engaged in traditional group work.

Furthermore, CAI can facilitate higher-order learning by providing students with opportunities for inquiry-based learning and collaborative problem-solving. CAI programmes can incorporate virtual experiments, simulations, and interactive activities that allow students to explore and analyze real-world phenomena and make predictions. However, it is important to consider the potential benefits and drawbacks of CAI in Physics Education. While CAI can enhance students' learning experiences and outcomes, it also poses challenges and limitations that should be addressed to ensure effective and equitable use.

2.14 Limitations of Computer Assisted Instructions

The primary limitation of CAI is its dependence on technology, which can create significant disparities in educational opportunities due to the digital divide (Adhikari *et al.*, 2016). While access to computers and the internet has improved globally, many developing

countries still have relatively low rates of computer and internet access. Students without access to the necessary technology are at a disadvantage, potentially leading to unequal learning outcomes. Studies of ICT and CAI in schools produce mixed evidence with a pattern of null results, although notable exceptions to this pattern occur in studies of developing countries and CAI interventions that target Mathematics rather than language (Bulman & Fairlie, 2016). A better understanding of how computer technology affects educational outcomes is critical because it sheds light on whether such technology is an important input in the educational production process and whether disparities in access will translate into educational inequality. As availability of resources has increased with limited change in their usage, teachers seem to have become the scapegoat for the failure of ICT to live up to its promises (Kumashiro, 2015). Accusations of a lack of creativity and innovativeness among teachers and limited technological skills among these “digital immigrants” have been made.

Despite advances in adaptive learning technologies, CAI may struggle to provide the level of personalization that some students require. Tailoring instruction to individual learning styles and abilities can be complex, and not all CAI programs have the capacity to do this effectively (Tirodkar & Lawrence, 2021). This limitation may result in some students not receiving the optimal support they need to excel academically. Personalized learning is a tailoring education to one's unique needs, preferences, and pace, which ultimately helps revolutionize education. Personalization can contribute to improving learning outcomes through enhancing motivation and attitude. Adaptive learning platforms personalize learning by providing individualized feedback to students based on their knowledge or

skills. Adaptive learning technology optimizes training content, meaning that each individual gets the content that matches their learning results. Personalized learning blends adaptive and customized learning, adapting to the learner's progress and allowing the learner to customize the experience to their preferences (Tirodkar & Lawrence, 2021).

CAI, in its digital format, may reduce face-to-face interactions and opportunities for peer collaboration, which could hinder the holistic development of students and their ability to navigate social situations effectively (Sun *et al.*, 2022). Traditional classroom settings foster social interactions, which are crucial for the development of communication skills, teamwork, and social-emotional learning. However, social media-based collaborative learning can enhance students' maturity, different experiences, and the formation of positive interactions. Synchronous learning can provide a lot of opportunities for social interaction, and cooperative learning requires that students work to collectively complete goals, providing opportunities to practice and reflect on their social and emotional competencies as they also develop their academic ones. Teaching effective communication skills, such as active listening and clear expression of thoughts, is essential for successful online interactions. While technology has created new challenges for kids' social-emotional development, it's not helpful to think of the two as distinct or in tension with one another. Technology is not going away, so we need to provide our young people with these skills.

The teacher helps students develop relationship skills by encouraging students to celebrate one another's efforts and brainstorming positive ways to support peers who are struggling. In some cases, CAI may lead to a depersonalized learning experience, which can result in

students feeling isolated or lacking the motivation that comes from direct human interaction (Ariani, 2019). Building meaningful teacher-student relationships and providing mentorship can be more challenging in a purely digital learning environment . However, improving students' relationships with teachers has important, positive, and long-lasting implications for both students' academic and social development. Empathy and communication are essential for building a safe environment for the student through good communication, allowing the students to feel like they can trust their teacher. Poor teacher-student relationships result from the instructor's lack of awareness, and some students require tailored educational approaches since they do not respond to learning in the same way as others (Schademan & Thompson, 2016). When a teacher fails to regard an individual student's educational needs, relationship problems between teachers and students arise. Each student's ability to learn and interact with educators is influenced by their personality, family backgrounds, mental processes, learning styles, priorities, maturity levels, and academic ambitions. When possible, teachers should treat each student as an individual who deserves one-on-one attention and specialized, concentrated education. A poor student-teacher relationship will develop if the educator's main or only priority in the classroom is academics.

In correspondence with academics, students need to feel cared for and have the chance to feel strong emotions. Positive teacher-student relationships draw students into the process of learning and promote their desire to learn, assuming that the content material of the class is engaging, age-appropriate, and well-matched to the student's skills. The teacher helps

students develop relationship skills by encouraging students to celebrate one another's efforts and brainstorming positive ways to support peers who are struggling.

CAI may struggle to replicate hands-on learning opportunities effectively, particularly in subjects like science, arts, and physical education (Pellas *et al.*, 2019). Hands-on learning is a method of instruction where students are guided to gain knowledge by experience, giving them the opportunity to manipulate the objects they are studying. Hands-on learning is essential for subjects like science and mathematics, which are practical and activity-oriented and can best be learned through inquiry and intelligent manipulation of objects and symbols. Through hands-on activities, students acquire knowledge, apply the taught concept, and may develop a feasible solution to the problem. Hands-on activities encourage the affection of lifelong learning as well as motivate learners to explore and discover new facts. When learners are fully engaged in hands-on activities, they are likely to appreciate and learn what they are being taught. While some hands-on learning experiences can be replicated in a digital environment, such as virtual labs and simulations, others cannot. For example, physical education requires physical activity, and arts education requires hands-on creation and manipulation of materials (Pellas *et al.*, 2019).

2.15 Delimitations of Computer-Assisted Instructions

One significant delimitation of CAI is its limited capacity to address highly complex or nuanced subjects (Cai *et al.*, 2019; Schott & Marshall, 2018). Advanced topics in fields like Philosophy, Theoretical Mathematics, or Abstract Sciences often require intricate discussions and nuanced explanations that may be challenging to convey effectively

through a digital medium. The absence of face-to-face interaction can hinder the depth of understanding in such subjects.

The effectiveness of CAI is contingent upon the user's level of digital literacy and proficiency. Students who lack familiarity with technology or digital platforms may face difficulties in navigating and engaging with CAI resources (Saadatzi *et al.*, 2017; McMahon *et al.*, 2016). This dependency can potentially exclude certain student demographics, leading to unequal access and learning experiences. While CAI can offer automated assessments and feedback, it may fall short in providing real-time, personalized feedback comparable to what a human instructor can deliver (Aslan *et al.*, 2019). For subjects where immediate correction and individualized guidance are paramount, the absence of timely human intervention can be a significant limitation.

CAI may not always accommodate the diverse spectrum of learning styles and preferences exhibited by students (Sanchez *et al.*, 2012). Some learners thrive in interactive, hands-on environments, which may not be fully replicated in a digital setting. As a result, certain students may not derive the same level of benefit from CAI as others.

2.16 Strategies/Methods for Teaching Physics

Physics is one of the most challenging subjects for students due to its abstract nature and mathematical complexity. Teaching Physics requires specialized strategies and methods to help students understand the subject and develop problem-solving skills. There are various

approaches to effectively teach Physics in order to improve upon students' learning outcomes.

2.16.1 Active Learning Strategies

Active learning strategies are approaches that actively engage students in the learning process. These strategies have been found to be effective in improving students' understanding of Physics concepts and promoting problem-solving skills (Freeman *et al.*, 2014) and in promoting critical thinking. A study by Deslauriers *et al.* (2011) compared the effectiveness of active learning to traditional lecture-based teaching and found that active learning increased students' performance by 12% compared to traditional methods. Examples of active learning strategies include peer instruction, problem-based learning, inquiry-based learning, interactive simulations and Clicker questions.

2.16.1.1 Peer Instruction

Any strategy that attempts to transfer knowledge more or less directly from teacher to student and 'teaching by telling' is ineffective for many if not most students (Spencer, 2006), and as cognitive load increases, the need for students' engagement increases. Peer instruction is a teaching method that involves students working in pairs or small groups to solve problems and discuss their understanding of the concepts. The instructor provides feedback and guidance to the groups. Studies have shown that peer instruction is effective in improving students' conceptual understanding of Physics (Eberlein *et al.*, 2008).

2.16.1.2 Problem-Based Learning (PBL)

Problem-Based Learning (PBL) is a teaching method that involves students solving real-world problems. PBL has been found to be effective in promoting problem-solving skills and improving students' understanding of Physics concepts (Eberlein *et al.*, 2008; Hmelo-Silver, 2004; White, 2001).

2.16.1.3 Inquiry-Based Learning (IBL)

Inquiry-Based Learning (IBL) is a teaching method that involves students conducting experiments and exploring concepts independently. As a student-centre approach to teaching, IBL has been found to be effective in improving students' problem-solving skills and promoting deeper understanding of Physics concepts (Hake, 1998). IBL also utilizes project-based learning to promote students' engagement (Dancy & Henderson 2007).

2.16.1.4 Interactive Simulations

According to Finkelstein *et al.* (2005), interactive simulations help students understand abstract Physics concepts by providing a visual representation of the concepts. The authors suggest that interactive simulations can be used to complement traditional teaching methods.

2.16.1.5 Clicker Questions

Clicker questions are multiple-choice questions that are used to gauge students' understanding and clicker questions are effective in promoting students' engagement and

improving their understanding of Physics concepts (Fraser *et al.*, 2014; Caballero *et al.* (2012).

2.16.1.6 Process-Oriented Guided Inquiry Learning

This educational approach entails active discussion and engagement with course content rather than passive listening. It relies on guided inquiry and follows a structured learning cycle consisting of three phases (Simonson & Shadle, 2013; Moog *et al.*, 2006). During the initial phase, students explore hypotheses and elucidate patterns and connections within the model. In the subsequent "concept invention" or "term introduction" phase, a distinct concept emerges, and a terminology may be introduced to label this freshly established concept or association. Ultimately, in the "application" phase, students utilize the concept in novel scenarios, thereby enhancing their comprehension of it. This method can be employed within small, self-directed student groups. (Eberlein *et al.*, 2008).

2.16.2 Collaborative Learning

Collaborative learning is a teaching method that involves students working together in small groups. It promotes teamwork and communication skills. According to Gan *et al.* (2015), collaborative learning is effective in promoting students' engagement and improving their understanding of Physics concepts. One example of collaborative learning is the use of peer instruction which involves students working in pairs to solve Physics problems (Crouch & Mazur, 2001).

2.16.3 Interactive Demonstrations

Interactive demonstrations are effective way of teaching Physics concepts. The use of visual aids and interactive demonstrations can enhance students' engagement and help them understand complex concepts easily. According to a study by Beichner (2011), interactive demonstrations can increase students' understanding of Physics concepts and help them retain the information for longer periods.

2.16.4 Flipped Classroom

The flipped classroom is an instructional method where students are assigned video lectures or reading materials to review before attending class. In-class time is then dedicated to discussions, problem-solving, and collaborative learning activities. Research has demonstrated that this flipped classroom approach is successful in enhancing students' grasp of Physics concepts (Toto, 2018).

2.16.5 Simulation-Based Learning

Simulation-based learning involves the use of computer simulations to teach Physics concepts. This approach allows students to visualize and interact with abstract concepts, which facilitates understanding (Chen *et al.*, 2013).

2.16.6 Conceptual Understanding

Conceptual understanding is a critical aspect of teaching Physics. Students who understand the underlying concepts of Physics are better equipped to solve problems and apply their knowledge in real-life situations. A study by Hestenes *et al.* (1992) found that teaching

Physics using conceptual understanding-based strategies was more effective than traditional methods.

2.16.7 Technology Integration

The use of technology in teaching Physics has become increasingly popular. The integration of technology into teaching can enhance students' engagement and improve their understanding of Physics concepts. Yeh *et al.* (2017) observed that the use of virtual reality simulations improves students' understanding of Physics concepts and, thus, increases their motivation to learn.

Generally, teaching Physics can be challenging, but various strategies and methods can be used to enhance students' learning and understanding. Active learning, interactive demonstrations, conceptual understanding, cooperative learning, and technology integration are effective teaching methods that can be used to teach Physics concepts. Implementing these methods can enhance students' engagement, increase their motivation to learn and improve their overall academic performance in Physics.

2.17 Knowledge Gap on CAI in Teaching and Learning

While there is a significant body of literature on Computer-Assisted Instruction (CAI), there are also some notable gaps in the research. One significant gap is the lack of research on the long-term effects of CAI. Most research on CAI has focused on short-term outcomes, such as immediate improvements in test scores, rather than long-term effects on

learning and retention (Xie *et al.*, 2020). To Gkatzidou *et al.* (2017), there is a need for longitudinal studies to better understand the long-term effects of CAI.

Another gap is the limited research on the use of CAI with diverse student populations. Al-Harbi and Al-Shehri (2016) assert that much of the research on CAI has been conducted with homogeneous student populations such as college students in developed countries. More research is needed to explore the effectiveness of CAI with diverse student populations, including students with disabilities and students in developing countries (Al-Harbi & Al-Shehri, 2016). There is also the limited research on the impact of CAI on different age groups. While there is considerable scholarly attention on the effectiveness of CAI for children and adolescents, research on the effectiveness of these programs for adults appears to have received little attention. Hence, as Chiu *et al.* (2018) argue, there is a need for more research on the effectiveness of CAI programmes for adult learners.

Furthermore, there is the lack of research on the impact of CAI on different subject areas. While there is a significant amount of research on the effectiveness of CAI for subjects such as Mathematics and Science, it appears there is little research on the effectiveness of these programmes for other subject, such as Language, Arts or Social Studies. As indicated by Joo and Lim (2017), much of the research on CAI has been conducted in traditional classroom settings, rather than in non-traditional environments such as online or distance learning programs.

Also, there is the limited research on the impact of CAI on students' motivation and engagement. While there are some researches on this topic, there is a need for more research to better understand how CAI programmes can be designed to increase students' motivation and engagement. A study by Hu *et al.* (2020) suggested the need for more research on how CAI programmes can be designed to meet the needs and preferences of individual learners. Also, most research on CAI have focused on the technology itself rather than the role of teachers in implementing and using CAI programmes. This situation motivates an exploration into the ways in which teachers can effectively integrate CAI into their teaching practices (Lin & Chen, 2018). Besides, there is lack of research on the ethical and social implications of CAI, which according to Ma and Ruhe (2016) raises important ethical and social questions, such as the potential for increased inequality and the impact on students' privacy.

Despite the increasing popularity of Computer-Assisted Instruction (CAI) in various educational settings, there is a notable lack of research focusing specifically on its effectiveness and challenges in the context of Physics' classrooms in colleges of education. While CAI has been widely studied in K-12 schools and higher education institutions, there is a dearth of empirical studies that specifically investigate the application of CAI in Physics' classrooms within colleges of education (Chevalère *et al.*, 2021; Luo *et al.*, 2021). This research gap leaves a significant knowledge void regarding the effectiveness of CAI in enhancing Physics learning outcomes and the unique challenges faced by educators and students in this particular setting.

2.18 Summary of Literature Review

The implementation of CAI in Physics' classrooms presents both opportunities and challenges for educators. While there is evidence to suggest that CAI can have positive effects on students' learning outcomes, there are also implementation challenges that need to be addressed. Educators must be prepared to address technical issues, provide adequate training and support for teachers, and ensure students' engagement. Furthermore, understanding teachers' attitudes towards CAI is crucial for effective implementation as teachers who are supportive and enthusiastic about using technology in the classroom are more likely to have positive impacts on student learning outcomes. Additionally, it is important to consider the broader implications of implementing CAI in education and its potential impact on traditional modes of instruction.

This literature review has explored the use of Computer-Assisted Instruction (CAI) in Physics classrooms in colleges of education. The review has highlighted the potential benefits of CAI, including improved student learning outcomes and teacher efficiency. The review has also identified challenges to effective implementation of CAI, including technical issues, teacher training and support and students' engagement.

The review has revealed that while there is evidence to suggest that CAI can have positive effects on students' learning outcomes, the extent to which it is effective varies according to various factors, such as the quality of software, teacher attitudes and student motivation. Additionally, the review has shown that CAI can have a positive impact on both higher and lower-order learning domains. The review has further underscored the importance of

understanding teacher attitudes towards CAI as they play a crucial role in its successful implementation. Teachers who are supportive and enthusiastic about using technology in the classroom are more likely to have positive impacts on student learning outcomes.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter provides an overview of the research's focal area, outlining the chosen research design, which is a quasi-experimental approach for data collection. It goes on to detail the population, sample, and the methods employed for selecting the sample size. Additionally, the chapter offers a comprehensive explanation of the research tools employed to gather data, along with discussions on the validity and reliability of these instruments. The chapter concludes by elucidating the data collection process and the subsequent data analysis techniques applied.

3.1 Study Sites

The study was conducted at two different locations in the Ashanti and Brong-Ahafo zone of the colleges of education in Ghana. Agona, in the Sekyere South District and Mampong Municipality were the two locations. Seventh-day Adventist College of Education, Agona, St. Monica's College of Education and Mampong Technical College of Education were the locations in Ashanti Region where the study was conducted.

The Mampong Municipal is one of the 261 Metropolitan, Municipal and District Assemblies (MMDAs) in Ghana, and forms part of the 43 of MMDAs in the Ashanti Region with Mampong as its administrative capital. It is located within longitudes 00 05W and 10 30W and latitudes 60 55N and 7 0 30N, and covers an area of about 23.9 km².

Mampong Municipality was created following the splitting and upgrading of the former Sekyere West District into Mampong Municipal and Sekyere Central District by Legislative Instrument (L.I.) 1908. It is bounded to the south by Sekyere South District, to the east by Sekyere Central District, and to the north by Ejura Sekyedumase Municipal. The population of the Mampong Municipality according to the 2021 Population and Housing Census stands at 116,632 with 56,965 males and 59,667 females (Ghana Statistical Service, 2021).

The Sekyere South District (formerly Afigya Sekyere District) is one of the 261 Metropolitan, Municipal and District Assemblies (MMDAs) in Ghana, and forms part of the 43 MMDAs in the Ashanti Region, and has its administrative capital at Agona. The Sekyere South District (formerly Afigya Sekyere District) is located in the north eastern part of the Ashanti Region and is 37 kilometers from Kumasi, along the Kumasi-Mampong trunk road. The district has a total land area of 416.8 square kilometers representing about 1.7 percent of the total land size of the Region of 24,389 square kilometers. The district lies between latitude 6° 50'N and 7° 10'N and Longitude 10° 40'W and 10° 25' W. The district shares common borders with Ejura Sekyedumase Municipal to the north, Mampong Municipal and Sekyere East District to the east, Kwabre East Municipal to the south and Offinso Municipality to the west. The population of the district according to the 2021 Population and Housing Census stands at 120,076 with 58,065 males and 62,011 females (Ghana Statistical Service, 2021).

3.2 Research Paradigm

Morgan (2007) in his view described paradigms as “worldviews or all-encompassing ways of experiencing and thinking about the world, including beliefs about morals, values, and aesthetics” (p. 50). It is a framework of thoughts or beliefs or understandings within which theories and practices operate. It acts as a function of how a researcher thinks about the development of knowledge. Therefore, Ugwu et al. (2021) defined a research paradigm as a basic system or world view that guides the researcher or investigator. That is, the researcher’s perspective that influences what should be studied, how it should be studied, and how the results of the study should be interpreted. This means that by choosing a paradigm for a particular study, it will put the researcher in a position to know what can be researched (ontological assumptions), linking it to what we can know about (epistemological assumption), and how to go about it (methodological approach). In view of this, various paradigms have been found to exist in educational research, and these include; positivism, post-positivism, interpretivism, pragmatism, constructivism, and transformative paradigms. This study however, is designed to operate in the realm of pragmatism perspective.

As stated by Kivunja and Kuyini (2017), pragmatism is based on the belief that comprehending the "truth" of the real world cannot be achieved solely through a single scientific method, as proposed by the positivist paradigm, nor can it be determined solely through the lens of social reality constructed in the interpretivist paradigm. Therefore, relying on a single paradigmatic perspective is insufficient. Instead, proponents argue that a comprehensive worldview is necessary, one that offers research methods or a blend of

methods capable of illuminating our understanding of the actual behaviors of individuals. This is because, according to Kaushik and Walsh (2019), knowledge is always founded on experience, and this idea is a key tenet of pragmatic epistemology. The social experiences we have shape how we perceive the world. As a result of their individual experiences, each person has knowledge that is unique. Since it originates from shared experiences, a significant portion of knowledge is socially disseminated. Consequently, in pragmatic epistemology, all knowledge is considered to be social knowledge. This perspective does not view knowledge as an objective reality; rather, it is perceived as a creation designed to assist individuals in navigating their lives and engaging with society. As a result, Siddiqui (2019) explains that utilizing positivistic and interpretive epistemologies according to applicability and viewing reality as both objective and socially produced, pragmatism uses a methodologically diverse and pluralistic approach to study, which is the foundation of this study.

3.3 Research Design

Research design encompasses the comprehensive approach employed to conduct research, offering a clear and rational blueprint for addressing defined research inquiries by collecting, interpreting, analyzing, and deliberating on data. Therefore, the choice of the research design ensures that the study's objectives and research questions are achieved and answered by using the appropriate research methodologies (Bostley, 2019). However, Thakur (2021) explains that the choice of methodologies and methods in crafting a research study is contingent upon the researcher's perspective regarding their beliefs about the nature of knowledge (epistemology) and reality (ontology), frequently influenced by their

academic field of expertise. By selecting an appropriate design, Thakur continues that, decisions regarding what, where, when, how much, by what means concerning an inquiry or a research study are catered for.

There are various types of research designs depending on the nature of research questions the study seeks to answer. These according to Creswell (2009) include; quantitative design (comprising experimental, correlational, and survey designs), qualitative design (comprising grounded theory, ethnographic, and narrative research designs), and mixed methods design (comprising a blend of quantitative and qualitative designs, and actions research design). This study, however, employed the mixed-methods design.

Schoonenboom and Johnson (2017) explain mixed methods research as a research approach in which a researcher or a research team integrates aspects of both qualitative and quantitative research methodologies. This includes incorporating qualitative and quantitative perspectives, data collection methods, analytical techniques, and inferential methods with the overarching goals of achieving a comprehensive and an in-depth understanding while also corroborating findings. Essentially, in a mixed methods design, data are gathered and analyzed in both quantitative and qualitative ways within a single study (Boru, 2018). Data can be gathered either at the same time or in a sequential manner, and they are combined or integrated at one or more points during the research process (Creswell, 2014). In other words, the approach helps the researcher to answer questions that cannot be answered using only quantitative or qualitative methods alone. Additionally, mixed methods research asserts that it offers a more comprehensive understanding by

identifying trends, making generalizations, and delving deeply into the viewpoints of participants (Boru, 2018). Nonetheless, there exist various categories of mixed methods research designs, which encompass the convergent parallel design, explanatory sequential design, exploratory sequential design, concurrent embedded design, transformative design, and multiphase design (Creswell, 2014). In this study, the concurrent embedded design was employed.

According to Creswell (2014), the concurrent embedded design in mixed methods research is characterized by the simultaneous collection of both quantitative and qualitative data in a single data collection phase. In this design, there is a primary method that takes the lead in guiding the research project, while a secondary method plays a supporting role in the process. The secondary method, whether quantitative or qualitative, is given lower priority and is embedded or "nested" within the dominant method, which can be either qualitative or quantitative. This embedding means that the secondary method is used to investigate a different question than the primary method. For example, in this study, research questions 1 and 2 were analyzed using qualitative methods, while research question 4, which addressed a different aspect compared to questions 1 and 2, was analyzed using quantitative methods. In other words, combining data from both methods was done to merge the information and make comparisons between the two data sources, as exemplified in research question 3. Creswell also suggests that the data can be compared while still maintaining their distinctiveness, presenting two separate but complementary perspectives that contribute to an overall comprehensive evaluation of the issue. This combination allowed for a deeper exploration of the research questions that allowed for triangulation,

enabling the researcher to validate findings and enhance the credibility and reliability of the study.

3.3.1 Overall Study Design

Figure 3.1 presents a flowchart of this study's design. As seen from Figure 3.1, this study adopted the mixed method approach where the research questions were addressed quantitatively and qualitatively.

The study was designed in stages as shown in Figure 3.1. The first phase involved designing of research instruments, after formulation of research topic and objectives. At phase 2, the instruments were pilot tested after which they were validated and their reliabilities determined at phase 3. After checking for validity and reliability of the instruments, the instruments were administered in the main study, where both quantitative data (through questionnaires) and qualitative data (through semi-structured interview) were collected concurrently at Phase 4. At Phase 5, the collected data were analysed to answer the research questions at phase 6.

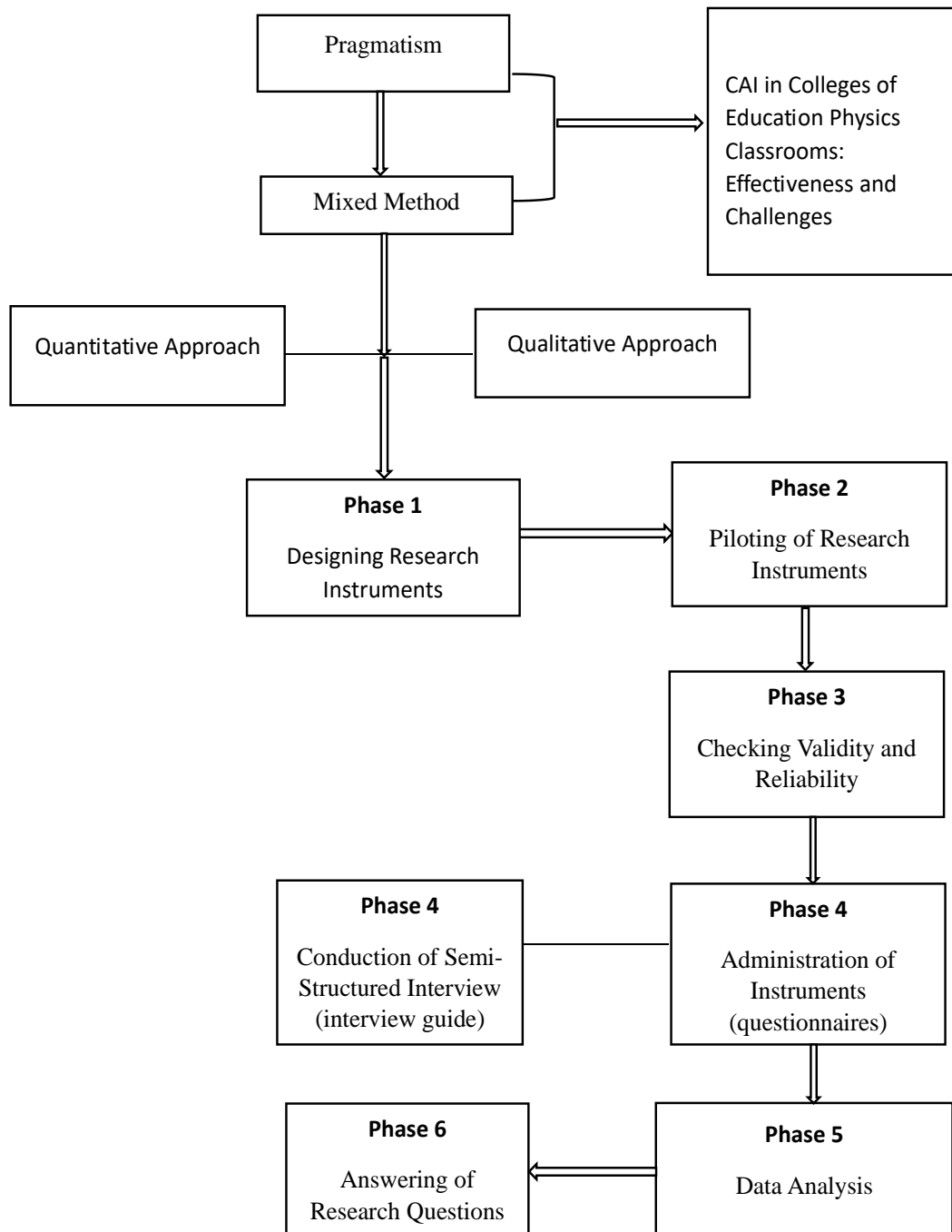


Figure 3.1: A flowchart of the study’s design

3.4 Population

In this study, the target population were all B.Ed. Basic Education Students in the colleges of education in the Sekyere South District and Mampong Municipality who study General Physics as a course, as well as all Physics tutors in the colleges of education in the Sekyere South District and Mampong Municipality. However, the accessible population were all second year Physics students who studied B.Ed. Basic Education in the three colleges of education in the Sekyere South District and Mampong Municipality. It was found that General Physics was studied only in the second year in all three CoEs. As a result, only second year Physics students from the three CoEs were considered for this study. This, therefore, provided a total of four-hundred and five (405) Physics students, consisting of two hundred and ninety-nine (299) males and one hundred and six (106) females.

3.5 Sample and Sampling Technique

According to Creswell (2012), in multi-stage sampling, the researcher opts for a multi-stage sample selection approach when either it's challenging to readily identify the population or when the population is exceptionally vast, as was the situation in this particular study. Table 3.1 shows the multi-stage sampling procedure employed. From Table 3.1, purposive sampling was used to select second year CoE students and teachers who study and teach Physics in all the three CoEs in Sekyere Central District and Mampong Municipality, where they were four hundred and five (405) in number. This was because Physics was studied only in second year in all three CoEs. However, simple random sampling was also employed to select participants who took part in the study. Purposive sampling was also used to select experienced Physics tutors who were using CAI in their

classrooms, and expressed willingness to participate in the study. In this study a CoE tutor was considered experienced when he or she had been in service for four or more years. Therefore, using Krejcie & Morgan (1970) criteria for selecting sample size, two hundred and fifty-four (254) second year Physics students were selected from the three (3) CoEs to participate for the quantitative aspect of study.

Table 3.1: Details of Multi-stage Sampling Procedure Used in the Study

Stage	Sampling procedure	Activity	Sample Size (N)
Stage 1	Purposive sampling	Selection of second year Physics students and tutors in all three CoE	405
Stage 2	Simple random sampling	Selection of CoE Physics students to participate in the study	254
Stage 3	Total Purposive sampling	Selection of experienced and willing Physics tutors, who use CAI in all three CoE	12

However, in the qualitative phase of the study, using identical sample, that is, participants who took part in the quantitative aspect (Onwuegbuzie & Collins, 2007), twelve (12) students were selected through stratified random sampling (six students from both gender groups). This sample size for the qualitative study was selected according to the recommendation by Onwuegbuzie & Collins (2007). Also, with regards to the number of Physics tutors who took part in the study, since the researcher aimed at using experience tutors, it was found that all Physics tutors (12) who were in service qualified to participate in the study. As a result, total purposive sampling was used to select the twelve (12) Physics tutors, who took part in both the quantitative and qualitative components.

3.6 Research Instruments

In a research study, an instrument serves as a means of quantifying, observing, or recording both quantitative and qualitative data. These instruments, which are selected prior to data collection, can take various forms, such as tests, questionnaires, tally sheets, logs, observational checklists, inventories, assessment tools, or interview guides. Researchers employ these instruments based on the type of data they aim to gather, whether it involves measuring accomplishments, evaluating individual capabilities, observing behavior, constructing a psychological profile of an individual, or conducting interviews (Creswell, 2012). In this study, to collect qualitative data from research participants, semi-structured interview was used, using an interview guide. The quantitative data however, was collected using a questionnaire. The questionnaires were in four folds, Teacher Challenges and Solutions Questionnaire, CAI Usage Questionnaire, Students' Perceptions and Factors Questionnaire, and Attitude Towards Physics Learning Questionnaire.

3.6.1 Interview

As per Creswell (2012), a qualitative interview is a process in which researchers pose broad, open-ended questions to one or more participants and then document their responses. In these interviews, open-ended questions are employed to enable participants to freely express their experiences without being influenced by the researcher's viewpoints or prior research findings. An open-ended response to a question grants the participant the freedom to shape their own answers. Interviews can be categorized into structured, semi-structured, or unstructured formats (Cohen *et al.*, 2018). In a structured interview, Taherdoost (2021) explains that participants are asked the same set of standard questions

that have been pre-written and are ready to be asked before the interview. Participants may only be presented with a few open-ended questions, and the range of viable answers is restricted. Taherdoost explains that unstructured interviews are informal interview techniques that lack a specific format. These interviews do not follow a set guide and involve casual conversations. Interviewers gather information through brief notes and attempt to remember the responses. On the other hand, semi-structured interviews are more formal and are conducted following a predefined guide. Interviewers pose questions in accordance with the provided guidance, but they have the flexibility to extend the conversation based on the pre-established questions when additional information is needed. In this study, a semi-structured interview was employed. This helped to collect a range of participants' responses.

3.6.1.1 Interview Guide

The employment of a semi-structured interview required that an interview guide be prepared in advance. Topics and issues which were covered were specified in advance, in outline form; the researcher decided sequence and working of questions in the course of the interview. The interview guide contained five open-ended questions, where respondents were allowed the freedom to provide in-depth responses to each question, however under the guidance of the researcher. The outline increased the comprehensiveness of the data and made data collection somewhat systematic for each respondent. By using an interview guide, CoE Physics students expressed their perceptions towards the effectiveness on the use of CAI in the classrooms.

3.6.2 Questionnaire

Both closed and open-ended questions helped the researcher to collect wide range of responses from respondents to better understand the challenges teachers encounter in implementing CAI, as well as the perceptions of students on the effectiveness of CAI in the Physics classroom. In this study, three separate questionnaires were used during data collection. These are; Teacher Challenges Questionnaire, Students' Perceptions Questionnaire, CAI Usage Questionnaire, and Attitudes Towards Physics Learning Questionnaire, which were all designed by the researcher.

3.6.2.1 Teacher Challenges and Solutions Questionnaire

The “Teacher Challenges and Solutions Questionnaire” (see Appendix B) was designed to assess the challenges CoE Physics tutors encounter in the integration of CAI in their Physics lessons, and the solutions they employ to address the challenges. This instrument consisted of two sections. The first section (PART A) sought for the background information of respondents, while the section (PART B) of this instrument was adapted from Bariham *et al.* (2019) and consisted of fourteen (14) items which were grouped into two domains. The detailed structure of the “Teacher Challenges and Solutions Questionnaire” is shown in Table 3.2.

Table 3.2: Structure of “Teacher Challenges and Solutions Questionnaire”

Domain	Description
Challenge (Items 1 – 9)	Measures CoE Physics tutors challenges they encounter during the integration of CAI
Solution (Items 10 – 14)	Measures the solutions CoE Physics tutors employ to address the challenges

The first domain of the “Teacher Challenges and Solutions Questionnaire”, which assessed the challenges CoE Physics tutors encounter in the integration of CAI, consisted of nine (9) items (items 1 – 9), as shown in Table 3.2 and Appendix B. However, the second domain, which assessed the solutions CoE Physics tutors employ to address the challenges, consisted of five (5) items (items 10 – 14). The “Teacher Challenges and Solutions Questionnaire” was designed as a rating scale type, which is characterised by closed-ended response options. Responses to the individual items lie on a four-point scale: “strongly agree”, “agree”, “disagree”, and “strongly disagree”. The respondents were asked to state their levels of agreement to the statements by choosing one response from a selected number from the following four responses given for each statement in the instrument.

3.6.2.2 CAI Usage Questionnaire

The “CAI Usage Questionnaire” (Appendix C1) consisted of two sections, thus, “PART A” and “PART B”. The first section (PART A) sought for the background information of respondents. The second section, “PART B” consisted of 15 items, which were also adapted from Bariham *et al.* (2019). The 15 items were statements which measured the use of CAI by CoE Physics tutors in their Physics lessons. The “CAI usage questionnaire” was also designed as a rating scale type, which is characterised by closed-ended response options. Responses to the individual items lie on a four-point scale: “Mostly used”, “Moderately used”, “Less used” and “Not used”. Respondents were asked to state their levels of usage to the statements by choosing one response from a selected number from the following four responses given for each statement in the instrument.

3.6.2.3 Students' Perceptions and Factors Questionnaire

The “Students’ Perceptions and Factors Questionnaire” (Appendix C2) was used to measure CoE Physics students’ perceptions towards the effectiveness of CAI in their learning of Physics, and the factors which contribute to their perceptions. This instrument was adapted from Gambari & Shuaibu (2013) and Arthur-Baidoo *et al.* (2022), and consisted of three sections. The first section, “PART A” sought for the background information of respondents, while the second section, “PART B”, which consisted of thirteen (13) item statements, characterised by closed-ended response options, sought to determine CoE Physics students’ perceptions towards the effectiveness of CAI in their learning of Physics. The third section, “PART C”, which consisted of five (5) “perception factors” also sought to determine the factors which contributed to CoE Physics students’ perceptions towards the effectiveness of CAI. Responses to the individual items and factors lie on a four-point scale: “strongly agree”, “agree”, “disagree” and “strongly disagree”. Respondents were asked to state their levels of agreement to the statements and factors by choosing one response from a selected number from the following four responses given for each statement and factor in the instrument.

3.6.2.4 Attitude Towards Physics Learning Questionnaire

The “Attitude Towards Physics Learning Questionnaire” was used to determine CoE Physics students’ attitudes towards the learning of Physics through the use of CAI. This instrument was also adapted from Boadu *et al.* (2014), and consisted of fourteen (14) attitude statements characterised by closed-ended response options. Responses to the individual items lie on a four-point scale: “strongly agree”, “agree”, “disagree” and

“strongly disagree”, where respondents were asked to state their levels of agreement to the statements by choosing one response from a selected number from the following four responses given for each statement in the instrument.

3.7 Validity of the Research Instruments

According to Appiah-Twumasi *et al.* (2022), a research instrument's validity determines that the tool accurately measures what it is intended to measure. In this study, content validity, a type of validity, which according to Cohen *et al.* (2018), determines the content appropriateness of the items on the instrument, was assessed. Cohen *et al.* furthers that in determining the content validity, the instruments must show that they fairly and comprehensively covers the domain or items that it purports to cover. One way to determine the content validity of instruments is by the use of expert judgment (Appiah-Twumasi *et al.*, 2022).

Accordingly, the research instruments were given to content evaluation panel to examine the items on the instruments, and made suggestions where necessary. According to Lawshe (1975) the content evaluation panel are composed of knowledgeable persons in the given field of study. As a result, the instruments were given to five (5) experts in the field of science education who determined whether each item on each instrument was “essential”, or “not essential”. Afterwards Lawshe's (1975) criteria was used to determine the content validity of the instruments, using Lawshe's Content Validity Ratio (CVR).

Table 3.3: CVI and CVR for “Teacher Challenges and Solutions Questionnaire”

Item	Panel 1	Panel 2	Panel 3	Panel 4	Panel 5	Panel 6	Agreement	CVI
1	X	X	0	X	X	X	5	0.833
2	X	X	X	X	X	X	6	1.000
3	X	X	0	X	X	X	6	0.833
4	X	X	X	X	X	X	6	1.000
5	X	X	X	X	X	X	6	1.000
6	0	X	X	X	X	X	5	0.833
7	X	X	X	X	X	X	6	1.000
8	X	X	X	X	X	X	6	1.000
9	X	X	0	X	0	X	4	0.670
10	X	X	X	X	0	X	5	1.000
11	X	X	X	X	X	X	6	1.000
12	X	X	0	X	X	X	5	0.833
13	X	X	X	X	X	X	6	1.000
14	X	X	X	X	X	X	6	1.000
CVR								0.928*

**CVR=CVI/14, where CVR=Content Validity Ratio, **CVI=Content Validity Index*

To determine the CVR, an initial Content Validity Index (CVI) must be determined for each item on the instrument. According to Ayre & Scally (2014), the CVI is computed as the number of experts rating the item as essential divided by the total number of experts who evaluated the item.

Afterwards, an overall CVI for the entire items is calculated, which, is determined by the mean of all individual CVIs. The CVR is then determined by dividing the overall CVI by the total number of items. The results for CVI for the items and the overall CVR for “Teacher Challenges and Solutions Questionnaire” is presented in Table 3.3. According to Almanasreh *et al.* (2018), CVR varies between 1 and -1, where high values of CVR indicate the agreement of panelists on the relevance of an item in the instrument.

As presented in Table 3.3, in this study, the content validity ratio of the “Teacher Challenges and Solutions Questionnaire” was 0.928, which according to Almanasreh *et al.* (2018), indicate a valid instrument.

CVI and CVR values were also determined for “CAI Usage Questionnaire”, as shown in Table 3.4.

Table 3.4: CVI and CVR for “CAI Usage Questionnaire”

Item	Panel 1	Panel 2	Panel 3	Panel 4	Panel 5	Panel 6	Agreement	CVI**
1	X	X	X	X	X	X	6	1.000
2	X	X	X	X	X	X	6	1.000
3	X	0	X	X	X	X	5	0.833
4	X	X	X	X	X	X	6	1.000
5	X	X	X	X	X	X	6	1.000
6	0	X	X	X	X	X	5	0.833
7	X	X	X	X	X	X	6	1.000
8	X	X	X	X	X	X	6	1.000
9	X	X	X	X	X	X	6	1.000
10	X	X	0	X	X	0	4	0.670
11	X	X	X	X	X	X	6	1.000
12	X	X	X	X	X	X	6	1.000
13	X	X	X	X	X	X	6	1.000
14	X	X	X	X	X	X	6	1.000
15	X	X	0	X	X	X	5	0.833
CVR								0.945*

* $CVR = CVI/15$, where $CVR = \text{Content Validity Ratio}$, ** $CVI = \text{Content Validity Index}$

It can be observed from Table 3.4 that the content validity ratio of the “CAI Usage Questionnaire” was 0.945, which according to Almanasreh *et al.* (2018), indicate a valid instrument.

Similarly, Table 3.5 shows the CVI and CVR values determined for “Students’ Perceptions and Factors Questionnaire”.

Table 3.5: CVI and CVR for “Students’ Perceptions and Factors Questionnaire”

Item	Panel 1	Panel 2	Panel 3	Panel 4	Panel 5	Panel 6	Agreement	CVI**
1	X	X	0	X	X	X	5	0.833
2	X	X	X	X	X	X	6	1.000
3	X	X	X	X	X	X	6	1.000
4	X	X	X	X	X	X	6	1.000
5	X	X	X	X	X	X	6	1.000
6	0	X	X	X	X	X	5	0.833
7	X	X	X	X	X	X	6	1.000
8	X	X	X	X	X	X	6	1.000
9	X	X	0	X	X	X	5	0.833
10	X	X	X	X	X	X	6	1.000
11	X	X	X	X	X	X	6	1.000
12	X	X	X	X	X	0	5	0.833
13	X	X	X	X	X	X	6	1.000
CVR								0.949*

* $CVR = CVI/13$, where $CVR = \text{Content Validity Ratio}$, ** $CVI = \text{Content Validity Index}$

The results as shown in Table 3.5 revealed that, the content validity ratio of the “Students’ Perceptions and Factors Questionnaire” was 0.949, which according to Almanasreh *et al.* (2018), indicate a valid instrument.

Table 3.6: CVI and CVR for “Attitude Towards Physics Learning Questionnaire”

Item	Panel 1	Panel 2	Panel 3	Panel 4	Panel 5	Panel 6	Agreement	CVI**
1	X	X	0	X	X	X	5	0.833
2	X	X	X	X	X	X	6	1.000
3	X	X	X	X	X	X	6	1.000
4	X	X	0	X	X	X	5	1.000
5	X	X	X	X	X	X	6	1.000
6	0	X	X	X	X	X	5	0.833
7	X	X	X	X	X	X	6	1.000
8	X	X	X	X	X	X	6	1.000
9	X	X	0	X	X	X	5	0.833
10	X	X	X	X	X	X	6	1.000
11	X	X	X	X	0	X	5	0.833
12	X	X	X	X	X	0	5	0.833
13	X	X	X	X	X	X	6	1.000
14	X	X	X	X	0	X	5	0.833
CVR								0.928*

**CVR=CVI/14, where CVR=Content Validity Ratio, **CVI=Content Validity Index*

Moreover, CVI and CVR values were determined for “Attitude Towards Physics Learning Questionnaire” and the results are presented in Table 3.6.

It can be observed from Table 3.6 that, the content validity ratio of the “Attitude Towards Physics Learning Questionnaire” was 0.928, which according to Almanasreh *et al.* (2018), indicate a valid instrument.

3.8 Pilot Study of the Instruments

The instruments were piloted in order to determine the reliability of the scores of the instruments. The pilot study was therefore conducted in Offinso College of Education, who shared similar characteristics with the research participants, but did not take part in the main study. According to Johanson & Brooks (2010), when conducting a pilot study with the aim of conducting preliminary surveys or developing scales, it is advisable to consider

a minimum of 30 representative participants from the population of interest as a reasonable recommendation for the sample size. Also, a sample size ranging from ten (10) to forty (40) per group, according to Hertzog (2008) is appropriate for determining the suitability of a research instrument. From the above recommendations in the literature, the sample size for the preliminary survey in this study was fifty-three (53) B.Ed. Basic Education students who study Physics took part in the pilot study, which was in excess of the recommendations in the literature (Hertzog, 2008; Johanson & Brooks, 2010).

3.9 Reliability of the Instruments

Reliability, as defined by Cohen *et al.* (2018), pertains to the degree of consistency in research findings over time. This implies that for research to be considered reliable, it should demonstrate that if conducted with a comparable group of participants in a similar context, it would yield consistent results. Therefore, a reliable tool in a specific study will produce consistent data from similar respondents across different time periods. The reliability of a research instrument can be evaluated by examining its internal consistency, where Cronbach's alpha is used to gauge the strength of this consistency. Thus, in assessing the reliability of the research instruments, the method of internal consistency reliability, namely Cronbach's alpha, was employed. The results are presented in Tables 3.7, 3.8, 3.9 and 3.10.

Table 3.7: Reliability of “Teacher Challenges Questionnaire”

Cronbach's Alpha	No. of Items	Sample size
.831	14	12

According to Mohajan (2017) alpha values range from 0 to 1, where 0 indicates no consistency among the items on a given scale, and 1 indicates absolute internal consistency. Mohajan (2017) further states that alpha values above or equal to 0.7 are generally considered acceptable and satisfactory; values above or equal to 0.8 are usually considered quite good, and values above or equal to 0.9 are considered exceptional internal consistency. Therefore, from Table 3.7, the Cronbach Alpha value, which measured the internal consistency of the scores of “Teacher Challenges Questionnaire” was 0.831. This value indicates a “good” internal consistency of the scores according to Mohajan (2017). This means that the internal consistency of “Teacher Challenges Questionnaire” was reliable, and that the Cronbach Alpha value of “Teacher Challenges Questionnaire” was high for the instrument to be used. Table 3.8 also shows the internal consistency of “CAI Usage Questionnaire”.

Table 3.8: Reliability of “CAI Usage Questionnaire”.

Cronbach's Alpha	No. of Items	Sample size
.726	15	254

Also, from Table 3.8, the Cronbach Alpha value, of the scores of “CAI Usage Questionnaire” was 0.726, which indicates an “acceptable” internal consistency of the scores according to Mohajan (2017). This means that the internal consistency of “CAI Usage Questionnaire” was reliable, and that the Cronbach Alpha value of “CAI Usage Questionnaire” was high for the instrument to be used.

The internal consistency of the scores of the “Students’ Perception Questionnaire” was also determined and the results are presented in Table 3.9.

Table 3.9: Reliability of “Students’ Perception Questionnaire”

Cronbach's Alpha	No. of Items	Sample size
.782	13	254

It can be observed from Table 3.9 that, the Cronbach alpha value for the “Students’ Perception Questionnaire” was 0.782, which represents an “acceptable” internal consistency of the scores according to Mohajan (2017), indicating that the “Students’ Perception Questionnaire” was reliable to be used in the main study.

Table 3.10 also determines the internal consistency of the scores from “Attitude towards Physics Learning Questionnaire”.

Table 3.10: Reliability of “Attitude Towards Physics Learning Questionnaire”

Cronbach's Alpha	No. of Items	Sample size
.799	14	254

As revealed in Table 3.10, the Cronbach alpha value for the “Attitude Towards Physics Learning Questionnaire” was 0.799, which represents an “acceptable” internal consistency of the scores according to Mohajan (2017), indicating that the “Attitude Towards Physics Learning Questionnaire” was reliable to be used in the main study.

3.10 Data Collection Procedure

During data collection, both quantitative and qualitative data were gathered. The data collection was done in three stages. The researcher oversaw the implementation of data collection procedures to ensure consistency and adherence to ethical guidelines. These included conducting interviews and administering surveys, as well as providing clear instructions on data collection protocols. In the first stage, official permission was sought from the respective Principals, Deans, and Head of Departments in the participating CoEs to include their students and tutors in this study, and they were assured of the confidentiality of any information provided by the students and tutors. The second stage involved the collection of quantitative and qualitative data from Physics tutors in the various CoEs. During this stage, Physics tutors were contacted and invited to participate in individual interviews, as well as completion of questionnaires. The interviews were conducted in person. Consent from the tutors was sought from the respondents for their view and opinions to be recorded.

The third stage of the data collection procedure involved the administration of Student Perception Questionnaires, CAI Usage Questionnaire, and Attitude Towards Physics Learning Questionnaire, to the sampled students during regular Physics class sessions. Informed consent was obtained from all participants, and their anonymity and privacy were safeguarded throughout the data collection process. The questionnaires were distributed, and students were given twenty (20) minutes to complete each of them. However, they were administered on different days. The researcher was available to clarify any questions or concerns raised by the students during the data collection process. Participants had the

freedom to withdraw from the study at any point without facing any negative consequences or anytime they felt uncomfortable or compromised. After administration of the questionnaire, twelve (12) students who were willing, and participated in the completion of the questionnaire, were randomly selected for the interview in order to determine qualitatively, their perceptions on the effectiveness of CAI in the Physics classrooms. As with the tutors, students' consents were sought for their views to be recorded for further analysis. Data were collected within the period of January to June, 2023.

3.11 Data Analysis Procedure

The data collected from respondents in this study were analysed quantitatively and qualitatively. Quantitative data analyses were conducted on the scores from the questionnaires, while qualitative data analysis was conducted on the responses from participants in the semi-structured interview. Table 3.11 shows the Statistical approaches employed to analyse the data collected in this study.

Table 3.11: Statistical Approaches Employed to Analyse Data Collected

Research question	Nature of data collected	Statistical approach used
Research Question 1	Scores from Teacher Challenges and solutions Questionnaire, and responses from interview	Descriptive and Thematic analysis (triangulation)
Research Question 2	Scores from Students' Perception and factors Questionnaire, and responses from focus group interview	Descriptive and Thematic analysis (triangulation)
Research Question 3	Quantitative and Qualitative findings of Research Questions 1 and 2	Descriptive and Thematic analysis (triangulation)
Research Question 4	Scores from CAI Usage Questionnaire and Attitudes Towards Physics Learning Questionnaire	Correlation

As presented in Table 3.11, three main statistical approaches were employed to answer the research questions in this study. These were descriptive statistics, thematic analysis, and correlational analysis. Statistical analysis was carried out using Statistical Package for Social Science (IBM SPSS), version 26.0 for Windows.

3.11.1 Descriptive Statistics

Descriptive statistics employed in this study were mean, standard deviation, and mean rank. These were determined from the scores of “Teacher Challenges and Solutions Questionnaire”, as well as “Students’ Perception and Factors Questionnaire”. By so doing, research questions 1, and 2 were answered quantitatively. Lovelace and Brickman (2013) argue that Likert-type items are ordinal, however, as response options, items, and sample sizes increase, a composite score from a measurement scale made up of the sum of a number of connected items might develop characteristics that seem much more continuous than categorical. Therefore, mean and standard deviation were used to analyse the scores from the instruments.

3.11.2 Thematic Analysis

Thematic analysis was used to analyse qualitative data from the responses of the interviews, as seen from Table 3.10. The data was coded and analysed to identify common themes and patterns. This helped to answer the research questions 1, and 2 qualitatively, thereby triangulating the findings of the research questions, which was determined in research question 3.

3.11.3 Correlational Analysis

To determine the relationship between the use of CAI and CoE Physics students' attitude towards Physics, a correlational analysis was conducted using the scores of "CAI Usage Questionnaire" and "Attitude Towards Physics Learning Questionnaire".

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter presents the demographic characteristics of the respondents, results and findings of the study. The results are presented based on the research questions. The information collected during the administration of research instruments have been analysed in terms of descriptive, correlational and thematic analysis. Statistical analysis was carried out using Statistical Package for Social Science (IBM SPSS), version 26.0 for Windows. A number of tables have been constructed for easy presentation of data. The results are presented based on the following research questions:

1. What challenges do teachers face when integrating Computer-Assisted Instruction (CAI) in Physics classrooms in colleges of education, and how do they address these challenges?
2. How do students perceive the effectiveness of Computer-Assisted Instruction in Physics classrooms in colleges of education, and what factors contribute to their perceptions?
3. To what extent do the quantitative findings on CoE Physics tutors' challenges in integrating CAI and CoE Physics students' perceptions on the effectiveness of CAI corroborate with the qualitative findings on CoE Physics tutors' challenges in integrating CAI and CoE Physics students' perceptions on the effectiveness of CAI?
4. What is the relationship between the use of Computer-Assisted Instruction in Physics classrooms in colleges of education and students' attitudes towards Physics?

4.1 Results of the Study

4.1.1 Results for Research Question 1

What challenges do tutors face when integrating Computer-Assisted Instruction (CAI) in Physics classrooms in colleges of education, and how do they address these challenges?

In order to ascertain the challenges Physics tutors encounter in using CAI for Physics instructions, tutors' views were sought using a four-point Likert-type questionnaire, as well as transcribed data of teachers' views from a semi-structured interview. Accordingly, the results were answered quantitatively and qualitatively, thereby triangulating the findings. Quantitatively, descriptive statistics, specifically means, standard deviations, overall mean scores, and mean ranks of the responses from the "Teacher Challenges and Solutions Questionnaire" were determined. To interpret the results, Pimentel (2019) developed a scale of interpretation for a four-point Likert scale questionnaire, which was adapted in this study. The scale of interpretation is presented in Table 4.1.

Table 4.1: Adapted Scale of Interpretation for a four-Point Likert-type Scale

Questionnaire			
Point	Scale Range	Level of Agreement	Interpretation
1	1.00 – 1.75	Strongly Disagree	Least
2	1.76 – 2.51	Disagree	Low
3	2.52 – 3.27	Agree	High
4	3.28 – 4.00	Strongly Agree	Highest

Source: (Pimentel, 2019)

Therefore, using Pimentel's scale of interpretation, the items were ranked according to the level of challenges based on their mean scores, as presented in Table 4.2.

Table 4.2: Descriptive Analysis of Scores from Teacher Challenges Questionnaire

Domain	Item	N	Mean	Std. Dev.	Interpretation	Mean Rank	
Challenges	Item 1	12	3.67	.492	Highest	4	
	Item 2	12	4.00	.000	Highest	1	
	Item 3	12	3.99	.000	Highest	2	
	Item 4	12	3.33	.492	Highest	6	
	Item 5	12	1.58	.515	Least	8	
	Item 6	12	3.52	.522	Highest	5	
	Item 7	12	2.58	.515	High	7	
	Item 8	12	1.50	.522	Least	9	
	Item 9	12	3.75	.452	Highest	3	
		Overall Mean/Std. Dev.	12	3.10	0.390	Highest	
Solutions	Item 10	12	3.21	.421	Highest	2	
	Item 11	12	1.99	.505	Low	3	
	Item 12	12	1.02	.523	Least	5	
	Item 13	12	1.23	.554	Least	4	
	Item 14	12	3.78	.010	Highest	1	
		Overall Mean/Std. Dev.	12	2.248	.421	High	

Table 4.2 summarises the mean scores and standard deviations of the 14 items of the “Teacher Challenges and Solutions Questionnaire”. When the analysis of results given in Table 4.2 is examined, it is observed that the mean scores of the items of the challenge dimension of the “Teacher Challenges and Solutions Questionnaire” ranged from 1.50 to 4.00, while standard deviations ranged between 0.00 and 0.522. The overall mean score of the challenge dimension was 3.10 (SD = 0.390), suggesting that CoE Physics tutors generally “agreed” that the challenges they encounter during the integration of CAI in their Physics classrooms is at a “high” level, per Pimentel’s scale of interpretation.

Specifically, as presented in Table 4.2, per Pimentel's scale of interpretation, items 1, 2, 3, 4, 6 and 9 were reported by CoE Physics to pose the "highest" level of challenge during their integration of CAI in their Physics lessons; item 7 was reported to be at a "high" level of challenge encountered by CoE Physics tutors, while items 5 and 8 were reported to pose the "least" level of challenge. Moreover, from Table 4.2, CoE Physics tutors' responses from the "Teacher Challenges and Solutions Questionnaire" revealed that, the highest ranked challenge encountered by CoE Physics tutors in integrating CAI into their Physics lessons is item 2 (lack of internet in the school), while the least ranked challenge is item 8 (unstable electricity supply).

As revealed in Table 4.2, in the "solutions dimension", which measures how CoE Physics tutors address the challenges they encounter, the mean item scores ranged from 1.02 to 3.78, standard deviations also ranged from 0.010 and 0.554. The overall mean score of the "solution" dimension was 2.248 (SD = 0.421), suggesting that CoE Physics tutors "agreed" that they address the challenges they encounter during the integration of CAI in their Physics classrooms at a "high" level, per Pimentel's scale of interpretation.

Specifically, per Pimentel's scale of interpretation, items 10 and 14 were reported by CoE Physics to be the "highest" level of solution employed to address the challenge they encounter during their integration of CAI in their Physics lessons; item 11 was rated to be at a "low" level of solution employed by CoE Physics tutors, while items 12 and 13 were reported to be at the "least" level of solution employed. Moreover, from Table 4.2, CoE Physics tutors' responses from the "Teacher Challenges and Solutions Questionnaire"

revealed that, the highest ranked solution employed by CoE Physics tutors in addressing the challenges they encounter in integrating CAI into their Physics lessons is item 14 (I purchase internet bundle with my personal money), while the least ranked solution employed is item 12 (I purchase my personal technological tools like projector, laptop, etc).

To validate this finding, CoE Physics tutors were interviewed in a semi-structured interview and the findings from the interview were thematically analysed, where the themes are presented in Table 4.3, with some representative statements stated below, where all names are pseudonyms.

Table 4.3: Thematic Analysis of Challenges CoE Physics Tutors Encounter in Implementing CAI

Theme	Challenge	Solution
1	lack of internet access for instructional purposes	Purchase of personal internet bundles
2	insufficient and faulty technological equipment	Drawing attention of school authorities
3	limited time to complete course work	Organising extra classes after normal school sessions
4	Lack of technological skills	Seeking help from well-versed colleagues and students

Theme 1: Lack of internet access for instructional purposes

As presented in Table 4.3, CoE Physics tutors suggested that tutors saw a lack of technological resources as a major obstacle to using CAI in their Physics classes. Despite a few instructors acknowledging that they have access to computers and internet in their

schools, the majority of them admitted they do not. Therefore, CoE Physics tutors articulated that in their attempt to implement CAI into their Physics lessons, access to internet has become one of the limiting factors. For instance, Mr. Nyarko, a Physics tutor who had taught Physics for eight years in a college of education said;

“I have been teaching Physics in this institution for eight years, but neither the government nor the authorities have made any effort to set up active internet services in the school that tutors and students may use to enhance teaching and learning in the classroom.” Mr. Nyarko further voiced out, *“Sometimes I would want to show video demonstrations in the course of instruction to help students understand and conceptualise some complex and abstract Physics concepts. Nevertheless, due to lack of internet access in the school, I find it difficult to do so. As a result, I always hear students complaining about the abstract nature of some Physics concepts we learn in the classroom”*.

Also, Mr. Ntiamoah, a CoE tutor who had taught Physics at the CoE for seven years added, *“...my brother, you agree with me that we are in days where the computer is assisting man to ease the complexities in life. But for academic purposes, it (the computer) can only be useful when we can access the internet. However, as we talk now, we do not have internet access in our college here.”* Mr. Ntiamoah continued that *“One thing is that Physics is always abstract. Sometimes you can draw a diagram or make an illustration to represent a Physics phenomenon, however, most of the concepts we learn in Physics are not always seen in real life by students and they may need to view an image or video for better understanding. But in this*

advanced technological world, those resources can only be acquired online. And here we are where we cannot even access those images online”.

Mr. Opoku, a Physics tutor who had been in service at the CoE for six years equally added that:

“...I always try to let students download video demonstrations and some tutorials relevant to the Physics concepts we learn in the classroom. However, students always complain they have limited amounts of money to purchase internet bundles all the time, which makes the integration of CAI very challenging. This is because no provision has been made to improve internet connectivity in the school for enhanced educational activities.”

Solution

In an attempt to provide a solution to this challenge, CoE Physics tutors asserted that they only try to purchase their own internet bundles which will enable them access the internet.

For example, in his own words, Mr. Nyarko stated that:

“Sometimes, what I do to solve this challenge is to use my personal money to buy internet bundles, so that I will be able to access the internet in search for content which will help me deliver lessons to students successfully. But will I always get money to buy internet bundles for my lessons”, Mr. Nyarko rhetorically asked.

In support of Mr. Nyarko’s initiative, Mr. Opoku also added that:

“The only way I could help is to purchase internet bundle for myself so as a professional who loves his job, I will have to purchase internet bundle with my own money before I can look for appropriate videos and tutorials to help students

understand difficult and abstract Physics concepts. And even if I buy, I do not think I can buy also for students.

Theme 2: Insufficient and faulty technological equipment

Another major challenge which hampers the integration of CAI by CoE Physics tutors into their Physics lessons is insufficient and faulty technological equipment which will help them integrate CAI successfully. For example, in his voice, Mr. Agyemang, who had also taught Physics in the CoE for six years articulated that:

“My friend, I have a laptop, and I am ready to sacrifice part of my salary to purchase internet bundle in order to access the internet for some tutorials and demonstrations to be implemented in my lessons, yet there are limited projectors in our department which could assist me to project videos and tutorials for students to understand the Physics concepts better”.

In agreement with Mr. Agyemang, Mr. Ofosu added that:

“Personally, I do not have a laptop, however, I always prefer to send students to the computer laboratory for some simulations on certain abstract concepts. Yet, I observe that, majority of our computer systems are faulty, and the good ones are also outdated which makes it difficult to run modern-day software for instructional purposes”.

Solution

To address this challenge, views of CoE Physics tutors were sought to determine how best they fix this challenge. In their attempt, tutors reported that they only try to forward their concerns to the appropriate authorities for their immediate intervention. For instance, in his voice, Mr. Agyemang stated that:

“I think for this challenge, it will only request appropriate authorities to intervene. This is because, when equipment like projectors is insufficient, it is only the institution which can provide or make arrangements for sufficiency. What I can only do is to borrow from other colleagues from different institution/department, but that obviously will be difficult”.

Not only Mr. Agyeman, but Mr. Ofosu, also suggested that:

“When computers and accessories are faulty, I think it is the responsibility of the institution to fix them. That is beyond the tutor. Therefore, what I do is to forward the challenge to the appropriate authority for their intervention”.

Theme 3: Limited time to complete course work

Additionally, CoE Physics instructors reported that time is another limiting factor which interferes the use CAI in class. Teachers must dedicate time to lesson planning, choosing the right software or digital resources, and becoming technological savvy in order to successfully integrate CAI (Boadu et al., 2014). For instance, Mr. Asiedu stated:

“I would love to integrate CAI into my Physics lessons, however, looking at the workload and time schedule, with the added responsibility of completing the course in time for students to get ready for their external examinations, I am always restrained to limit the usage of CAI”. Mr. Asiedu went further to say that *“mostly, when I plan using CAI, I will have to spend inordinate amount of time to gather resources, as well as finding the appropriate software to use. Due to this I mostly use the marker board for my Physics lessons”.*

Also Mr. Owusu, a CoE tutor who had taught Physics at CoE for nine years said that

“...the topics we are treating per semester are many, which we have to be diligent to complete them within few weeks in a semester, which can also be packed with numerous co-curricular activities for students, and other official responsibilities for tutors. Though in spite of all these, I integrate CAI in my lessons, but at a very minimal rate. Sometimes I download video demonstrations and tutorials for students to watch before face-to-face classroom activities. But I always see that additional information in the face-to-face classroom lessons may require further demonstrations, but due to time coupled with other official duties, I am not able to employ these videos and demonstrations at the maximum”.

Solution

To provide a solution to this challenge, CoE Physics tutors voiced out that they sometimes organise extra classes outside the normal school sessions so that they can complete their lessons within the semester if they are to integrate CAI into their lessons. For example, Mr. Owusu stated that:

“Oh, sometimes I try to organise extra classes (evenings/weekends/early mornings) apart from the usual school curriculum sessions, but that is not comfortable for students since they also need time to do other activities in addition to their personal studies. And because the extra classes are not organised by the college with students being comfortable, I have decided to stop”.

Mr. Asiedu further added that:

“... in this situation, the only solution is to organise extra classes for students, and these are also against the school’s regulations, so that means I do that in secret”.

Theme 4: Lack of technological skills

According to Boadu et al. (2014), initial time commitment can be significant, especially for tutors who are not accustomed to integrating technology into their lessons. For example, Mr. Nkansah, who had taught Physics in the CoE for over five years said that:

“I prefer using CAI and would be happy and willing to use it all the time since we are in an age where the use of computer has become the norm in every aspect of life. However, frankly speaking, I am not well versed in computing and we have few tutors who are ready to come to my aid when I encounter challenges. As a result, my usage of CAI is limited”.

In the same way, Mr. Aboagye, a CoE Physics tutor who had also taught Physics in the college for nine years said:

“There are skills and techniques which I think I must be acquainted with to be able to use CAI effectively in my Physics lessons; however, I lack some of those basic skills. Also, rarely do we get trained to acquire those basic skills needed to effectively use the computer to improve teaching and learning of Physics, since there are new and modern advancements in the use of the computer. Though I have colleague tutors who can come to my aid when I need them, they are very few in number. This makes it very difficult and stressful to integrate CAI fully in my lessons”.

Solution

To address this challenge, CoE Physics tutors stated that they only try to seek help from knowledgeable colleagues. For instance, Mr. Nkansah said,

“There are few young modern tutors who are more technologically inclined than I do, so I try to sometimes reach out to them for their assistance if the need be. I sometimes do not mind whether they are in my department or not”.

To add to Mr. Nkansah’s solution, Mr. Aboagye also said that:

“Some of the students are more knowledgeable in operating these technological equipment and resources. Anytime I want to integrate CAI and I feel like lacking the required knowledge to use it, I call on them to assist me so that I can successfully integrate it”

4.1.2 Results for Research Question 2

How do CoE students perceive the effectiveness of Computer-Assisted Instruction in Physics classrooms in colleges of education, and what factors contribute to their perceptions?

This research question sought to determine how Physics students in the CoE perceive the effectiveness of the implementation of CAI during Physics lessons, and the factors that contribute to their perceptions. This research question was also answered using both quantitative and qualitative data, thereby triangulating the findings. Thus, quantitatively, the perceptions and factors contributing to the perceptions of CoE Physics students towards the effectiveness of CAI were sought using means, standard deviations, overall mean scores, and mean rank, from a four-point Likert-type “Students’ Perceptions and Factors Questionnaire”. The results are presented in Table 4.4; while qualitative analysis was done using transcribed quotes of students’ views from a semi-structured interview.

Table 4.4: Descriptive Analysis of Scores from Students' Perceptions Questionnaire

Item	N	Mean	Std. Deviation	Mean Rank	Interpretation
ITEM 1	254	3.35	.615	9	Highest
ITEM 2	254	3.41	.513	7	Highest
ITEM 3	254	3.31	.671	12	Highest
ITEM 4	254	3.44	.624	4	Highest
ITEM 5	254	3.46	.634	3	Highest
ITEM 6	254	3.66	.632	1	Highest
ITEM 7	254	3.42	.563	6	Highest
ITEM 8	254	3.34	.582	10	Highest
ITEM 9	254	3.33	.587	11	Highest
ITEM 10	254	3.62	.554	2	Highest
ITEM 11	254	3.43	.554	5	Highest
ITEM 12	254	3.30	.630	13	Highest
ITEM 13	254	3.40	.545	8	Highest
Overall Mean Score	254	3.42	.593		Highest

The analysis of responses from “Students’ Perceptions Questionnaire”, as presented in Table 4.4, shows that for all the 13 items, the mean scores of the items from the “Students’ Perceptions and Factors Questionnaire” ranged from 3.30 to 3.66, while standard deviations ranged from 0.513 and 0.671. The overall mean score of the items from the “Students’ Perceptions and Factors Questionnaire” was 3.42 (SD = 0.593), suggesting that CoE Physics students’ general perception towards CAI is at the highest level according to Pimentel’s scale of interpretation. Specifically, all the items from the “Students’ Perceptions Questionnaire”, which measured the perceptions of CoE Physics students’ perceptions towards the implementation of CAI were interpreted as highest level of perception. It was also revealed from Table 4.4 that the highest ranked item was item 6 (CAI provides me with better understanding of complex issues in Physics), while the least ranked item was item 12 (I like learning with CAI because it can accommodate different learning styles).

The second part of research question 2, which sought to determine the factors that contribute to students' perceptions towards CAI was also answered using "PART C" of "Students' Perceptions and Factors Questionnaire". The scores of the responses from CoE Physics students were analysed using mean, standard deviations, and mean rank from the four-point Likert-type "Students' Perceptions and Factors Questionnaire". The results are presented in Table 4.5.

As revealed in Table 4.5, using Pimentel's scale of interpretation, students strongly agreed that all the factors stated in Table 4.5 contributed to their highest level of perception as indicated in Table 4.5. However, according to their ranks based on individual item means, perceived learning outcomes was the highest ranked factor which contributed to students' highest level of perception towards CAI, while interactivity was the least ranked factor which contributed to students' highest level of perception towards CAI.

Table 4.5: Descriptive Statistics of Students' Responses of Perception Factors from "Students' Perceptions and Factors Questionnaire"

Factor	Mean	Std. Dev.	Mean Rank
Teacher's Pedagogical Approach	3.69	.525	4
Learning Style	3.67	.543	3
Interactivity	3.30	.571	5
Relevance of Content	3.52	.550	2
Perceived Learning Outcomes	3.79	.505	1

To confirm the findings in research question 2, the perceptions of CoE Physics students were sought qualitatively through a face-to-face semi-structured interview and the replies from CoE Physics students suggested that students had positive perceptions concerning the

effectiveness of CAI in the Physics classrooms. Students’ perceptions were analysed in themes which are presented in Table 4.6. Some of the views of CoE Physics students (all names are pseudonyms) from the interview are also presented.

Table 4.6: Thematic Analysis of CoE Physics Students’ Perceptions Towards the Effectiveness of CAI

Theme	Perception	Contributory Factor
1	Understanding of Physics concepts	Better Academic Performances
2	Adoption of CAI in their professional careers	Tailoring Instructions to students’ need through real world applications
3	Recommendation of the continuous use of CAI by Physics tutors in the Physics classrooms	Guidance and Support from tutors and active participation

Theme 1: Understanding of Physics concepts

As presented in Table 4.6, CoE Physics students voiced that, one of their perceptions towards the implementation of CAI is understanding of Physics concepts. Students perceived that being exposed to CAI raise their understanding of Physics concepts to another level.

Owusuaa, a 23-year-old female CoE Physics student said

“...personally, I am so happy and very much comfortable with how my Physics tutor takes advantage of the computer to improve our understanding of Physics concepts. My Physics tutor most of the time gives us videos and tutorials before and after the lesson, especially when he perceives that particular topic was going to be difficult for us to understand. In this way, after watching the video demonstrations

and the tutorials, in addition to my Physics teacher's explanation of concepts in the classroom, I understand Physics concepts much better".

Alex, a 22-year-old male Physics student also said

"My Physics tutor does a great job by taking advantage of the social media. Sometimes before he comes to class, he sends us videos in addition to assignments from what we learnt from the video, concerning the topic he is yet to teach. Since my tutor adopted this teaching strategy, I have observed that my understanding of Physics concepts has moved to another level. I now enjoy Physics more than anyone in the class".

In the words of a 21-year-old female Physics student, Felicia remarked that

"...it is only in this school that I have experienced that Physics teachers make good use of the computer sometimes. In our Physics classroom, my Physics tutor always presents to us video demonstrations and tutorials when we find it difficult to understand the ideas which he wants us to grasp. Since then, I prefer not to learn from the textbook anymore. I have been a student who learns all the time using the computer, because my understanding level has improved".

Mohammed, who is a 23-year-old Physics student in the CoE also added that

"In fact, prior to my coming to the CoE, all that I was hearing in the house concerning Physics were not encouraging but I was determined to study Physics in the college. Some were saying it is too abstract, others were saying it is the most difficult subject among the sciences, and many more. But Sir, frankly speaking, since I came here, I have seen it to be absolutely opposite. In fact, I think my Physics tutor also acknowledges the fact that the subject is very difficult and sometimes

abstract, he uses the computer and internet to make sure that the concept is turned from abstract to concrete. This has really helped me in my learning of Physics in the college”.

Contributory Factor: Better Academic Performances

CoE Physics students expressed that what causes them to have the perception of understanding Physics concepts much better is how those understandings are reflected in their quizzes and assignments. For instance, Owusuaa added that:

“...This is evident in my performances during assessments. I always find out that, anytime my Physics tutor uses CAI to teach, my performance in quizzes is much better than when he only comes to the class to lecture”.

Also, Alex stated that:

“...I see my performance in class quizzes and assignments is always improved”.

In addition, Mohammed remarked that:

“...My second semester result in Physics was better than my first semester’s. I think in the second semester, my Physics teacher used technology more than the first semester. So I was able to learn according to my characteristic”.

Theme 2: Adoption of CAI in their professional careers

Also, CoE Physics students responded that if they are given opportunities and support from their prospective educational authorities, they would in no doubt use CAI in their professional careers. This is because student-teachers believe they have greatly benefit from the use of CAI in their training by their CoE Physics tutors and could equally transfer

such benefitted to their learners when posted to their field of practice. For instance, Ibrahim, a 24-year-old CoE Physics student acknowledged that:

“I think it is better to begin the introduction of learning with the computer in our basic schools, as well as the Senior High Schools. At least starting with the basic concepts which are required at their levels. This is because, how the introduction of the computer in our Physics lessons has benefited me is another world to me. For example, the way my Physics tutor uses CAI has really motivated me to use it when I get the opportunity to teach. I will therefore definitely apply it in my professional career if only I get the support and backing from the school’s authorities”.

In her view, Diana, a 23-year-old female Physics student added that:

“Sir, you know we are in the computer world where I think everything, including learning should be done with the computer. Therefore, personally, I will be happy to integrate the computer in the teaching and learning process in my professional career. I think this will draw young learners’ attention to the importance and benefits of mobile phones, tablets and modern technological devices and equipment in their academic lives, rather than using it for entertainment. I have actually learnt a lot through the way my teacher uses CAI, where he wants all students to be actively involved in the lesson.”

By adding to the views of Frimpong and Ibrahim, Cecilia also expresses her delight and anticipation on the use of CAI in her professional career since it would be of immense benefit to learners under her care. In her own words, Cecilia stated that;

“I will make no mistake to let this knowledge and benefit I have received here in the college be in vain. I will make sure that the younger ones whom I will also get the opportunity to train in the future will also benefit greatly from using the computer to learn, maybe beginning with the simple aspects. So that by the time they grow and advance to the higher levels in their academic careers, they would have understood the benefits of the computer in teaching and learning. This is because, the use of computer in the classroom and outside the classroom has transformed me as a student”.

Contributory Factor: Tailoring Instructions to Students’ Needs Through Real World Applications

CoE Physics student-teachers further explained that the contributory factor to them utilising CAI in their professional careers was as a result of how their Physics tutors integrated CAI in their Physics lessons. For instance, Cecilia, in her expression continued that:

“... my Physics tutor can connect CAI activities to real-world applications and scenarios. This helps me to see the practical value of what we always learn in Physics. And we are told that, students learn better when information is presented from concrete to abstract. So, I have witnessed this for myself, and I think it will be very good to also implement it with the younger students who even need to learn in more concrete ways”.

Ibrahim also added to Cecilia's voice that:

"...I think my Physics tutor can use CAI to modify instruction to individual student needs. I can now see that CAI adapts to my level and speed at which I understand some Physics topics. It is because of this reason that I personally believe what we are taught that, adapting instructions to students' level and pace of learning helps students to do well. Because of this I think it will be very good to also use it when I begin my service".

Theme 3: Recommendation of the continuous use of CAI by Physics tutors in the Physics classrooms

Lastly, Physics students in the CoE endorsed that they would like Physics tutors to continue and increase the use of CAI in Physics lessons. Students acknowledged that though the benefits they enjoy and the importance CAI has on their academic lives cannot be overlooked, however this benefit is the results of the minimal usage of CAI in the Physics classrooms. For example, Anthony, a 22-year-old Physics student-teacher in the CoE expressed that:

"...it is so exciting what I see the computer brings to me as a Physics student, however, this is only done less times. It is not always used by my tutor, but whenever he uses it, the way he uses it to suit my learning style makes me have a good experience. I do not know why he does not frequently use it, but I think they should not discontinue the use and integration of computer in the teaching and learning of Physics".

Paulina, a 22-year-old female Physics student-teacher similarly said:

“... perhaps for genuine reasons, I do not see my Physics tutor use it regularly, but even my tutor knows that his lessons become interesting to almost all students whenever he uses or integrates the computer into the Physics lessons. I will therefore recommend that, my Physics tutor should continue the use of computer during the instruction”.

Similarly, Angela, a 23-year-old female Physics student-teacher in the CoE said:

“In my class, some of my colleagues have this attitude that, whenever our Physics tutor comes to the class to lecture without using any aspect of the computer to facilitate instruction, they (students) feel bored and doze off while the tutor is teaching. I think it is because, students are not really engaged and also do not understand the concept being taught that day. But anytime, my tutor engages us through the integration of CAI, we become active. Therefore, I will recommend that my Physics tutor should use the computer often in the teaching and learning of Physics”.

Lydia, a 23-year-old female Physics student-teacher in the CoE also added that:

“... I have observed that, in any semester, topics which my tutor integrates the computer in the teaching and learning process, our grades are exciting to see, but in semesters where the computer and its other aspects are not used, we struggle in the exams. So, I hope that the computer and its other aspects are often used, even if it can be used every day in the teaching and learning of Physics”.

Contributory Factor: Guidance and Support from Tutors and Active Participation

CoE Physics student-teachers also recommended the continuous use of CAI by Physics tutors in the Physics classrooms due to the pedagogical approach by their tutors when they use CAI. For instance, Lydia expressed that:

“...my Physics tutor can offer guidance and support as we use CAI, especially when we encounter difficulties. Because this assistance always boost our confidence to use CAI”.

Angela also explained that:

“...my Physics tutor can plan activities that require active participation rather than sitting down and listening to him. When we interact with what learn and solve problems through CAI, we find it more engaging and effective, that is why I think it is better to use it always”.

4.1.3 Results for Research Question 3

To what extent do the quantitative findings on CoE Physics tutors' challenges in integrating CAI and CoE Physics students' perceptions on the effectiveness of CAI corroborate with the qualitative findings on CoE Physics tutors' challenges in integrating CAI and CoE Physics students' perceptions on the effectiveness of CAI?

This research question sought to determine how quantitative findings in this study validate with the qualitative findings. The results are presented in Table 4.7.

Table 4.7 showed that in merging quantitative and qualitative results, a merging-converging nature existed in Challenges CoE Physics tutors encounter in integrating CAI in their Physics lessons.

Table 4.7: Data Integration of Qualitative and Quantitative Findings

Aspect of focal point	Dimension	Quantitative finding	Qualitative finding	Nature of integration
CAI Implementation Challenge	Challenges	CoE Physics tutors challenges they encounter during the integration of CAI in their Physics classrooms is at a “high” level, with an overall mean score of the challenge dimension was 3.10 (SD = 0.390).	Tutors acknowledged that lack of internet access for instructional purposes, insufficient and faulty technological equipment, limited time to complete course work, and lack of technological skills hamper their integration of CAI.	Merging-converging
	Solutions	The overall mean score of the “solution” dimension was 2.248 (SD = 0.421), suggesting that CoE Physics tutors address the challenges they encounter during the integration of CAI in their Physics classrooms at a “high” level	CoE Physics tutors stated that they resort to purchase their personal internet bundles, drawing the attention of school authorities, organising extra classes after normal school sessions, and seeking help from well-versed colleagues and students.	Merging-converging
Students Perceptions Towards the Effectiveness of CAI	Perceptions	CoE Physics students generally had highest level of perception towards the effectiveness of	understanding of Physics concepts, adoption of CAI in their professional careers, and, recommendation of the continuous use	Merging-converging

	CAI. The overall mean score of the items from the “Students’ Perceptions Questionnaire” was 3.42 (SD = 0.593).	of CAI by Physics tutors in the Physics classrooms were some of the perceptions CoE Physics students had towards the effectiveness of CAI.	
Factors Influencing Perceptions	Using mean ranks, perceived learning outcomes was the highest ranked factor which contributed to students’ highest level of perception towards CAI, while interactivity was the least ranked factor which contributed to students’ highest level of perception towards CAI.	Students think their better academic performances in Physics assessments, Instructions tailored to students’ need through real world applications, as well as guidance and support from tutors and active participation, were some contributory factors leading to their highest level of perceptions	Merging-converging

4.1.4: Results for Research Question 4

What is the relationship between the use of Computer-Assisted Instruction in Physics classrooms in colleges of education and students’ attitudes towards Physics?

This research question sought to examine the relationship between the use of CAI in CoE Physics classrooms and students’ attitudes towards learning Physics. Therefore, to answer this research question, Pearson product-moment correlation analysis was used to examine the relationship between the use of CAI in CoE Physics classrooms and students’ attitudes

towards Physics learning, using the mean scores of items on “CAI Usage Questionnaire” and “Attitudes Towards Physics Learning Questionnaire”. However, before conducting correlation analysis, the data sets detected to be outliers were removed from both variables. This screening was done using the z-score from the scores of participants. Z-scores values that were not between -3, and +3 were removed from the data (Pallant, 2011).

Also, Pearson product-moment correlation analysis assumes that the scores on each variable, thus, use of Computer-Assisted Instruction in CoE Physics’ classrooms and Students’ attitudes towards Physics learning, should be normally distributed (Pallant, 2011). Subsequently, normality tests were conducted for the scores from “CAI Usage Questionnaire” and “Attitudes Towards Physics Learning Questionnaire”. In assessing the normality of the scores of both instruments, the Kolmogorov-Smirnov and Shapiro-Wilk assessments, which was guided by an assumption that each set of scores should be normally distributed (Pallant, 2011), with the null hypothesis stating that, the data sets are normally distributed. Therefore, to reject the null hypothesis, the p-value should be < 0.05 (Mishra *et al.*, 2019). The results of the normality tests are presented in Table 4.8.

Table 4.8: Results for Tests of Normality for Scores for CAI Usage and Attitude Towards Physics Learning

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CAI Usage	.118	254	.074	.967	254	.062
ATPL	.098	254	.062	.980	254	.079

a. Lilliefors Significance Correction; ATPL – Attitude Towards Physics Learning

The normality assessment presented in Table 4.8 indicates non-significant alpha (p) values of both Kolmogorov Smirnov and Shapiro-Wilk tests for CAI Usage Scores and Attitude Towards Physics Learning Scores. That is, the results show that the alpha (p) values were above 0.050 for both Kolmogorov-Smirnov test and Shapiro Wilk test. However, according to Mishra *et al.* (2019), Shapiro-Wilk test of normality is more powerful when considering a sample size of 50 or more participants. Accordingly, from Table 4.8, the Shapiro-Wilk test of normality for both CAI Usage Scores and Attitude Towards Physics Learning Scores are 0.967 ($p = 0.062$) and 0.980 ($p = 0.079$) respectively, produced a non-significant alpha (p) value, $p = 0.62 > 0.05$ as well as a Kolmogorov-Smirnov. Thus, the results as presented in Table 4.9, indicate a normal distribution of the scores of CAI Usage and Attitude Towards Physics Learning. This can be confirmed by a visual inspection of the histograms and standard Q-Q plots as shown in Appendix A1 to A4. Therefore, all the assumptions were met to use the correlation analyses to assess the relationships between CAI usage and Attitude Towards Physics Learning. Table 4.9 presents the results of the correlation between the two variables.

Table 4.9: Correlation Between CAI Usage and Attitude Toward Physics Learning

		CAI USAGE	ATPL
CAI USAGE	Pearson Correlation	1	.661*
	Sig. (2-tailed)		.028
	N	254	254
ATPL	Pearson Correlation	.661*	1
	Sig. (2-tailed)	.028	
	N	254	254

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

As stated by Pallant (2011) correlation coefficient, r , from 0.10 to 0.29 indicates a small correlation, 0.30 to 0.49 indicates medium correlation, and 0.50 to 1.00 indicates a strong correlation. Thus, the results of the analysis of the Pearson product-moment correlation conducted to determine the relationship between CAI Usage and Attitude Towards Physics Learning as presented in Table 4.9 show that a large significant positive correlation was obtained between CAI usage and Attitude Towards Physics Learning ($r = + 0.661$, $p < 0.028$).

4.2 Discussion of Results

This section described the major findings revealed in this study. The findings are discussed based on the specific research questions.

4.2.1 Discussion of Results of Research Question 1

What challenges do teachers face when integrating Computer-Assisted Instruction (CAI) in Physics classrooms in colleges of education, and how do they address these challenges?

The research question sought to determine the major challenges encountered by CoE Physics tutors in their quest to integrate CAI into the teaching and learning of Physics in their lessons. By triangulating the finding of this research question, qualitative and quantitative data were collected and analysed. Quantitatively, descriptive statistics of the scores from the challenge dimension of the “Teacher Challenges and Solutions Questionnaire” showed that CoE Physics tutors generally “agreed” that they encounter a “high” level of challenge according to Pimentel's (2019) scale of interpretation, with an overall mean score of 3.10 (SD = 0.390).

Specifically, CoE Physics tutors' responses from the "Teacher Challenges and Solutions Questionnaire" revealed that inadequate number of computers in the school, insufficient number of projectors in the school, lack of technical support for teachers, insufficient time for integration of CAI into teaching and learning process due to pressure to prepare students for exams, as well as lack of funds to purchase and maintain CAI resources in the colleges posed a "highest" level of challenge. Lack of funds to purchase and maintain CAI resources in the school was reported to pose a "high" level of challenge, while unstable electricity supply, and lack of relevant digital content to support the integration of CAI were reported by CoE Physics tutors to pose the "least" level of challenge. Overall, lack of internet in the school and unstable electricity supply were the highest and least ranked challenge hampering CoE Physics tutors' integration of CAI in their Physics lessons.

CoE Physics tutors were therefore asked how they address these challenges they face in the integration of CAI in their Physics lesson. Descriptive statistics from the "solutions" dimension of the "Teacher Challenges and Solutions Questionnaire" revealed that the overall mean score of the scores of "solution" dimension from "Teacher Challenges and Solutions Questionnaire" was 2.248 (SD = 0.421), suggesting that COE Physics tutors "agreed" that they address the challenges they encounter during the integration of CAI in their Physics classrooms at a "high" level, per Pimentel's (2019) scale of interpretation. In specificity, CoE Physics tutors reported that the "highest" level of solution they employ to address the challenges are to "purchase internet bundle with their personal money", as well as "always drawing the attention of school authorities to seek for their intervention". "Attending online seminars for knowledge and skills update" was employed at a "low"

level while “purchasing personal technological tools like projector, laptop, etc.” and “creating online blogs and websites for students to access important information relevant to the course” were employed at the “least” level to address the challenges CoE Physics tutors encounter in integrating CAI in their Physics lessons.

This was confirmed by CoE tutors through a semi-structured interview where CoE Physics tutors reported the lack of technological resources such as computers and their basic accessories, and lack of active internet connectivity, as well as lack of technological skills and inadequate time to integrate CAI into the teaching and learning of Physics in the CoEs. This finding agrees with that of Boadu *et al.* (2014), and Bariham *et al.* (2019), who also reported unavailability of technology resources, such as computers and projectors as a great challenge to their use of technology in teaching. Bonsu *et al.* (2020) also reported lack of funding, training of teachers, inadequate number of computers in schools; lack of internet in schools; insufficient number of projectors; lack of technical support for teachers; limited ICT skills among teachers and students; and lack of funds to purchase and maintain ICT resources in schools as the biggest challenges teachers encounter when using CAI in teaching and learning. But according to Bariham *et al.* (2019) if teachers are required to utilize CAI in a meaningful way, then unfettered access to training would constitute effective computer use. In this regard, effective leadership is essential for CAI implementation in general in teaching and learning.

However, many administrators and executives, particularly in Africa, lack computer literacy despite having minimal experience or education, limiting their usage of computers

to the most fundamental tasks like word processing and PowerPoint presentations Bello (2011). Also, according to Bello, the majority of emerging nations, particularly those in Africa, are severely constrained by a lack of resources. Even in cases where CAI's importance is explicitly endorsed, insufficient funding is frequently provided for the growth of ICT infrastructure in schools. For modern teachers who want to incorporate CAI into their lessons, this always presents many difficulties.

4.2.2 Discussion of Results of Research Question 2

How do students perceive the effectiveness of Computer-Assisted Instruction in Physics classrooms in colleges of education, and what factors contribute to their perceptions?

This research question sought to determine how Physics students in the CoE perceive the effectiveness of the implementation of CAI during Physics lessons, and the factors that contribute to their perceptions. Using both quantitative and qualitative data, it was found that CoE Physics students have “highest” level of perceptions about the effectiveness of CAI in their studies of Physics.

Quantitatively, responses from a four-point Likert-type “Students’ Perceptions Questionnaire” revealed an overall mean score of 3.42 (SD = 0.593), suggesting that COE Physics students’ general perception towards CAI is at the “highest” level according to Pimentel’s scale of interpretation, with all the items ranking at the “highest” level of perception towards the effectiveness of CAI. The highest ranked perception was “CAI provides me with better understanding of complex issues in Physics”, while the least

ranked perception was “I like learning with CAI because it can accommodate different learning styles”.

To determine the factors which contributed to CoE Physics students having their perception towards the effectiveness of CAI at “highest” level, descriptive statistics from “Perception Factors Questionnaire” revealed that, ranking from highest to lowest, Perceived Learning Outcomes (mean=3.79, SD=0.505), Relevance of Content (mean= 3.52, SD= 0.550), Learning Style (mean = 3.67, SD=0.543), Teacher's Pedagogical Approach (mean =3.69, SD=0.525) and Interactivity (mean = 3.30, SD= 0.571), were the factors which contributed to CoE Physics student-teachers’ highest level of perception towards the effectiveness of CAI.

This quantitative finding was also qualitatively validated through a semi-structured interview where students articulated that they understood concepts better anytime CAI is used by their Physics tutors, as well as seeking to implement CAI in their professional careers when they are given the needed support and opportunities to do so. Also, CoE Physics students recommended that due to the immense benefits they experience in learning Physics through CAI, their Physics tutors should continually use CAI in the lessons. This finding is in accordance with that of Gambari & Shuaibu (2013), Belal (2014) and Arthur-Baidoo *et al.* (2022), who all reported that students had positive perceptions about the integration of CAI. This finding is possible because according to Qaiser *et al.* (2017) the integration of CAI offers equal educational opportunities for students by using the same programme. It also helps to enable learners to focus on the physical meaning of

the abstract concepts, subsequently, to get a detailed understanding of the theory, while providing flexibility to learners. This will inevitably result in students becoming more engaged in the course and more motivated to study, which will improve their academic results (Ekundayo, 2022; Li et al., 2023).

4.2.3 Discussion of Results for Research Question 3

To what extent do the quantitative findings on CoE Physics tutors' challenges in integrating CAI and CoE Physics students' perceptions on the effectiveness of CAI corroborate with the qualitative findings on CoE Physics tutors' challenges in integrating CAI and CoE Physics students' perceptions on the effectiveness of CAI?

This research question sought to determine how quantitative findings in this study validate with the qualitative findings. When the quantitative finding was merged with qualitative findings under challenges CoE Physics tutors encounter during the integration of CAI, a converging of data was formed, as shown by the essential themes of lack of internet access for instructional purposes, insufficient and faulty technological equipment, limited time to complete course work, and lack of technological skills. Similarly, the “high level” solutions CoE Physics tutors employ to address such challenges also converged with the qualitative themes of purchasing their personal internet bundles, drawing the attention of school authorities, organising extra classes after normal school sessions, and seeking help from well-versed colleagues and students. By interpretation, this is the best CoE Physics tutors can do to overcome the challenges of integrating CAI. However, according to Wang (2008) and Lubis & Fithriani (2023), addressing the challenges for effective and successful

implementation of CAI does not involve only the tutor, but also authorities and major stakeholders of the educational system.

Furthermore, when merged together, the “highest” level of CoE Physics student-teachers’ perceptions towards the effectiveness of CAI, converged with the qualitative findings, as shown by the important themes of understanding of Physics concepts, adoption of CAI in their professional careers, and recommendation of the continuous use of CAI by Physics tutors. In addition, the factors which contribute to CoE Physics student-teachers’ “highest” level of perception (teachers’ pedagogical approach, learning style, interactivity, relevance of content, perceived learning outcomes) also merged with the qualitative findings as indicated by the themes of better academic performances, tailoring instructions to students’ needs through real world applications, guidance and support from tutors and active participation. This finding is also consistent with Gambari & Shuaibu (2013) who stated that more than 50 % of students who were exposed to CAI affirmed that CAI can help them learn some difficult concepts more easily, and also can accommodate different learning styles.

4.2.4: Discussion of Results of Research Question 4

What is the relationship between the use of Computer-Assisted Instruction in Physics classrooms in colleges of education and students' attitudes towards Physics?

The purpose of this research question was to determine the relationship between the use of CAI in CoE Physics classrooms and CoE student-teachers’ attitudes towards Physics learning. Therefore, correlational analysis was conducted between the two variables, thus

CAI Usage and Attitudes Towards Physics Learning. Using Pearson product-moment correlation analysis, it was found that there was a large significant positive correlation between CAI usage and Attitude Towards Physics Learning ($r = + 0.661$, $p < 0.028$). This provides a coefficient of determination of 43.69 %. The coefficient of determination (43.69 %) signifies that CAI usage accounts for a substantial portion of the variance in student-teachers' attitudes toward Physics learning. In other words, nearly 43.69% of the differences in attitudes among respondents can be attributed to the use of CAI. This finding highlights the significant influence of CAI on attitudes. The study suggests that maximizing the use of CAI in CoE Physics classrooms can have a positive impact on student-teachers' attitudes toward Physics learning. This implication is essential for educators and policymakers looking to enhance the teaching and learning of Physics. In support of this, Zhussupbayev *et al.* (2023) found that students who had access to CAI resources showed a significant improvement in their attitudes toward Physics. Jasmine & Subramanian (2017) also observed similar trends in their research regarding the influence of CAI on student attitudes, as well as, Pilli & Aksu (2013) who in their research demonstrated the impact of CAI on students' attitudes toward learning, particularly in the context of Physics Education. These studies collectively provided a body of evidence supporting the idea that CAI can influence attitudes toward Physics positively.

CHAPTER FIVE

SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.0 Introduction

This chapter summarises the findings of this study, as well as, recommendations/policy implications, future research directions, and conclusion.

5.1 Summary of Findings

1. Challenges faced by CoE Physics Tutors in Implementing CAI:
 - CoE Physics tutors in the Mampong Municipality and Sekyere South District encounter various challenges in integrating Computer-Assisted Instruction (CAI) into their teaching.
 - Main challenges include inadequate technological resources such as computers and projectors, lack of technical support, time constraints due to exam pressure, and financial constraints.
 - Lack of internet connectivity and unstable electricity supply were identified as the most significant challenges.
2. Strategies employed by CoE Physics Tutors to address Challenges:
 - CoE Physics tutors primarily address challenges by purchasing internet bundles personally and seeking intervention from school authorities.
 - Other strategies include attending online seminars for knowledge update and purchasing personal technological tools.

3. Perceptions of CoE Physics Students Towards CAI:

- CoE Physics students generally perceive CAI as highly effective.
- They believe that CAI enhances their understanding of complex Physics concepts.
- Factors contributing to students' positive perceptions included perceived learning outcomes, relevance of content, teaching pedagogical approach, and learning style accommodation.

4. Qualitative insights from CoE Physics Students:

- CoE Physics students reported that the integration of CAI by their tutors improves their understanding of Physics concepts.
- They express willingness to use CAI in their professional careers if provided with support and opportunities.
- Students desire more frequent use of CAI in Physics lessons.

5. Integration of Quantitative and Qualitative Findings:

- Both quantitative and qualitative findings aligned, indicating consistency in the results obtained from different research methods.

6. Relationship between CAI Usage and Attitude Towards Physics Learning:

- There was a significant positive correlation between the usage of CAI and CoE students' attitudes towards learning Physics.
- This suggested that the integration of CAI positively influenced students' attitudes towards Physics learning in CoE.

These findings collectively highlight the challenges faced by tutors, the positive perceptions of students towards CAI, and the significant impact of CAI integration on students' attitudes towards learning Physics in CoE settings in the Mampong Municipality and Sekyere South District.

5.2 Recommendations/Policy Implications

Based on the findings of this study, the following recommendations were made which inform major stakeholders of education in the Mampong Municipality and the Sekyere South District to make decisions concerning teaching and learning of Physics in the colleges of education.

1. **Increase Technological Infrastructure:** Educational authorities should prioritize increasing access to technological resources such as computers, projectors, and stable internet connectivity in Colleges of Education (CoE). This will help alleviate the challenges faced by Physics tutors in integrating CAI into their teaching.
2. **Provide Technical Support:** Institutions should establish mechanisms for providing technical support to teachers regarding the integration of CAI into their lessons. This may include training sessions, technical assistance teams, or help desks dedicated to addressing technological issues.
3. **Allocate Sufficient Time for CAI Integration:** Educational policymakers should consider revising curricula and exam schedules to allow adequate time for the integration of CAI into teaching and learning processes. This will reduce the pressure on tutors and enable them to effectively utilize CAI resources.

4. **Financial Support for CAI Resources:** Government agencies and educational institutions should allocate funds specifically for the purchase and maintenance of CAI resources in CoEs. This will ensure that tutors have access to the necessary tools and materials for effective implementation of CAI.
5. **Professional Development Opportunities:** Authorities should organize regular seminars, workshops, and training sessions to update tutors' knowledge and skills in using CAI effectively. This will enable tutors to stay abreast of technological advancements and pedagogical approaches in Physics education.
6. **Encourage Ongoing Use of CAI:** Institutions should encourage and incentivize tutors to incorporate CAI into their lessons regularly. Recognizing and rewarding tutors who effectively integrate CAI can foster a culture of innovation and continuous improvement in Physics education.
7. **Promote Student-Centered Learning:** Policies should emphasize the importance of student-centered learning approaches facilitated by CAI. This includes providing support for tutors to tailor CAI resources to accommodate diverse learning styles and preferences among CoE Physics students.
8. **Long-Term Planning and Sustainability:** Educational authorities should develop long-term plans for sustaining CAI initiatives in CoEs. This may involve establishing partnerships with technology companies, leveraging government funding, and incorporating CAI into institutional development strategies.
9. **Research and Evaluation:** Continuous research and evaluation should be conducted to monitor the effectiveness of CAI integration in CoEs. This will help identify

emerging challenges, assess the impact on student learning outcomes, and inform evidence-based decision-making in education policy.

10. Policy Alignment with National Goals: Education policies related to CAI integration should align with broader national goals and strategies for improving educational quality, enhancing digital literacy, and promoting innovation in teaching and learning across all levels of education in Ghana.

By implementing these recommendations and policy implications, educational stakeholders can enhance the effectiveness of CAI integration in CoEs, thereby improving the quality of Physics education and fostering positive attitudes towards learning among students.

5.3 Future Research Directions

Based on the findings of this study, the following suggestions were made.

1. Longitudinal Studies: Conduct longitudinal studies to explore the long-term effects of CAI integration on both student learning outcomes and tutors' instructional practices in CoEs. This would provide insights into the sustainability and scalability of CAI initiatives over time.
2. Comparative Studies: Compare the effectiveness of different CAI tools, platforms, and instructional approaches in Physics education within CoEs. Investigate how variations in technology use impact student engagement, learning outcomes, and tutors' experiences across different contexts.

3. **Exploration of Innovative Pedagogies:** Explore innovative pedagogical approaches that leverage CAI to enhance interactive and collaborative learning experiences in Physics classrooms. Investigate strategies for integrating virtual labs, simulations, and multimedia resources to promote inquiry-based learning and problem-solving skills among CoE Physics students.
4. **Teacher Professional Development:** Investigate the impact of targeted professional development programs on tutors' technological competencies, pedagogical practices, and attitudes towards CAI integration. Explore effective strategies for empowering tutors to overcome challenges and maximize the potential of CAI in Physics education.
5. **Student-Centered Learning Environments:** Examine the role of CAI in fostering student-centered learning environments and promoting active engagement among CoE Physics students. Investigate how personalized learning pathways, adaptive feedback mechanisms, and collaborative online platforms can enhance student motivation and self-regulated learning in Physics.
6. **Inclusion and Accessibility:** Investigate strategies for ensuring inclusive access to CAI resources and addressing potential equity issues in CoE settings. Explore how CAI can be adapted to accommodate diverse learning needs, preferences, and abilities among students, including those with disabilities or limited access to technology.
7. **Cross-Disciplinary Perspectives:** Explore interdisciplinary collaborations between Physics education researchers and experts in educational technology, cognitive

science, and instructional design. Investigate how insights from these fields can inform the design, implementation, and evaluation of CAI initiatives in CoEs.

8. Policy and Institutional Contexts: Investigate the influence of educational policies, funding structures, and institutional support mechanisms on the adoption and integration of CAI in CoEs. Examine how policy frameworks can be designed to incentivize innovation, foster collaboration, and support sustainable implementation of CAI initiatives.
9. Student Perspectives and Experiences: Conduct qualitative studies to further explore CoE Physics students' perceptions, experiences, and preferences regarding CAI integration. Investigate how students interact with CAI resources, their attitudes towards technology-mediated learning, and the factors influencing their learning experiences in Physics classrooms.
10. Global Perspectives and Comparative Analyses: Compare the findings of this study with similar research conducted in other countries or educational contexts. Investigate cross-cultural differences in the implementation and impact of CAI in Physics education, and identify transferable best practices for enhancing teaching and learning outcomes in CoEs.

By pursuing these future research directions, scholars can advance our understanding of the opportunities and challenges associated with CAI integration in CoEs, inform evidence-based educational policies and practices, and contribute to the ongoing improvement of Physics education in Ghana and beyond.

5.4 Conclusion

In conclusion, this thesis has shed light on the challenges faced by Physics tutors in integrating Computer-Assisted Instruction (CAI) into teaching practices within Colleges of Education (CoEs) in the Mampong Municipality and the Sekyere South District of Ghana. The findings underscore the critical importance of addressing issues such as inadequate technological infrastructure, limited technical support, and financial constraints to facilitate effective CAI implementation. Despite these challenges, the study revealed a strong positive perception among CoE Physics students regarding the effectiveness of CAI in enhancing their understanding of complex Physics concepts.

The recommendations and policy implications derived from this research highlight the need for concerted efforts from educational authorities, institutions, and policymakers to improve access to technology, provide ongoing support and training for tutors, and promote student-centered learning environments. By addressing these recommendations, CoEs can create a conducive ecosystem for the successful integration of CAI, ultimately enhancing the quality of Physics education and fostering positive attitudes towards learning among students.

Furthermore, the study identifies several promising avenues for future research, including longitudinal studies to assess the long-term impact of CAI, comparative analyses of different instructional approaches, and investigations into innovative pedagogies and inclusive practices. By continuing to explore these research directions, scholars can contribute to the ongoing improvement of Physics education in CoEs and inform evidence-

based policies and practices aimed at enhancing teaching and learning outcomes in Ghana and beyond.

Overall, this thesis underscores the transformative potential of CAI in Physics education within CoEs and emphasizes the importance of collaborative efforts to overcome challenges and maximize the benefits of technology-mediated learning for both tutors and students. Through strategic investments, innovative approaches, and ongoing research, CoEs can harness the power of CAI to cultivate a generation of scientifically literate and technologically proficient graduates equipped to thrive in an increasingly digital world.

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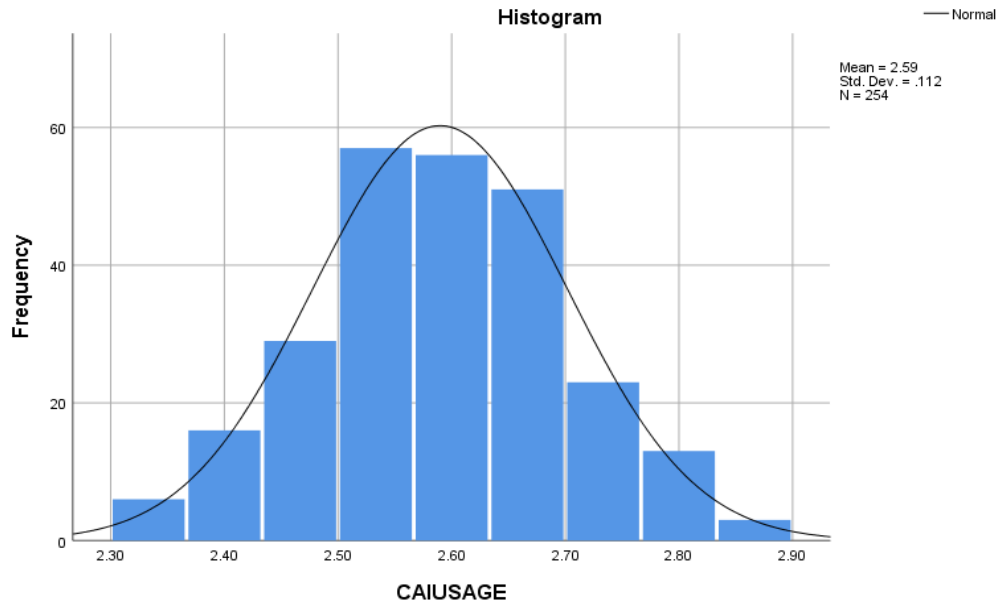
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APPENDICES

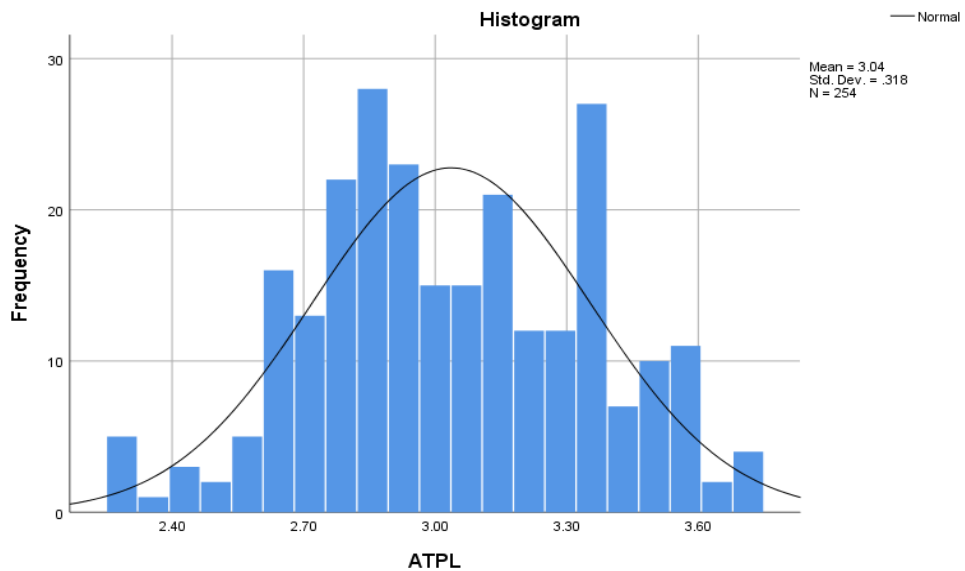
Appendix A1

Histogram for Scores of CAI Usage



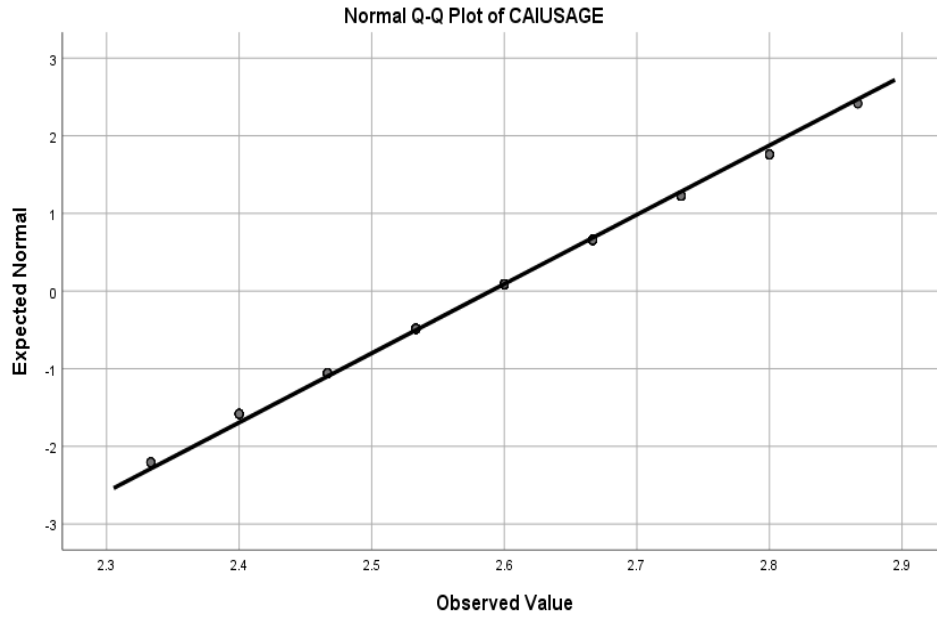
Appendix A2

Histogram for Score of Attitude Towards Physics Learning



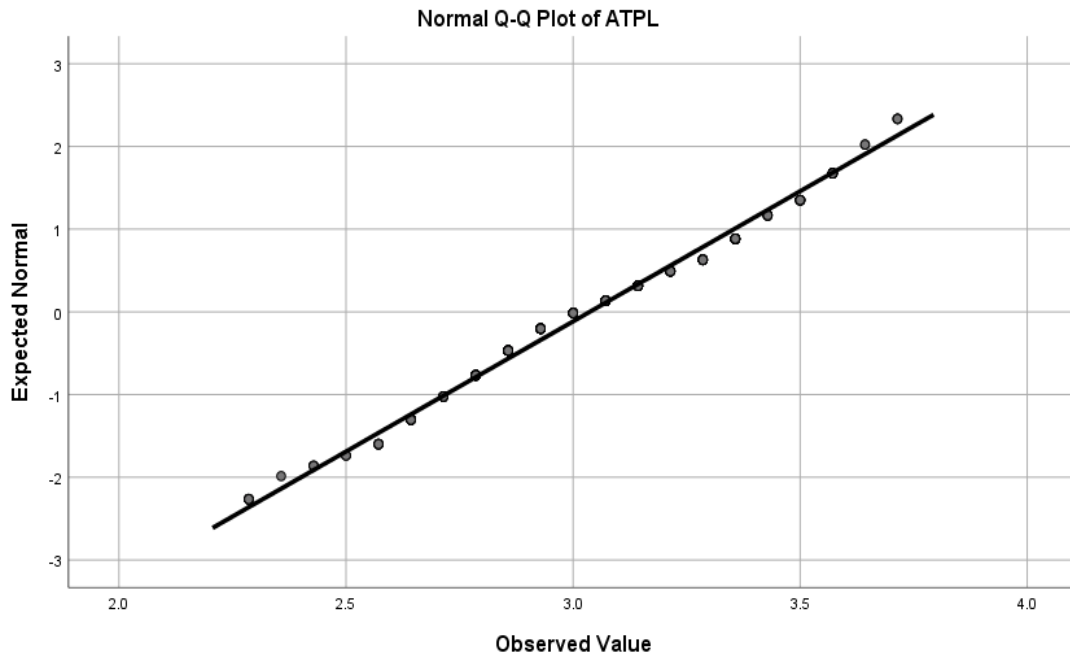
Appendix A3

Normal Q-Q Plot for Sores of CAI Usage



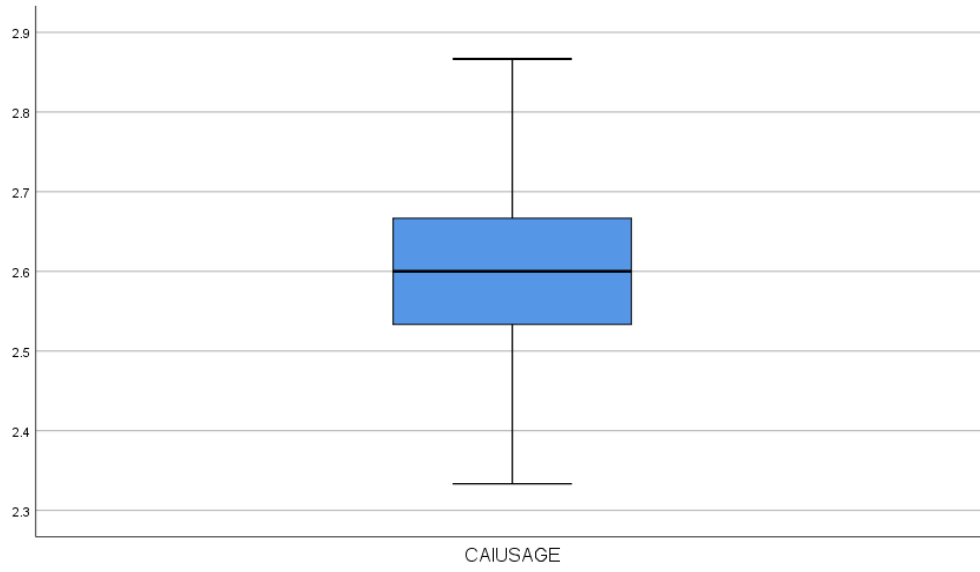
Appendix A4

Normal Q-Q Plot for Scores of Attitudes Towards Physics Learning Questionnaire



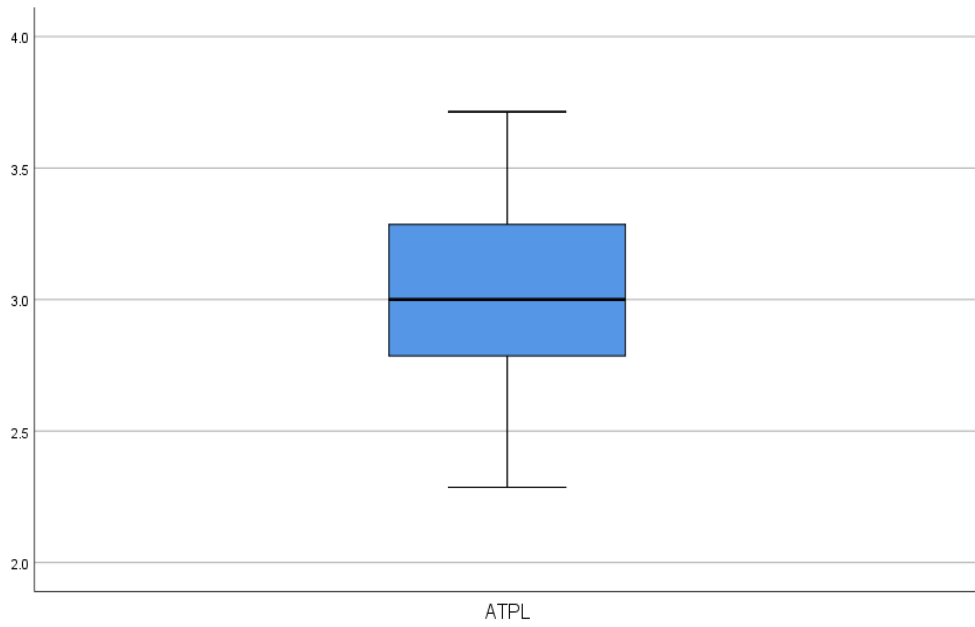
Appendix A5

Box Plot for Score of CAI Usage



Appendix A5

Box Plot for Score of CAI Usage



Appendix B

TEACHER CHALLENGE AND SOLUTION QUESTIONNAIRE

PART A

DEMOGRAPHIC CHARACTERISTICS

This section contains tutors' demographic characteristics. Please provide the appropriate information in the boxes provide beside each characteristic.

NUMBER OF YEARS IN SERVICE GENDER: Male Female

PART B

This section consists of a number of statements with their responses, concerning CoE tutors' challenges encountered through the usage of CAI in Physics lessons. The responses range from Strongly Agree to Strongly Disagree. Please provide the appropriate response by ticking the corresponding response scale beside each statement.

[Response scale: *Strongly Agree (SA) *Agree (A) *Disagree (D) *Strongly Disagree (SD)]

Domain	Item	Statement	Response			
Challenge	1	Inadequate number of computers in the school	SA	A	D	SD
	2	Lack of internet in the school	SA	A	D	SD
	3	Insufficient number of projectors in the school	SA	A	D	SD
	4	Lack of technical support for teachers.	SA	A	D	SD
	5	Limited ICT skills among teachers and students.	SA	A	D	SD
	6	Lack of relevant digital content to support the integration of CAI	SA	A	D	SD

	7	Insufficient time for integration of CAI into teaching and learning process due to pressure to prepare students for exams	SA	A	D	SD
	8	Unstable electricity supply	SA	A	D	SD
	9	Lack of funds to purchase and maintain CAI resources in the school.	SA	A	D	SD
Solution	10	I always draw the attention of school authorities to seek for their intervention	SA	A	D	SD
	11	I attend online seminars for knowledge and skills update	SA	A	D	SD
	12	I purchase my personal technological tools like projector, laptop, etc.	SA	A	D	SD
	13	I create online blogs and websites for students to access important information relevant to the course	SA	A	D	SD
	14	I purchase internet bundle with my personal money	SA	A	D	SD

Appendix C1

CAI USAGE QUESTIONNAIRE

PART A

DEMOGRAPHIC CHARACTERISTICS

This section contains students' demographic characteristics. Please provide the appropriate information in the boxes provide beside each characteristic.

AGE **GENDER: Male** **Female**

PART B

This section consists of a number of statements with their responses, concerning the usage of CAI in Physics lessons in colleges of education. The responses range from “Not Used” to “Mostly Used”. Please provide the appropriate response by ticking the box beside each statement corresponding to the response scale.

CAI USAGE STATEMENT	RESPONSE			
	Not Used	Less Used	Moderately Used	Mostly Used
1. Application of video and DVDs for demonstrations during teaching of Physics				
2. Use of radio to support students to learn concepts during teaching and learning of Physics				
3. Use Spreadsheet to plot graphs during teaching and learning				
4. Downloading images from YouTube and using them during teaching and learning process				

5. Use Power point presentation during teaching and learning process				
6. Use of SMART boards during teaching				
7. Use of mobile phones to support students search online for information during teaching and learning process				
8. Adding video clip to power point during instructions				
9. Use of WhatsApp to create a platform for learning				
10. Creating and maintaining blogs or website to support students learning				
11. Application of Computer games in teaching and learning				
12. Application of Computer tutorials during teaching and learning				
13. Application of Computer drills and practice to support students learning				
14. Application of Computer intelligent systems to enhance students learning				
15. Application of Computer simulations to enhance students learning				

Appendix C2

STUDENTS' PERCEPTIONS QUESTIONNAIRE

PART A

DEMOGRAPHIC CHARACTERISTICS

This section contains students' demographic characteristics. Please, provide the appropriate information in the boxes provide beside each characteristic.

AGE **YEAR** **PROGRAMME**

GENDER: Male **Female**

PART B

This section consists of a number of perception statements with their responses, concerning the effectiveness of CAI in Physics lessons in colleges of education. The responses range from Strongly Agree to Strongly Disagree. Please provide the appropriate response by ticking the corresponding response scale beside each statement.

[Response scale: *Strongly Agree (SA) *Agree (A) *Disagree (D) *Strongly Disagree (SD)].

PERCEPTION STATEMENT	RESPONSE			
I enjoy using computer to solve Physics problems	SA	A	D	SD
Using computer to solve Physics problems gives immediate feedback	SA	A	D	SD

I learn faster when I use computer to solve Physics problems	SA	A	D	SD
The usage of computer to solve Physics questions can be enjoyable and stimulating	SA	A	D	SD
Knowing how to use computers is a worthwhile skill for Physics students	SA	A	D	SD
CAI provides me with better understanding of complex issues in Physics	SA	A	D	SD
CAI links the various topics together	SA	A	D	SD
CAI brings out the meaning of the abstract concept better	SA	A	D	SD
Computer can be exciting when used to solve Physics problems among the group members.	SA	A	D	SD
I can learn Physics using computer without the help of teacher	SA	A	D	SD
Using computer to learn Physics improves my understanding of Physics	SA	A	D	SD
I like learning with CAI because it can accommodate different learning styles	SA	A	D	SD
I have a lot of self-confidence when it comes to working with computers	SA	A	D	SD

PART C

This section consists of five factors which contribute to your perception towards the effectiveness of CAI in Physics lessons in colleges of education, with their responses. The responses range from Strongly Agree to Strongly Disagree. Please, provide the appropriate response by ticking the corresponding response scale beside each statement.

Factor	Response			
Teacher's Pedagogical Approach	SA	A	D	SD
Learning Style	SA	A	D	SD
Interactivity	SA	A	D	SD
Relevance of Content	SA	A	D	SD
Perceived Learning Outcomes	SA	A	D	SD

Appendix D

ATTITUDE TOWARDS PHYSICS LEARNING SCALE

PART A

DEMOGRAPHIC CHARACTERISTICS

This section contains students' demographic characteristics. Please provide the appropriate information in the boxes provide beside each characteristic.

AGE YEAR PROGRAMME

GENDER: Male Female

PART B

This section consists of a number of statements with their responses, concerning CoE students' attitude towards Physics through the usage of CAI in Physics lessons. The responses range from Strongly Agree to Strongly Disagree. Please provide the appropriate response by ticking the corresponding response scale beside each statement.

[Response scale: *Strongly Agree (SA) *Agree (A) *Disagree (D) *Strongly Disagree (SD)]

ATTITUDE STATEMENT	RESPONSE			
CAI use makes Physics lessons exciting	SA	A	D	SD
I participate meaningfully in class when CAI is used	SA	A	D	SD
I become attentive in class and focus on the lesson through the use of CAI	SA	A	D	SD
I think critically about Physical events during CAI lessons in Physics	SA	A	D	SD

I show greater involvement and engagement in lessons during CAI lessons in Physics.	SA	A	D	SD
I ask questions that bother my mind during CAI lessons in Physics	SA	A	D	SD
I demonstrate better understanding in Physics concepts when CAI is used	SA	A	D	SD
I get good grades in Physics when CAI is used	SA	A	D	SD
I am regular and punctual at Physics lessons anytime CAI is used in Physics lessons	SA	A	D	SD
I learn Physics better through the use of videos or documentaries	SA	A	D	SD
I show interest in Physics lessons when CAI is used	SA	A	D	SD
I can learn from different perspectives	SA	A	D	SD
Physics can be improved with the introduction of CAI	SA	A	D	SD
I accept that tutors should use CAI in class	SA	A	D	SD

Appendix E1

Interview guide for CoE Physics tutors challenges they encounter in Integrating

CAI

1. How often do you use CAI during the teaching and learning of Physics, and what motivates you?
2. What are some of the challenges that are within and beyond your control, which you encounter during the implementation of CAI?
3. How do you address these challenges when they are met?
4. How do other tutors come to your aid when those challenges are met?
5. What necessary arrangements has your school put in place to help tutors effectively implement CAI during Physics lessons?

Appendix E2

Interview guide for Students' Perceptions Towards the Effectiveness of CAI

1. What aspects of CAI do you like best, and why?
2. How does CAI suit your style of learning?
3. Briefly describe the differences in your knowledge of Physics concepts when your Physics tutor uses CAI versus when he does not.
4. Why would you like your Physics tutor to use CAI more or less than they are currently using?
5. To what extent will you use CAI in the classroom when you become a professional teacher, and how do you intend to use it in your lessons?