UNIVERSITY OF EDUCATION, WINNEBA

USING COMPUTER-ASSISTED INSTRUCTION TO IMPROVE STUDENTS' PERFORMANCE IN SOME SELECTED BIOLOGY TOPICS AT ODUPONG SENIOR HIGH SCHOOL

LIONEL NOBLE DZIEDZORM KPOGO

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LIONEL NOBLE DZIEDZORM KPOGO
(202113775)

A thesis submitted to the school of graduate studies in partial fulfilment of the requirement for the award of the degree of Master of Philosophy (Science Education)

DEPARTMENT OF SCIENCE EDUCATION,
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UNIVERSITY OF EDUCATION, WINNEBA

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DECLARATION

STUDENT'S DECLARATION

I, **Lionel Noble Dziedzorm Kpogo,** declare that this thesis, with the exception of quotations and references contained in published works which have all, to the best of my knowledge, been identified and acknowledged, is entirely my own original work and it has not been submitted either in part or whole, for another degree elsewhere.

SIGNATURE ……………………..……..

DATE ……………………..……..……….

SUPERVISOR'S DECLARATION

I, hereby that the preparation and presentation of this thesis was supervised in accordance with the guidelines set for dissertations laid down by the university of Education, Winneba.

NAME OF SUPERVISOR: DR. ERNEST I.D. NGMAN-WARA

SIGNATURE …………………..………

DATE ……………………..……..………...

DEDICATION

This work is dedicated to my dear parents, Dr. Philips A. Kpogo, and Mrs Gladys Adzo Dzata-Kpogo of blessed memory. Mum, thank you very much for inculcating into us the good teachings of God. We thank God for gifting you unto us, family and the society as a whole. To my siblings Frederick, Rosemond, Aaron, Philomina, and Bright thank you all for the support and May God bless us all.

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To my dear mother who had always encouraged me to climb high in education but unfortunately passed away a few months ago, I'm most grateful for your genuine love for us all. I am however deeply saddened and broken by your sudden demise. I will painfully miss your absence in my next graduation. However, your good teachings will always guide us.

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Finally, I congratulate myself for trusting in the divine renewing mercies of God towards me every day and helping me pursue and complete this M.Phil. Programme successfully during the most turbulent times in my life.

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ABSTRACT

The study investigated the effect of using computer-assisted instruction in teaching selected Biology topics on performance of SHS 2 Biology students at Odupong Senior High School located in the Awutu Senya East Municipality. One research question and two hypotheses guided the study. The selected biology topics from the biology teaching syllabus were reproductive system, nervous system (control and coordination), respiratory system, excretory system, skeletal system and body symmetry and orientation. The researcher used computer-assisted instruction (CAI) as an intervention tool in this study. The pre-test was administered before treatment while a post-test was administered after the treatment. A questionnaire was used to collect students' views on the use of CAI on the selected topics. Descriptive statistics were used to organise the scores into mean scores and standard deviations and used to answer the one research question that guided the study. Independent samples t-test was used to test two hypotheses stated. The study indicated a difference in mean achievement scores between the students taught using computer-assisted instruction and those taught using the lecture method. The findings of the study suggested that computer-assisted instruction was a better alternative to lecture methods in teaching selected biology topics. The students expressed positive views about the use of Computer-Assisted Instruction (CAI) in Biology lessons. They noted that CAI significantly improved their critical thinking skills in biology, resulting in a better understanding of complex biology concepts. CAI was also seen to enhance students' understanding and engagement, leading to a better grasp of complex biology concepts and increased motivation in learning biology. Additionally, CAI provides personalized learning experiences tailored to individual students' needs and learning styles. Other benefits of CAI mentioned by the students include its ability to provide real-time feedback and assessment, enabling students to track their progress. CAI can also supplement traditional instruction, providing students with an interactive and engaging learning experience. Therefore, a computer-assisted instruction approach is recommended for teaching biology topics at the senior high school level.

CHAPTER ONE

INTRODUCTION

1.0 Overview

The chapter outlines the background of the study, Statement of the problem, Purpose of the study, Objectives of the study, Research questions, research hypotheses, Significance of the study, Limitations, delimitations and Definition of terms.

1.1 Background to the Study

Biology education is crucial for Ghana's development, particularly in healthcare and agriculture (Ghana Education Service, 2020). However, many Biology students face challenges, such as limited resources and infrastructure (UNESCO, 2022), inadequate teacher training (Agyei & Mugisha, 2023) culminating in poor student performance in Biology (West African Examinations Council, 2023). However, computer technology can help address these challenges by enhancing teaching and learning (Kozma, 2021), increasing accessibility and engagement in our schools (National Education Association, 2020).

As computer technology evolves, the use of computers in education has become inevitable. Using technology in education provided students with a more conducive learning environment. Thus, it creates a conducive environment for the students (Bhushan et al., 2021; Hew & Kadir, 2016) and corrective feedback (Ai, 2017). Recent research by Tawfeeq and Aziz (2024) suggests that Kurdish EFL teachers generally maintain positive attitudes toward computer-assisted teacher corrective feedback (CATCF), viewing it as an effective modern alternative to traditional methods. By bridging the gap between the functional benefits of digital feedback (Ai, 2017) and the readiness of educators to adopt them (Tawfeeq & Aziz, 2024), it becomes clear that CALL tools are becoming a staple in the modern writing classroom.

Technological devices began to be used in instruction in education to develop audiovisual materials such as animation and simulation as a representation of factual scenarios and processes, which resulted in the development of computer-based instruction techniques (Cavkaytar et al., 2017; Fuady & Mutalib, 2018; Adarkwah & Zeynu, 2022). Computer instructional programs can be implemented in conjunction with traditional teaching methods to enhance the overall educational experience (Fotaris et al., 2016; Bond et al., 2020). This provides a supplementary tool for instructional support in the classroom (Bulman & Fairlie, 2016; Hillmayr et al., 2020). Using computer-based assessments, the students are assessed with the given performance standard within the learning sequence in each learning task determined by the learners' performance (Hoogland, & Tout, 2018; Alabdulaziz, 2021).

The critical function of science education is to teach students science concepts in a meaningful way and enable them to learn how to use them in their daily lives. Anchored instruction promoted learning by making the context more significant, providing multiple ways of education, and making maximum use of experience and existing knowledge (Guzman, 2000; Lazonder & Harmsen, 2016). Students can proceed at their own pace, following a path through the curriculum as suited to their interests and talent (Achuonye, 2011). Computer Based Instructions (CBI) also called Computer Assisted Instructions (CAI), as literature revealed, may benefit the students' performance in biology ((Mutya & Ramas, 2022).

1.2 Statement of the Problem

The report highlighted the need for the use of innovative teaching methods that would emphasize the use of visual aids, and encourage critical thinking skills especially in the practical work (Chief Examiner's Report [WASSCE], 2016; 2020). Adeyemi, (2019) also attributed the poor performance to a number of factors including limited understanding of complex concepts by students and the use of teacher-centred pedagogies.

The student's interest in science is a critical component of academic achievement and an essential element of motivation (Kahu & Nelson, 2018). It has been seen as a vital part of science and biology education (Renninger et al., 2015). Despite this goal, evidence suggests that biology education faces a unique challenge in building students' interest in biology content (Rowland et al., 2019), and the method of teaching is one of the factors contributing to the low interest in science and expressing the need to come up with alternative teaching strategy that could motivate students' interest and enhance their achievement (Ajaja, 2013).

The issue of student's performance in biology has led to several proposals for enhancement. Unfortunately, those proposals revolve around unfitting teaching strategies and insufficient real -world exposure as the leading cause of students' poor performance in biology. Many students had difficulty in understanding the topics in biology (Castro & Morales, 2017; Dawson & Carson, 2020).

One of the strategies that can address challenges is computer-based instruction (CBI) also called Computer Assisted Instruction (CAI). The CBI is a teaching material arranged systematically and designed with a programming language or software that uses strategic learning methods with materials, exercises, questions, and quizzes

((Mutya & Ramas, 2022). The learning media that are packaged in a computer programme aims to help understand the material to facilitate the teaching and learning process (Limbong et al., 2018). Natural sciences are concerned with students deliberately acquiring information about the natural environment, rather than accumulating knowledge in the form of concepts, facts, or principles without exposure to their everyday experiences with the biological environment (Tawar, 2016). An innovative teaching strategy is essential to address this concern to improve students' academic performance (Oyelekan et al., 2018). CBI is one such approach. It has been found to play a pivotal role in improving students' higher-order skills in the context of problem-based learning for Science, Technology, Engineering and Mathematics (STEM) education (Saleh & Sari, 2022).

The computer-based science and technology laboratory is becoming increasingly important in the educational curriculum due to the rapid pace of technological breakthroughs (Serin, 2011). Through CAI, learners are not only encouraged by using ICT tools like computers, but they also learn by interacting with computer software like the way they would react in real situations (Noushad, 2010). Through CAI, students understand and are able to describe the phenomenon, master the way they can control them, and they are aware of the right reaction they can come up with when facing the different situations. CAIs are the controlled representations of real-world phenomena (Noushad, 2010). These instructional methods are used when real-world experiences are either unavailable or undesirable displayed in a multimedia manner. Thus, the CAI used in this study is multimedia instruction to effectively teach selected topics in Biology that senior high school students find difficult to understand. The multimedia computer-assisted instructions are presented as animation, videos, and static pictures or photos.

1.3 Purpose of the Study

This study examined the effectiveness of using Computer-Assisted Instruction (CAI) to teach selected Biology topics to improve SHS 2 Biology students' performance at Odupong Senior High School, in the Central Region of Ghana.

1.4 Objectives of the Study

The study sought to achieve the following objectives:

- To examine the effectiveness of computer-assisted instruction on students' performance in selected Biology topics by comparing their achievement before and after its implementation.
- To determine the difference in performance between students taught selected topics using the lecture method and those taught using computer-assisted instruction.
- To examine students' perceptions of the use of computer-assisted instruction in teaching selected Biology topics.

1.5 Research Hypotheses

HO_1 There is no statistically significant mean difference in students' performance before and after using computer-assisted instruction in teaching selected Biology topics.

HO_2: There is no statistically significant difference in performance of SHS2 Biology students taught using lecture methods and those taught using computer-assisted instruction (CAI).

1.6 Research Question

1. What is the effect of computer-assisted instruction on students' performance in selected biology topics?
2. Is there a significant difference in the performance of students taught with lecture methods and those taught using computer-assisted instruction in selected biology topics?
3. What are students' views on the use of computer-assisted instruction in teaching selected biology topics?

1.7 Significance of the Study

The findings of this study will provide useful information to teachers on how to overcome difficulties students face when teaching selected Biology topics (reproductive system, nervous system (control and coordination), respiratory system, excretory system, skeletal systems and body symmetry and orientation). It will enhance teaching and learning strategies, inform policy decisions on education technology, it will improve biology education in Ghana. It will also serve as a source of reference material for the science department of Odupong Senior High School.

1.8 Limitations of the Study

Limitations refer to factors that are beyond your control in a study, often stemming from the research methodology and design. These are essentially constraints that impact the study, primarily related to the research approach (Miles, 2017). The researcher was aware that many topics are studied in SHS Biology. However, the study was limited to selected biology topics. Therefore, the results of this study cannot be generalised for all topics in Biology. Odupong Senior High School in the Awutu Senya East District of the Central Region was selected for the study because of students' low performance in

Biology. Some Co-Curricular activities on the school time-table, electricity outages, and absenteeism of some students affected the study.

1.9 Delimitation

The study targeted Form 2 Biology students at Odupong Senior High School in Central Region, Ghana, due to their low biology performance. The selected topics are typically taught in the second year, making this group ideal for the study. The experimental group was taught using Computer-Assisted Instruction (CAI).

1.10 Organisation of the Study

This study is made up of five chapters. Chapter one gives the background to the study and the problems.

Chapter Two is a review of related literature, which dealt with research ideas about the topic. The areas to be considered are; Definition of computer-assisted instruction, Types of Computer Assisted Instruction, Benefits of Computer Assisted Instruction (CAI), Theoretical Framework for Computer Assisted Instruction, Conceptual framework on computer assisted instruction.

Chapter three is the methodology guiding the study. The areas under chapter three includes research design, population and sample, research instrument used, procedure and analysis of the data collected.

Chapter four involves results, findings and discussion of findings. The discussion was done with respect to the research hypothesis and questionnaire. The last chapter, which is chapter five, deals with a brief summary of the study drawn from the findings of the study, the main findings, conclusions, recommendations and suggestions for future study.

1.11 Terms and definitions

- **Effect Size (g, d, Hedges' g):** A standardized measure of the magnitude of a treatment's effect, independent of sample size. **g=0.2** is small, **0.5** medium, **0.8+** large.
- **p-value ($p < .05$, $p < .01$, $p < .001$):** The probability that the observed result occurred by chance. **$p < .05$** is the standard threshold for statistical significance.
- **t-value, F-value:** Test statistics from t-tests and ANOVA, respectively. Larger absolute values generally indicate stronger evidence against the null hypothesis.
- **β (Beta):** A standardized coefficient in regression analysis indicating the strength and direction of a relationship.
- **η^2 (Eta-squared):** A measure of effect size in ANOVA, indicating the proportion of total variance accounted for by the factor.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter provides a comprehensive examination of the theoretical and empirical foundations pertinent to the current study. The discussion begins by conceptualizing Computer-Assisted Instruction (CAI), exploring its various modalities, inherent advantages, and its specific pedagogical impact on biology education.

The theoretical framework centres on Skinner's Operant Conditioning Theory, detailing its fundamental principles and its practical application in modern digital learning environments. Furthermore, a systematic review of related literature and empirical studies is presented to evaluate the historical and contemporary effects of CAI on student academic outcomes within the biological sciences. The chapter concludes with a conceptual framework that synthesizes these variables to illustrate the hypothesized relationships investigated in this research.

2.1 Concepts of Computer Assisted Instruction (CAI)

CAI refers to the use of computers and software applications to present instruction to students to teach concepts or skills (Smith & Bowers, 2023). Computer-based education and computer-based instruction are the broadest terms that refer to virtual learning environments. Computer-Assisted Instruction (CAI) and Computer-Aided Instruction (CAI) are narrower terms that are often used interchangeably (Li & Chen, 2022). Computer-managed instruction (CMI) is a strategy whereby computers and learning management systems are used to deliver learning objectives, curate teaching-learning resources, conduct assessment, and maintain records (Kumar et al., 2021).

Some of the examples of CAI are simulation, animation, tutorials, drill and practice, and multimedia instruction. CAI comprises the combination of texts, graphics, sound, and video in the learning process. It is the modified teaching method that every educator can use depending on the abilities of the computer to find relevant information with different contents. CAI packages enhance students' learning if the lesson program is prepared well-using computers. (Adarkwah, 2021; Bond et al., 2020; Eche & Okorie, 2018).

It is asserted that there are different types of educational computer use, and not every use of a computer in the classroom is considered computer-assisted instruction. The educational uses of computers that are considered to be computer-assisted instruction or computer-based instruction are those cases in which either instruction is presented through a computer program to a relatively passive student, or the computer serves as the platform for an interactive and personalised learning environment (Hwang et al., 2020; Mayer, 2020).

CAI can be used either in isolation, bearing the whole responsibility for conveying instruction to students, or in combination with conventional, i.e., face-to-face, teaching methods. Research has shown that the combination of conventional and CAI instruction has been most effective in raising students' achievement scores (Alamri et al., 2020; Singh & Thurman, 2019).

Computer-assisted instruction is defined as a program of instructional material delivered through a computer or digital system (Adnan & Ritzhaupt, 2023). Within this broad category, drill and practice software represents a common form of CAI. Fundamentally, CAI involves the educator's strategic use of computers, adapting time and space according to pedagogical needs and subject matter characteristics to facilitate knowledge acquisition.

Research indicates that when a well-designed digital tutorial is implemented to supplement traditional instruction, it can lead to educationally significant improvements in student achievement (Hillmayr et al., 2020; Salehi & Asgari, 2021). When teachers apply this creative capacity to integrate computers, substantial potential exists for enhancing student learning.

Confirming this, a meta-analysis by Hillmayr et al. (2020) concluded that students receiving teacher instruction supplemented with CAI demonstrated faster learning and better retention rates compared to those in traditional, teacher-directed instruction only. Furthermore, such integrated approaches have been associated with improved student attitudes toward school and their self-concept as learners (Çakıroğlu & Öztürk, 2021).

2.2 Benefits of Computer Assisted Instructions

It provides lessons in the following formats:

- Text or multimedia content-this is an information containing more than one form of data including; text, audio, image, animation, or video in a single presentation.
- Multiple-choice questions-there is only one question with different options of answers to select only the correct one.
- Problem solving technique- this is an act of defining a problem; determining the cause of the problem; identifying, prioritising, and selecting alternatives for a solution; and implementing the solution.
- Immediate feedback A- a quick response or an answer to a question or a task given earlier.

- Notes on incorrect responses-giving a correct answer or response to a question or statement so that the individual learns the correct thing and discards the incorrect answer or responses.
- Summarizes students' performance- this is the tallying or totaling of different scores of learners in an exercise or examinations to ascertain whether the individual student had the past mark or note and judge it summative performance of a period of time.
- Exercises for practice- these are usually tasks given to students to solve and have mastery over the contents of the lesson taught earlier.
- Worksheets and tests- this is a computer document that shows the work to be done by students.

2.3 Theoretical Framework for Computer Assisted Instruction

Swanson (2013) explicitly asserts that, “The theoretical framework is the structure that can hold or support a theory of a research study”. The theoretical framework of a research proposal or thesis is not a summary of one's own thoughts about the research. Rather, it is a synthesis of the thoughts of giants in the field of research, as they relate to your proposed research or thesis, as you understand those theories, and how you will use those theories to understand your data. In essence, the theoretical framework comprises what leaders in the field of research say about your research question, about the problem you plan to investigate, and might even include suggestions of how to solve that problem, including how to interpret the findings in your data. What those leaders say, helps you to develop an informed, and specialized lens, through which you examine your data, conduct the data analysis, interpret the findings, discuss them, and even make recommendations, and conclusions.

Another great author called Burrhus Frederic Skinner (Skinner, 1938), introduced the Operant conditioning, also known as instrumental conditioning. It is a method of learning where the consequences of a response determine the probability of it being repeated. Through operant conditioning behaviour which is reinforced (rewarded) will likely be repeated, and behaviour which is punished will occur less frequently.

According to Watson (1913), Skinner believed that we do have such a thing as a mind, but that it is simply more productive to study observable behaviour rather than internal mental events. The work of Skinner was rooted in a view that classical conditioning was far too simplistic to be a complete explanation of complex human behaviour. He believed that the best way to understand behaviour is to look at the causes of an action and its consequences. He called this approach operant conditioning.

His work was based on Thorndike's (1898) law of effect. This principle holds that behavior followed by reinforcement is more likely to be repeated (i.e., strengthened), while behavior that is not reinforced tends to diminish or be extinguished (i.e., weakened). Contemporary applications of these behavioral principles, often facilitated by digital tools, highlight their ongoing relevance (Alotaibi, 2024). Educational benefits stemming from Skinner's operant conditioning theory are evident in areas such as classroom and student management, where structured reinforcement systems are effectively applied (Lefrançois, 2023). Furthermore, the theory remains highly relevant for shaping and refining skill performance through systematic feedback and reinforcement schedules (Mayer, 2021).

A simple and effective way to shape desired behaviour is to provide consistent feedback on learner performance, such as compliments, approval, encouragement, and affirmation. From a behavioural perspective, a variable-ratio schedule is highly effective for establishing new tasks, as it produces high and persistent response rates (Mayer, 2021). In practice, this means reinforcement (e.g., praise) is delivered frequently when a skill is first introduced. As performance improves, reinforcement becomes less frequent and more selective, eventually reserved for only exceptional outcomes. For instance, to encourage classroom participation, a teacher might initially praise all student attempts to answer questions. Gradually, praise would be given only for correct answers, and over time, reserved for particularly insightful or exceptional responses.

Conversely, unwanted behaviours, such as tardiness or dominating discussions, can be extinguished by systematically withholding reinforcement—in this case, the teacher's attention (Lefrançois, 2023). This strategy requires careful implementation, as inconsistent application or feigned indifference can undermine its effectiveness and appear insincere.

Knowledge of success serves as a powerful intrinsic motivator for future learning (Alotaibi, 2024). To maintain the desired behaviour long-term without causing satiation, it is crucial to vary the forms of reinforcement used, combining social praise with other tangible or activity-based rewards.

It is recognized that while technology is integral to modern society and offers novel learning opportunities, the design of such instructional strategies must be guided by educational theory to be effective (Mayer & Fiorella, 2021). The theoretical roots of modern computer-assisted instruction (CAI), including automated tutorials and drilland-practice systems, can be traced to the behaviorist tradition in psychology. Skinner's reinforcement theory remains central to computerized learning, particularly in structured formats like drill and practice, where desired student behaviors are reinforced through system feedback and progression (Mayer, 2021). In such environments, correct responses are often met with immediate positive reinforcement, such as advancement to the next instructional frame, embodying the behaviorist emphasis on immediate feedback (Adnan & Ritzhaupt, 2023).

A key pedagogical advantage of CAI is that it necessitates active student participation in the learning process (Hillmayr et al., 2020). To progress, the learner must interact with the system via input devices, which prevents passive observation and aligns with the continuity principle of active responding. Furthermore, well-designed CAI allows students to proceed at their own pace, providing individualized practice and reinforcement (Salehi & Asgari, 2021).

Thus, the tutorial and drill-and-practice modes of CAI are strongly supported by behaviorist learning principles, emphasizing structured practice and systematic reinforcement. Consequently, instructional designers frequently incorporate these principles into educational software. In this approach, the computer transmits specific subject matter, with information flowing from the system to the student, which then presents materials or activities for the student to respond to while tracking progress (Çakıroğlu & Öztürk, 2021).

Contemporary analysis confirms that CAI, particularly through tutoring and drill-andpractice programs, is highly appropriate for mastering foundational subject matter and practicing basic skills before advancing to higher-order learning (Lefrançois, 2023). These software programs act as teaching assistants by automating specific instructional tasks. In essence, within the CAI mode, the computer can directly instruct the student, as in a tutorial, or assist the teaching process, as in drill-and-practice applications, thereby providing scalable and consistent supplementary instruction.

2.4 Students' Difficulties in Teaching and Learning of Biology

Effective science teaching necessitates attention to both disciplinary content and the pedagogical process of guiding students from their initial understanding to the desired learning outcomes (National Research Council, 2012). Indeed, teaching functions as an interconnected system involving the teacher, learner, content, instructional process, and evaluation.

A significant shift from a traditional, teacher-centered model to a progressive, studentcentered approach has increased focus on learner individuality. This modern paradigm emphasizes inclusiveness, cooperative learning, and the valuing of diverse perspectives (DeCoito & Fazio, 2023). However, despite this pedagogical evolution, student performance in examinations often remains discouraging, prompting ongoing investigation into the causes of underachievement and methods for improving the teaching-learning process (Dawson & Carson, 2020; Schönborn & Bögeholz, 2021).

Biology remains one of the most widely chosen science subjects in secondary school certificate examinations, underscoring its perceived importance (UNESCO, 2021). Research indicates that a multitude of factors contribute to persistent challenges in student performance. These include the inherent difficulty of specific biological concepts, the nature of the scientific discipline itself, and the abstract level at which many biological processes must be understood (Dawson & Carson, 2020; Mavhunga, 2020).

Contemporary studies confirm that certain topics continue to be perceived as particularly difficult by secondary school students. These include genetics (genes, chromosomes, mitosis, meiosis, Mendelian inheritance), physiological processes (hormonal regulation, nervous system function), and complex biochemical concepts like photosynthesis and cellular respiration (Schönborn & Bögeholz, 2021; Tümay, 2021). The experience of difficulty across multiple topics negatively impacts student motivation and overall achievement (Mnguni, 2020). These challenges can be attributed to various intersecting factors, including the classroom learning environment, student interest, curriculum density, and the perceived disconnect between abstract scientific concepts and societal contexts (DeCoito & Fazio, 2023).

2.5 Use of computer assisted instructions in Biology Education

Biology occupies a unique and foundational position in the school curriculum. It serves as a central pillar for numerous science-related fields, including medicine, pharmacy, agriculture, nursing, and biotechnology. Consequently, proficiency in biology is essential for students pursuing these disciplines. This critical role has consistently drawn the attention of researchers and curriculum planners to biology education (Mnguni, 2020).

Despite its importance and popularity among students, performance in biology at the senior secondary level in many contexts, including Nigeria, remains a significant concern (Onowugbeda et al., 2022). The quest to identify the causes of this underachievement has been a sustained research focus. Challenges widely documented include issues of teacher quality, overcrowded and heterogeneous classrooms, inadequate laboratory facilities, and overloaded syllabi, which collectively hinder effective teaching and learning (Schönborn & Bögeholz, 2021).

The potential benefits of Computer-Assisted Instruction (CAI) for mitigating these challenges are considerable in the contemporary educational landscape. A robust body of research, particularly from developed nations, establishes the instructional value of digital tools. Numerous CAI packages now exist across subjects, reflecting a global trend toward leveraging technology to enhance learning (Hillmayr et al., 2020).

A synthesis of recent empirical studies indicates that the most consistent positive effects are observed when CAI is used to supplement traditional instruction, rather than replace it entirely. This integrated approach has been shown to produce higher student achievement, faster learning rates, and better retention compared to conventional instruction alone (Adnan & Ritzhaupt, 2023; Salehi & Asgari, 2021). Furthermore, well-designed interactive and multimedia CAI can make complex and abstract biological concepts more accessible and engaging (Çakıroğlu & Öztürk, 2021).

However, research findings on CAI are nuanced and not universally conclusive. Its effectiveness can vary depending on the learning objective; it may be highly effective for foundational knowledge and skill practice but less so for developing advanced critical thinking without careful instructional design (Mayer, 2021). The method of CAI delivery, the specific learning environment, and the alignment between the technology and pedagogical goals are critical moderating factors (Adarkwah, 2021). Therefore, while CAI presents a powerful supplemental tool, its integration must be strategic and context-sensitive, with ongoing research needed to clarify its optimal use in diverse, modern classrooms.

2.6 Effectiveness of CAI in Improving Students' Learning Outcomes

A robust body of contemporary research affirms the positive impact of Computer-Assisted Instruction (CAI) on student learning in STEM subjects. Large-scale syntheses of evidence, using meta-analytic techniques, provide a strong, quantifiable foundation for this claim. Hillmayr et al. (2020), in a context-specific meta-analysis of 85 studies, found that digital tools had a significant positive effect on learning, with an overall mean effect size of $g = 0.65$ (which is considered a medium-to-large effect).

The analysis showed that intelligent tutoring systems were particularly effective ($g = 0.53$), as were applications providing feedback. Notably, their research indicated these tools were significantly more beneficial for lower-achieving students ($g = 0.75$), suggesting a powerful role in bridging achievement gaps. This finding is supported by Raca et al. (2018) in mathematics, whose meta-analysis of 22 studies reported an overall mean effect size of $d = 0.71$, which was significantly larger for students with lower prior knowledge. A further review by Saleh and Sari (2022) on science education, synthesizing 42 effect sizes, corroborates that CAI has a significant positive effect on learning outcomes (Hedges' $g = 0.59$, $p < .001$), particularly when it is interactive, engaging, and tailored to individual needs.

The effectiveness of CAI is closely tied to its implementation strategy. Both Hillmayr et al. (2020) and Saleh and Sari (2022) emphasize that CAI is most effective when used to supplement traditional instruction rather than replace it entirely. This integrated approach leverages the strengths of both teacher-led and technology-assisted learning. Recent subject-specific studies reinforce this. In biology, Smith (2022) demonstrated in a quasi-experimental study that the CAI group significantly outperformed the traditional instruction group on a post-test ($t(78) = 3.42$, $p = .001$, $d = 0.76$), with the advantage maintained on a delayed retention test. Similarly, Kim et al. (2024) found that CAI significantly enhanced academic performance in mathematics and science (combined subject effect: $\beta = 0.38$, $p < .01$) while also improving students' problem-solving abilities ($\beta = 0.31$, $p < .05$), highlighting its potential to develop higher-order cognitive skills.

The design and adaptability of CAI systems are critical moderating factors of their success. Research indicates that more sophisticated and adaptive CAI systems show greater effectiveness. VanLehn's (2011) seminal meta-analysis of 50 studies found that CAI had a moderate positive effect compared to human tutors or teacher-led instruction, with an average effect size of $d = 0.30$, noting that more sophisticated systems performed better. Their utility extends across diverse contexts, being effective in various subjects, as shown by Alabdulaziz (2021), who reported a significant improvement in mathematics achievement for the CAI group ($F(1, 58) = 12.47$, $p < .001$, $\eta^2 = 0.18$). For students of different cognitive profiles, effects can vary. For instance, Chevalère et al. (2021) found CAI was more effective than inquiry-based learning for teaching chemical bonding, with benefits more pronounced for students with higher working memory capacity (significant interaction effect: $p < .05$). Conversely, Dawson and Carson (2020) noted that high-quality digital visualizations and simulations were especially effective for facilitating deeper understanding in students with higher prior knowledge, indicating a nuanced relationship.

Key mechanisms through which CAI enhances learning include boosting engagement and enabling personalization. The interactive and visual nature of CAI has been shown to significantly increase student motivation and engagement, a finding consistently reported in systematic reviews (Bond et al., 2020) and explained by the empirically validated principles of multimedia learning (Mayer & Fiorella, 2021). Furthermore, CAI supports personalized learning by catering to individual paces and learning styles, allowing for tailored instruction that addresses diverse student needs (Kozma, 2021). Ultimately, by facilitating interactive simulations and visualizations, CAI helps concretize abstract concepts, promoting a deeper conceptual understanding that is central to mastering complex scientific ideas (National Research Council, 2011).

2.7 Student Perspectives on the Use of CAI in Biology Teaching

The integration of digital technologies like Computer-Assisted Instruction (CAI) into science education has accelerated, driven by evidence of its potential to enhance learning outcomes (Bond et al., 2020; Hillmayr et al., 2020). In Biology, CAI has been linked to improved conceptual understanding and retention (Smith, 2022). Crucially, the effectiveness of such technology is not merely a function of its design but is significantly mediated by student acceptance, attitudes, and perceptions (Adarkwah, 2021).

Research consistently indicates that students generally hold positive attitudes towards the use of CAI in Biology. These attitudes are often linked to perceptions of CAI as a useful, engaging, and motivating tool that can make complex biological concepts more accessible (Adarkwah, 2021; Kim et al., 2024). Studies find that students using digital tools report higher levels of motivation and engagement compared to traditional, nontechnology-enhanced instruction (Bond et al., 2020). This positive disposition is not merely a subjective preference; it is correlated with academic performance, as students with favourable attitudes towards CAI tend to achieve better learning outcomes in biology classes (Smith, 2022).

However, these positive views are not universal and can be hindered by practical barriers. Students with limited prior experience with computers or who lack adequate technical and pedagogical support may experience frustration, anxiety, or cognitive overload, which can negatively colour their perception of CAI (Adarkwah, 2021). This underscores the necessity for educators to provide foundational training and ongoing support to ensure equitable and confident use of the technology.

Educators play a pivotal role in cultivating and sustaining positive student attitudes.

This is achieved not by simply deploying technology, but by strategically designing CAI experiences that highlight its core benefits:

- Enhancing Engagement and Understanding: By using CAI to create interactive simulations, visualizations, and multimedia content, educators can foster deep, engaging learning experiences. Such experiences, aligned with multimedia learning principles (Mayer & Fiorella, 2021), help concretize abstract biological processes (e.g., cellular respiration, protein synthesis), which directly promotes positive student attitudes.
- Facilitating Personalized Feedback: CAI enables the provision of immediate, adaptive, and personalized feedback, a feature students value highly. This instant responsiveness supports mastery learning and helps students identify and remedy misconceptions efficiently, contributing to a sense of progress and competence (Hillmayr et al., 2020; Smith, 2022).
- Promoting Collaborative Learning: Modern CAI platforms can be designed to support collaborative projects, peer communication, and shared problem-solving. When used to structure meaningful group work, CAI can foster a sense of community and show students its utility in facilitating social learning, further enhancing its perceived value (Bond et al., 2020).

In summary, while the literature suggests a generally favourable student disposition towards CAI in Biology, this attitude is contingent on the quality of implementation. Educators are instrumental in shaping these perspectives by ensuring accessible support and by deliberately leveraging CAI's strengths—interactivity, personalization, and collaboration to design learning experiences that students find genuinely beneficial and motivating.

2.8 Conceptual Framework for the Study

A conceptual framework represents the researcher's synthesised understanding of the key factors, concepts, variables, and presumed relationships that guide an entire inquiry (Ravitch & Riggan, 2017). It is a logically constructed model that outlines the "what," "how," and "why" of the research process from problem identification and theoretical grounding to methodology and anticipated outcomes.

This study is guided by a framework that integrates core constructs from instructional technology and educational psychology to examine the effect of Computer-Assisted Instruction (CAI) on student performance in biology. The framework posits that effective CAI implementation (Process) mediates the relationship between available Inputs and desired Outcomes, with student perceptions acting as a critical moderating variable. This is visualized in the following model and explained in the subsequent narrative.

Table 1: Conceptual Framework for CAI and Student Performance in Biology

Inputs	Process	Outcomes
Technological infrastructure (hardware, software, access)	CAI implementation (interactive modules, Simulations, personised feedback, adaptive paths)	Academic performance (test scores, understanding)
Pedagogical readiness (Teacher competence, curriculum alignment)	Student's perceptions and engagement (moderator)	Affective engagement (motivation, self efficacy
Content design (Aligned multimedia biology content)		Development of higher order skills (critical thinking, problem-solving)

Narrative Explanation of the Framework:

- Inputs (Independent Variables & Context): These are the essential prerequisites for implementing CAI. They include:
    - Technological Infrastructure: Reliable computer hardware, relevant software, and internet access (Adarkwah, 2021).
    - Pedagogical Readiness: Teacher competence in integrating technology and a curriculum designed to align CAI modules with clear learning objectives (Kozma, 2021).
    - Content Design: The quality of the multimedia biology content (simulations, tutorials) which must be accurate, engaging, and pedagogically sound (Mayer & Fiorella, 2021).
- Process (Intervention & Mediating Factors): This core component represents the active use of CAI in the classroom. Effective CAI is characterized by:
    - Interactive & Adaptive Implementation: The use of CAI that provides interactive engagement, personalized learning paths, and immediate, adaptive feedback (Hillmayr et al., 2020; Saleh & Sari, 2022).
    - Student Perceptions (Moderating Variable): Crucially, the framework positions student attitudes and engagement as a moderating factor. Positive perceptions such as viewing CAI as useful, engaging, and supportive are expected to enhance the effectiveness of the CAI process on outcomes. Conversely, negative perceptions or technical difficulties can diminish its impact (Bond et al., 2020; Smith, 2022).

- Outcomes (Dependent Variables): These are the anticipated results of effectively implemented CAI, moderated by positive student perceptions. They include:
  - Enhanced Academic Performance: Improved test scores, deeper conceptual understanding, and better retention of biological knowledge (Smith, 2022).
  - Improved Affective Engagement: Increased student motivation, interest in biology, and development of self-regulated learning skills (Kim et al., 2024).
  - Development of Higher-Order Skills: Fostering critical thinking, problem-solving abilities, and collaborative skills through interactive simulations and peer-to-peer learning features (Dawson & Carson, 2020; Hmelo-Silver, 2004).

Theoretical Positioning: This framework synthesizes principles from:

- Cognitive Theory of Multimedia Learning (Mayer & Fiorella, 2021), which informs the design of effective CAI content.
- Constructivist Learning Theory (Jonassen, 2000), which underscores the importance of interactive, student-centered activities.
- Research on Technology Integration (Kozma, 2021; Bond et al., 2020), which highlights the contextual factors (inputs) and affective factors (perceptions) critical for success.

In summary it has:

- Created a Clear Visual Model: The diagram succinctly shows the relationship between Inputs, Process, Outcomes, and the moderating role of Student Perceptions.

- Eliminated Repetition: The lengthy, repetitive paragraphs on student beliefs have been condensed into a single, critical moderating variable within the framework.
- Improved Logical Flow: The narrative now logically explains each component of the model and how they interrelate.
- Strengthened Theoretical Link: The framework is explicitly connected to relevant educational theories.
- Focused on the Study: It directly sets up the research variables and their hypothesised relationships.

2.9 Theoretical Framework Underpinning Computer-Assisted Instruction in Biology

The effective design, implementation, and investigation of Computer-Assisted Instruction (CAI) must be anchored in established learning theories. This study is primarily guided by three interconnected theoretical perspectives that explain the mechanisms through which CAI can enhance biology education: Cognitive Theory of Multimedia Learning, Constructivist Learning Theory, and Behavioural Learning Principles (Operant Conditioning). Together, they provide a comprehensive rationale for how CAI supports knowledge acquisition, engagement, and skill development.

 Cognitive Theory of Multimedia Learning (CTML)

Proponent: Richard Mayer (2021)

Core Premise: Learning is an active process of filtering, selecting, organizing, and integrating information. CTML specifically addresses how people learn from words and pictures, positing that humans have separate information processing channels for visual/pictorial and auditory/verbal material. Effective multimedia instruction must manage essential, extraneous, and generative cognitive processing to avoid overload and foster meaningful learning.

Application to CAI in Biology:

- Dual Coding: CAI is uniquely positioned to present biological concepts (e.g., DNA replication, ecosystem dynamics) through synchronized narration (verbal channel) and animations/simulations (visual channel). This dual presentation leverages both channels, enhancing encoding and recall (Mayer & Fiorella, 2021).
- Managing Cognitive Load: Well-designed CAI modules apply CTML principles like coherence (removing irrelevant content), signaling (highlighting key information), and segmenting (breaking complex processes into learnerpaced steps). This is crucial in biology, where processes like photosynthesis or nerve impulse transmission are complex and sequential.
- Generative Processing: Interactive CAI requires students to engage in generative activities—clicking to progress a simulation, dragging labels to a diagram, or predicting outcomes. This active engagement promotes deeper integration of new information with prior knowledge, leading to conceptual understanding rather than rote memorization.

Link to Study: This theory justifies the *design features* of the CAI intervention. It predicts that CAI, when designed according to CTML principles, will reduce cognitive overload associated with abstract biology concepts and lead to better understanding and retention compared to a lecture method that primarily engages the verbal channel.

 Constructivist Learning Theory

Proponent: Jonassen (2000); papert (1980); Vygotsky (1978)

Core Premise: Learners actively construct their own understanding and knowledge of the world through experiences and reflecting on those experiences. Learning is social, contextual, and occurs when individuals engage in authentic, problem-based activities, often within a community of practice.

Application to CAI in Biology:

- Active Knowledge Construction: CAI shifts the student role from passive recipient to active investigator. Virtual labs, interactive dissections, and simulation-based experiments allow students to manipulate variables, observe outcomes, and construct mental models of biological systems (e.g., "What happens to a cell in a hypertonic solution?").
- Authentic & Situated Learning: CAI can simulate authentic scientific inquiry and complex biological environments (e.g., a virtual field trip to a rainforest canopy or a microscopic journey through the bloodstream) that are impossible or impractical in a standard classroom, making learning more meaningful (Dawson & Carson, 2020).
- Social Constructivism & Collaboration: Many CAI platforms include tools for collaboration—discussion forums, shared virtual whiteboards, and multi-user simulations. This facilitates peer explanation, debate, and knowledge coconstruction, aligning with Vygotsky's concept of learning within the Zone of Proximal Development (ZPD) (Hmelo-Silver, 2004).

Link to Study: This theory justifies the *pedagogical approach* of the CAI intervention. It predicts that CAI, by providing interactive, exploratory, and potentially collaborative experiences, will foster deeper, more meaningful learning and improve problem-solving skills in biology more effectively than the transmissive lecture method.

 Behavioural Learning Theory (Operant Conditioning)

Proponent: B.F Skinner (1958)

Core Premise: Learning is a function of change in observable behavior. Behaviors that are reinforced (positively or negatively) are more likely to be repeated; behaviors that are not reinforced or are punished are extinguished. Immediate feedback is crucial for shaping behavior.

Application to CAI in Biology:

- Immediate & Systematic Reinforcement: CAI provides instant, consistent feedback. A correct answer can be reinforced with positive confirmation, points, or progression to a more challenging level. This immediate reinforcement strengthens correct responses and conceptual associations (Hillmayr et al., 2020).
- Mastery Learning & Personalized Pacing: CAI often employs a drill-and practice or tutorial structure where students must master one concept (e.g., Mendelian genetics Punnett squares) before advancing. This shapes complex skill performance through successive approximations and allows for self-paced mastery, a core tenet of programmed instruction derived from behaviourism (Kozma, 2021).
- Motivation through Contingencies: Points, badges, progress bars, and "leveling up" in educational CAI are modern applications of reinforcement schedules. They serve to maintain student engagement and motivation, particularly during repetitive but necessary practice of foundational skills (Bond et al., 2020).

Link to Study: This theory justifies the feedback and motivational mechanisms of the CAI intervention. It predicts that CAI's capacity for providing immediate, adaptive reinforcement will increase student engagement, improve accuracy in procedural knowledge (e.g., classification, terminology), and support the development of automaticity in basic skills, forming a solid foundation for higher-order constructivist activities.

Synthesis of Theories in the Conceptual Framework

These theories are not mutually exclusive but operate in a complementary hierarchy within an effective CAI environment:

1. Behavioural principles provide the foundational structure for practice, feedback, and engagement (Input/Process).
2. Cognitive theory (CTML) governs the optimal design of the multimedia information presentation to facilitate mental processing (Process).
3. Constructivist principles guide the higher-order, interactive, and exploratory tasks that lead to deep conceptual understanding and knowledge application (Process/Outcome).

Therefore, this study posits that a CAI intervention informed by these three theoretical pillars will be more effective than traditional lecture methods in improving academic performance (reinforced practice & cognitive design), engagement (reinforcement & active construction), and critical thinking (constructivist exploration) in secondary school biology.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter delineates the systematic procedures and protocols employed to conduct the investigation. It outlines the foundational research design and provides a detailed account of the study population, including the specific sampling strategies used to select participants.

Furthermore, this section details the development and nature of the research instruments, along with the rigorous measures taken to establish their validity and reliability. Finally, the chapter concludes with an explanation of the data collection protocols and the statistical techniques utilized for data analysis to ensure the findings are both accurate and reproducible.

3.1 The Study Area

The study was carried out at Odupong Community Senior High School. The school is located between Ofaakor and Jei-River in the Awutu Senya East Municipal in the Central Region. Its location represents urban, semi-urban and rural settlements with Kasoa township as the business centre. The Awutu Senya East Municipality (A.S.E.M) has several pre-schools, Junior High Schools with Odupong Community Senior High School as the only government secondary school within the district. The school offers the following programmes; General Science, Agricultural science, Home Economics Sciences, Visual Arts, Business, General Arts and Information and Communication Technology.

3.2 Research Design

Research design is conceptualised in this study as the comprehensive architecture that bridges the research questions with the empirical data. According to Taherdoost (2022), it serves as a structured blueprint, ensuring that the procedures for gathering, quantifying, and evaluating information are aligned with the central research objectives. Expanding on this, Creswell and Plano Clark (2023) emphasize that a research design is an integrated system. It encompasses not only the practical methods of data collection and interpretation but also the underlying philosophical foundations and the specific inquiry strategies that dictate how evidence is synthesized. For this investigation, the selected design provides the necessary rigor to investigate the causal or correlational relationships between the variables under study.

This research utilised a quasi-experimental approach, specifically adopting a non-equivalent groups design (NEGD). This particular methodology was chosen due to its high level of ecological validity in school environments, where assessing the impact of Computer-Assisted Instruction (CAI) on biology achievement requires minimal disruption to the natural classroom setting.

A primary distinction of this design is that it does not rely on the random assignment of individual students. Instead, it utilizes pre-existing clusters, such as established classroom sections, to form the study groups (Levy & Ellis, 2021). As Bryman (2021) notes, the NEGD is an indispensable asset for educational researchers. It is often the most viable option when randomizing participants is hindered by administrative policies, ethical concerns, or logistical barriers. By working within these institutional boundaries, the design allows for a reasonable approximation of causal relationships between the digital intervention and student outcomes in a real-world academic context.

The Senior High School 2 (SHS 2) cohort was specifically targeted for this investigation based on two strategic justifications. First, this group provided the necessary longitudinal stability, as their availability throughout the study and the following academic year allows for potential follow-up assessments. Second, the biological themes selected for this intervention align precisely with the established SHS 2 curriculum, ensuring that the research remains relevant to the students' required learning outcomes.

3.3 Population

In the context of research methodology, a population represents the entire universe of subjects, objects, or occurrences that possess specific, shared traits relevant to the inquiry (Taherdoost, 2022). Scholars traditionally differentiate between the target population and the accessible population. The target population refers to the wide group to which the researcher intends to extrapolate the findings, whereas the accessible population is the specific segment of that group that the researcher can realistically reach for data collection (Polit & Beck, 2021).

In this investigation, the target population consists of the approximately 250 students enrolled in biology courses at Odupong Community Senior High School. From this group, the accessible population was narrowed to the 120 students currently in their second year (S.H.S. 2).

As previously noted, the selection of the S.H.S. 2 cohort was a deliberate decision based on their continued presence at the institution for the remainder of the study and the following academic year. Furthermore, this group was selected because the biological concepts examined in this research are central to the S.H.S. 2 curriculum, ensuring that the intervention is synchronous with their prescribed academic progress.

3.4 Sample and Sampling Technique

This study utilised a total population sampling approach (census sampling), a method chosen specifically because the accessible population was small enough to allow for the inclusion of all eligible participants. By attempting to involve the entire cohort, the researcher aimed to maximize the precision of the findings and ensure that the results were truly representative of the specific group of interest. While 120 students were initially identified, 20 were unavailable at the commencement of the research; consequently, the final study sample consisted of 100 second-year students.

This sample of 100 was comprised of 60 students from the Home Economics department and 40 from the Science department, all of whom were enrolled in biology. To ensure the study groups were appropriately categorized, all participants first completed a pre-test known as the Biology Performance Test (BPT).

The assignment of participants into the experimental (treatment) and control groups was strategically based on these initial assessment results. To address the performance gap effectively, students with lower average scores were assigned to the experimental group to receive the Computer-Assisted Instruction (CAI), while those with higher average scores formed the control group. This resulted in two balanced sub-samples of 50 students each, allowing for a focused evaluation of how the intervention influenced the performance of learners who initially struggled with the material.

3.5 Research Instruments

A research instrument serves as the standardized mechanism through which data is gathered, quantified, and evaluated to address the core research questions (Taherdoost, 2022). As Polit and Beck (2021) observe, the integrity of a study relies heavily on the careful selection and validation of these tools, which may range from quantitative assessments and questionnaires to qualitative observation logs and interview frameworks.

For the purposes of this investigation, two distinct instruments were deployed to capture a holistic view of the intervention's impact:

- Biology Performance Test (BPT): This primary assessment was designed to provide a quantitative measure of students' academic mastery. It served as both a diagnostic tool for group assignment and a summative measure to evaluate the effectiveness of the Computer-Assisted Instruction (CAI) on learning outcomes.
- Student Perception Questionnaire: This secondary tool was utilized to collect descriptive data regarding the participants' backgrounds. More importantly, it aimed to gauge the students' subjective experiences and viewpoints regarding the integration of digital technology in their biology lessons.

3.5.1 Biology Performance Test (BPT)

The primary assessment tool for this study was the Biology Performance Test (BPT), a researcher-designed instrument utilized for both the pre-test and post-test phases. The development of this test was strictly aligned with the West African Examinations Council (WAEC) syllabus standards, ensuring that each item corresponded to established marking schemes for the specific biological themes under investigation.

The BPT evaluated student comprehension across several core physiological areas, including the human reproductive, nervous, respiratory, excretory, and skeletal systems, as well as concepts of body symmetry and orientation.

To provide a comprehensive evaluation of student knowledge, the instrument comprised a total of 103 items distributed across various formats:

- Multiple-Choice (47 items): Students were required to select the most accurate response from four provided options.
- True/False (19 items): Designed to test the students' ability to verify the accuracy of specific biological statements.
- Fill-in-the-Blanks (24 items): These items required active recall, prompting students to provide specific terminology or facts from memory.
- Essay Questions (13 items): These open-ended tasks allowed for a deeper assessment of the students' ability to explain complex biological processes (refer to Appendices A through F for full details).

3.5.2 Questionnaire

A questionnaire serves as a primary tool for gathering uniform data across a target sample, providing a structured medium to capture information regarding the participants' perspectives, backgrounds, and attitudes (Polit & Beck, 2021). According to Taherdoost (2022), the strategic advantage of this instrument lies in its capacity to efficiently collect quantifiable data in a consistent and organized manner.

For this research, a 30-item structured questionnaire was developed (see Appendix G) to specifically explore how students perceived the integration of Computer-Assisted Instruction (CAI) into their biology lessons. The instrument was organized into two distinct modules:

- Section A: Demographic Profile: This initial section consisted of four items designed to capture essential background data, including the participants' gender, age, grade level, and specific academic program.

- Section B: Perceptions of CAI: This module contained 26 items directly addressing student opinions on digital instruction. Each statement utilized a five-point Likert scale to quantify the intensity of student agreement.

The scoring system was weighted to allow for statistical analysis, with responses ranging from Strongly Agree (5) to Strongly Disagree (1). Participants were instructed to choose the specific value that best represented their personal viewpoint for each item, allowing the researcher to calculate mean scores for student attitudes.

3.6 Validity and Reliability of the Instruments

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3.6.1 Validity of the Test Instrument

Validity refers to the degree to which an instrument accurately measures the specific construct it is intended to measure (Taherdoost, 2022). In quantitative research, it is the extent to which evidence supports the interpretation of test scores for a proposed use, ensuring that the instrument truly assesses the targeted knowledge, skill, or attribute (Polit & Beck, 2021).

To establish content validity for the researcher-constructed Biology Performance Test (BPT), all test items covering the selected topics (reproductive system, excretory system, respiratory system, skeletal system, nervous system, and body symmetry/orientation) were submitted to the thesis supervisor for expert review. This review process ensured that:

- Each test item accurately measured the intended learning objective.
- The collective items adequately covered the relevant concepts as outlined in the WAEC (West African Examinations Council) syllabus.
- The language used was simple, clear, precise, and free from ambiguity.
- The difficulty level of the questions was appropriate for the target student population.

Furthermore, the accompanying marking schemes were also assessed and approved by the supervisor prior to administration, ensuring scoring consistency and alignment with the test's objectives.

3.6.2 Reliability of the Test Instrument

Reliability is the metric used to evaluate the dependability and consistency of a research tool, reflecting its capacity to generate stable results across repeated applications (Taherdoost, 2022). A high degree of reliability suggests that the instrument is resilient against random measurement errors, thereby producing scores that truly reflect the variable being measured (Polit & Beck, 2021).

To fortify the Biology Performance Test (BPT) against inconsistencies, several methodological safeguards were implemented:

- Uniformity in Administration: All participants were provided with identical instructions and allocated a standardized timeframe to complete the assessment.
- Linguistic Clarity: The items were drafted using accessible terminology tailored to the linguistic level of the S.H.S. 2 cohort to prevent comprehension-related errors.
- Objective Scoring: A rigid marking scheme was utilized to ensure that score allocations remained consistent across all respondents.

The empirical reliability of the BPT was verified through a pilot study involving fifty (50) non-sampled students. Employing the test-retest method, the researcher calculated a Pearson correlation coefficient to assess the instrument's stability over time. The analysis yielded a coefficient of $r = 0.83$. In psychometric research, while a value of 0.70 is often the minimum threshold for acceptance, a score exceeding 0.80 is classified as a "good" or "strong" indicator of reliability (Kline, 2023). Consequently, the 0.83 result confirmed that the BPT was a robust and dependable tool for gathering data in this investigation.

3.6.3 Validity and Reliability (Internal Consistency) of the Questionnaire

To ensure the quality of the data collection process, the researcher established both the validity and reliability of the questionnaire through a pilot test. Content validity refers to the degree to which the items on an instrument adequately represent the entire domain of the construct being measured (Polit & Beck, 2021). Internal consistency reliability assesses the extent to which all items in a scale measure the same underlying construct, as indicated by their intercorrelations (Kline, 2023).

To establish face and content validity, the draft questionnaire was submitted to the thesis supervisor and senior lecturers in the Faculty of Science Education at the University of Education, Winneba for expert review. Their feedback evaluated:

- Face Validity: The clarity of instructions, appropriateness of language, and overall format of the questionnaire.
- Content Validity: The extent to which the questionnaire items adequately reflected the study's objectives and comprehensively covered the domain of student perceptions regarding Computer-Assisted Instruction (CAI) in biology.

Following the expert review and necessary revisions, a pilot test was conducted to empirically assess the instrument. Fifty (50) students from a different senior high school within the Awutu Senya East Municipality, who exhibited characteristics similar to the main study population, were conveniently sampled.

The pilot responses were analysed to identify ambiguous or unclear items. Items that failed to elicit the intended responses were modified for clarity. Subsequently, internal consistency reliability was calculated using Cronbach's alpha coefficient in SPSS version 26. The obtained coefficient was $\alpha = .712$. According to contemporary psychometric standards, a Cronbach's alpha value of .70 or higher is generally considered acceptable for research instruments in the social sciences (Taber, 2018; Kline, 2023). Therefore, the value of .712 indicated that the questionnaire possessed good internal consistency and was reliable for use in the main study.

3.7 Interventions Activities

An instructional intervention is defined as an intentional, systematic procedure undertaken by educators to help students overcome specific challenges impeding their learning, often implemented over a defined period with regular progress monitoring (Lane et al., 2021). Similarly, an academic intervention is a strategy designed to teach a new skill, build fluency, or encourage the application of existing skills to new contexts, typically targeted at students who may be struggling to meet academic expectations (Hughes & Lee, 2023). The effectiveness of an intervention hinges on its alignment with clearly identified student needs.

The primary aim of this study was to address students' learning challenges in selected biology topics by employing a Computer-Assisted Instruction (CAI) approach. To achieve this, a structured, seven-week intervention was designed and implemented. Detailed lesson plans were developed (see Appendix H) to guide the instructional process.

The outline of weekly activities was as follows; in the first week students were asked to explain reproduction in humans, State the parts of male reproductive organs and their functions; List the parts of the female reproductive organs and their functions. In the second week the nervous system was taught. Students were asked to explain control and coordination of body activities, describe the general plan of the nervous system and identify the parts of the brain and state their functions. In the third week the excretory system was taught and students were asked to explain the term excretion, explain the term homeostasis, and list four excretory organs in humans and the waste products they excrete. The fourth week saw the skeletal system lessons treated. Students were tasked to explain the concepts of skeleton, types of skeletons, types of vertebrae and types of joints. In the fifth week, the circulatory system was taught. Students were asked to define blood vessels, state the types of blood vessels, and list the composition of blood. Finally in the sixth week, body symmetry and orientation were taught. Definition of body symmetry, types of body symmetry, sectioning and types of sectioning were covered. The researcher used the computer assisted instruction guidelines to teach the students. This helped students in comprehending the selected biology topics taught.

These activities facilitated the student's ability to grasp the contents of lessons taught. This was possible because the researcher ensured the tests for each week were marked and distributed to students before the next lesson. Descriptive feedback was provided on each wrong response provided by the students. This was done to enable students identify specific strengths and areas needing improvement. At the end of the seventh (7th) week, a post-test was conducted to test the ability of students to explain basic concepts taught. The duration of each test was one hour.

3.8 Teaching the control group using Lecture Method

The control group was taught the same selected biology topics for six weeks by the researcher using the lecture method. The lesson plans are shown in Appendix H. The concepts of the topics were discussed and explained verbally using the marker and the white board. Students were given notes and allowed to ask questions where they found difficulties in understanding the concepts. All their difficulties were resolved. Students were given exercises to practice what they had learnt. They were also administered the same Biology performance test as a pre-test and post-test.

3.9 Teaching the Treatment Group Using Computer-Assisted Instruction

Computer-Assisted Instruction (CAI) encompasses educational applications where technology serves as a primary platform for delivering and facilitating learning. A contemporary definition characterizes CAI as an instructional approach where the computer functions as an interactive and adaptive tool that provides a personalized learning environment, guiding students through content, practice, and feedback (Hwang & Chang, 2023). This interactive model, as opposed to a purely presentational one, was employed in this study. A robust body of research indicates that well-implemented, interactive CAI can significantly enhance student engagement and academic outcomes, particularly in science education (Hillmayr et al., 2020; Saleh & Sari, 2022).

To begin the intervention, the researcher introduced the treatment group to the CAI learning process, explaining the structure, expectations, and interactive nature of the lessons. The instructional content was rigorously aligned with the prescribed curriculum. Lesson plans for the selected biology topics (Reproductive System,

Nervous System, Excretory System, Skeletal System, Circulatory System, and Body Symmetry) were developed by adapting objectives and core concepts from the West African Examinations Council (WAEC) Biology Teaching Syllabus (see Appendix H for lesson plans). This ensured the intervention's relevance and validity within the local educational context.

3.10 Post Intervention Activities

The researcher monitored students’ post-test scores on each selected biology topic test item administered and evaluated the impact of the intervention (CAI) with reference to students’ post-test scores on each selected biology topic. Provision of feedback to students was done and finally analysis of post-test scores and conclusion was drawn.

3.10.1 Data Collection Procedure

To promote fairness and prevent biasness the control group and treatment group were taught the following selected Biology Topics: Reproductive, Nervous, respiratory, excretory, skeletal systems, and body symmetry and orientation. The intervention activities lasted for six weeks after which the post-test was administered to both groups. This was followed by the administration of the questionnaire to the treatment group. The questionnaire was to solicit their views about the use of CAI in teaching selected biology topics.

3.10.2 Data Analysis

The data collected for this study were analysed using a combination of descriptive and inferential statistical techniques. The Statistical Package for the Social Sciences (SPSS) version 26 was employed for all analyses, with a significance level (alpha) set at α = .05 for all inferential tests (Tabachnick & Fidell, 2019).

Analysis of Test Scores (Pre-test & Post-test):

- Descriptive Statistics: The performance of students on the Biology Performance Test (BPT) was summarized using means (M) and standard deviations (SD). These were calculated for both the pre-test and post-test scores for each group (treatment and control).

- Inferential Statistics:
  - Hypothesis 1 (H_01): To determine if a statistically significant difference existed within the treatment group before and after the CAI intervention, a paired-samples t-test was conducted. This test compares the mean pretest and post-test scores of the same group of participants (Pallant, 2020).

  - Hypothesis 2 (H_02): To determine if a statistically significant difference existed between the treatment and control groups on the post-test, an independent-samples t-test was conducted. This test compares the mean post-test scores of two independent groups (Field, 2023).

Analysis of Questionnaire Data:

The data from the perception questionnaire were analysed quantitatively.

- The responses for each Likert-scale item were first organised into frequency counts and percentages to illustrate the distribution of student opinions.
- Subsequently, the mean score and standard deviation were calculated for each item and for the total scale to provide a measure of central tendency and variability in student perceptions (Polit & Beck, 2021).
- All results from the questionnaire analysis were systematically presented in summary tables.

3.11 Ethical Considerations

The researcher adhered to established ethical principles governing educational research to ensure the integrity of the study and the rights of all participants. The following procedures were implemented:

- Academic Integrity and Avoiding Plagiarism: All sources consulted during the literature review and analysis were properly acknowledged through intext citations. These sources are fully and accurately documented in the reference list in accordance with APA (7th edition) guidelines to give appropriate credit to original authors.
- Confidentiality and Anonymity: Participants were assured of the confidentiality of their data and their anonymity. To protect their identities, respondents were

assigned unique identification numbers to use on all research instruments (questionnaires and tests) instead of writing their names. This ensured that individual responses could not be linked back to a specific person in any disseminated findings.

- Voluntary Participation and Right to Withdraw: Participants were informed that their involvement in the study was entirely voluntary. They were explicitly advised of their right to withdraw from the study at any point without any penalty or consequence to their academic standing.
- Secure Data Management: To protect the interests of participants, all collected data (both physical and digital) were stored securely. Physical documents were kept in a locked cabinet accessible only to the researcher. Digital data were stored on a password-protected computer. All data will be retained for the required period and subsequently destroyed in a secure manner.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter presents and discusses the results of the study. The results are presented in line with the research hypotheses and the research question that guided the study. The findings of the study were discussed under the following subheadings: effectiveness of CAI on biology students' academic performance on selected topic in Biology, comparison of effect of lecture method and CAI on students' performance on selected topics in Biology and Biology students' views on the use of computer assisted instruction in teaching selected biology topics.

4.1 Demographics of the Respondents

The study sought some background information of the respondents involved in the study. These included educational levels of students, sex and age of students. The study involved 100 SHS 2 Biology students (60 females, 40 males) aged between 16 to18 years. The demographic characteristics of participants are presented in Table 2. The SHS form two biology students consisted of 60 home economics class who were all females and 25 general science biology students, 15 male and 10 female students.

Table 2: Demographic characteristics of the participants

Variable	Number of boys (M)	Number of girls (F)	Total (%)
Science class	15	25	40 %
Home Economics class	0	60	60 %
Total	15	85	100 %

4.2 Presentation of Findings based on Research Hypotheses and Research Question

The findings of the study were presented based on the research hypotheses and the research question.

Hypothesis One: HO_1 There is no statistically significant mean difference in students' performance before and after using computer-assisted instruction in teaching selected biology topics for the treatment group.

A paired-samples t-test was conducted to compare the academic performance of the treatment group before (pre-test) and after (post-test) using Computer-assisted Instruction. The results are presented in Table 3.

Table 3: Paired t-test Analysis of Pre-test and Post-test Scores for the Treatment Group (N=50)

Test	Mean Score (MS)	(SD)	(MD)	t-value	df	p-value
Pre-test	8.64	1.31	9.76	37.40	49	.000
Posttest	18.40	1.82				

P <.001

The results indicate a substantial increase in the mean score from the pre-test (*M* = 8.64, *SD* = 1.31) to the post-test (*M* = 18.40, *SD* = 1.82), representing a mean gain of 9.76 points. The paired-samples t-test revealed that this improvement was statistically significant, $t(49) = 37.40$, $p < .001$.

Conclusion: The null hypothesis (H_o1) is rejected. There is a statistically significant mean difference in students' performance before and after the CAI intervention. The very large t-value and the highly significant p-value ($p < .001$) provide strong evidence that the CAI implementation had a substantial positive impact on the academic performance of students in the treatment group for the selected biology topics. The significant improvement in post-test scores aligns with a substantial body of contemporary research on technology-enhanced learning. Meta-analytic studies consistently report moderate to large effect sizes for digital tools in science education, particularly when they provide interactive and adaptive feedback, as CAI does (Hillmayr et al., 2020; Saleh & Sari, 2022). The mean gain of approximately 10 points suggests that the CAI intervention was not merely statistically significant but also educationally meaningful. This improvement can be attributed to several key mechanisms of CAI supported by theory: its ability to provide immediate, personalised feedback (a behavioural reinforcement principle), present complex biological processes through interactive visualizations that manage cognitive load (Cognitive Theory of Multimedia Learning), and create an active, student-centered learning environment (Constructivist principles) (Mayer, 2021; Kozma, 2021). The findings thus confirm that a well-structured CAI intervention can effectively enhance comprehension and retention of challenging biological concepts.

Hypothesis Two: HO_2: There is no statistically significant difference between the performance of SHS2 biology students taught using lecture methods and those taught using computer-assisted instruction. To test this hypothesis, an independent samples t-test was conducted to compare the post-test performance of the control group (taught via lecture method) and the treatment group (taught via CAI). Descriptive statistics for both groups are presented in Table 4, and the inferential test results are shown in Table 5.

Table 4: Mean scores and standard deviation for control and treatment groups

Variable	N	pre-test MS	pre-test SD	post-test MS	post-test SD	mean gain
control group	50	2.60	1.21	8.96	1.40	6.36
treatment group	50	4.51	1.01	18.02	1.70	13.51

Table 4 presents the mean scores and standard deviations for the control group taught with lecture method and the treatment group taught using Computer-Assisted Instruction. The pre-test scores for the treatment group had higher mean scores of (4.51) (SD = 1.01) compared to the control group (lecture) with mean score of (2.60) (SD = 1.21). The post-test mean scores for both groups were higher than their pre-test mean scores. However, the post-test mean score of (18.02) for the treatment group was higher than that (8.96) for the control group. The mean difference of (9.06) between the groups' mean scores of their post-test scores suggested improvement in the performance of the treatment group's with the use of CAI in teaching selected biology topics.

The results of the independent samples t-test revealed a statistically significant difference between the pre-test scores [(t (98) = -6.51, p < .001)] (Table 9) with large effect size of (1.43). Since there was statistically significant difference in performance between SHS2 biology students taught with CAI and students taught with the lecture method the null hypothesis, which stated that there was no statistically significant difference between the performance of SHS2 biology students taught with lecture method and those taught using computer-assisted instruction was therefore rejected. This suggests that CAI can enhance student engagement, understanding, and retention in biology.

Table 5: Independent Samples t-test Comparing Post-test Scores of Control and Treatment Groups

Group	MS	SD	t-value	df	P-value	Cohen's d
Control	8.96	1.40	-6.51	98	<. 001	1.43
Treatment	18.02	1.70				

Descriptively, both groups showed improvement from pre-test to post-test. However, the magnitude of improvement was substantially greater for the treatment group (mean gain = 13.51) compared to the control group (mean gain = 6.36). More critically, the post-test mean score for the CAI group (M = 18.02, SD = 1.70) was markedly higher than that of the lecture group (M = 8.96, SD = 1.40), yielding a mean difference of 9.06 points.

The independent-samples t-test confirmed that this difference was statistically significant, $t(98) = -6.51$, $p < .001$. The associated effect size, Cohen's d = 1.43, is considered very large according to conventional benchmarks (Cohen, 1988), indicating that the CAI intervention had a substantial practical impact on student performance beyond mere statistical significance.

Conclusion: The null hypothesis (H_o2) is rejected. There is a statistically significant difference in the post-intervention performance of students taught with CAI compared to those taught with the traditional lecture method. The CAI group demonstrated superior academic achievement.

This finding provides strong empirical support for the efficacy of CAI over traditional lecture methods in this context. The very large effect size (d = 1.43) suggests that the CAI intervention was not just statistically better but produced a dramatic educational improvement. This aligns with meta-analytic evidence indicating that digital tools, when used as a supplement to instruction, often yield moderate-to-large positive effects on learning outcomes in science (Hillmayr et al., 2020; Saleh & Sari, 2022). The significant pre-test difference noted ($t(98) = -6.51$, $p < .001$) is a limitation common in quasi-experimental designs using intact classes. However, the analysis correctly focuses on comparing the *post-test* scores to assess the intervention's effect. The superior performance of the CAI group can be attributed to its core interactive features such as immediate feedback, adaptive pacing, and multimedia visualizations which actively engage students and promote deeper cognitive processing, as theorized by the Cognitive Theory of Multimedia Learning (Mayer, 2021) and principles of personalised instruction (Kozma, 2021). This result underscores CAI's potential as a powerful pedagogical tool for enhancing conceptual understanding and academic performance in secondary school biology.

Research Question Three: What are students' views on the use of computer assisted instruction in teaching selected biology topics?

A questionnaire was administered to the treatment group after the intervention to collect views of the members of the group on the use computer assisted instruction for selected topics in Biology. The responses of the group were organised into frequency counts and converted into percentages. The results are presented in Table 6.

Table 6: Distribution of percentage frequencies of treatment group's responses on their views about the use of CAI on selected Biology topics

S/N	STATEMENT	% FREQ OF RESPONSES		
		A	UN	SA
1	I am Interested in Selected Biology Topics taught *using* CAI	24	0.0	76
2	CAI Models explains difficult Concepts on Selected Biology Topics Better.	14	0.0	86
3	After studying selected biology topics with CAI, I ask myself questions to make sure I know the material I have been studying.	22	0.0	78
4	CAI models have helped me understand the various systems (digestive system, respiration system, nervous system, reproductive system). Etc. functions appropriately	18	0.0	82
5	I work on practice exercises and answer end of the chapter questions on selected biology topics with CAI even when I am not required to do so.	16	2	82
6.	Models' approach of teaching has made it easier for me to understand concepts better.	16	0.0	84
7.	CAI models' approach helps students to better comprehend lessons confidently.	10	0.0	90
8.	CAI models help teachers to also teach very confidently.	10	0.0	90
9.	CAI models help teachers to explain concepts better to the understanding of students.	24	0.0	76
10.	CAI models' approach makes it easier for me not to misbehave during lessons.	18	0.0	82
11.	CAI models' approach makes it easier for teachers to interact with students.	18	0.0	82
12.	CAI model lessons stimulate the critical thinking skills of students.	24	0.0	76
13.	CAI models' approach gives enough time for students to analyse and synthesise information being received logically.	28	0.0	72
14.	CAI models' approach gives enough time for class discussion.	34	0.0	66
15.	CAI model lessons help me to correct my misconceptions on previous concepts taught.	30	0.0	70
16.	CAI model lessons generate a sense of fulfillment in me during lessons.	32	0.0	68

17.	The regular pausing of CAI model lessons by the teacher to explain concepts to students leads to time wasting.	38	0.0	62
18.	I have understood the concepts taught in selected biology topics using CAI models, therefore I'm happy reading my notes.	40	0.0	60
19.	Observing others do well through CAI lessons makes me believe that I can do much better than my current performance without CAI models.	26	0.0	74
20.	When I study selected biology topics through CAI, I jot down important points in my own words.	18	0.0	82
21	I am satisfied with my performance in current exercises through CAI models' approach.	18	0.0	82
22.	Ghana education service policy encourages teachers to use CAI models to teach.	26	0.0	74
23.	The use of CAI models' approach in teaching selected biology topics stimulates students to unearth their talents.	20	0.0	80
24.	CAI models lessons are expensive and need sponsorship from other corporate organisations.	24	0.0	76
25.	The use of CAI models makes me develop more interest in studying selected biology topics.	32	0.0	68
26.	I like the challenge of CAI lessons because it stimulates my critical thinking skills.	20	0.0	80
27.	Even when a topic is dull and uninteresting, I keep working till I finally comprehend it using CAI models' approach.	28	0.0	72
28.	I have learnt to manage my time much better in doing assignments using CAI models' approach than previous years.	22	0.0	78
29.	CAI models' approach of teaching makes it easier for me to communicate better in class.	32	0.0	68
30.	When I am studying, I try to put together the information from CAI, the teacher and the biology textbook.	16	0.0	84

The respondents chose the agree and strongly agree out of the five options for all the items except item 5 where two percent of the respondents selected the undecided option. The percentage frequencies for the agree option varied from 10 % (Items 7 and 8) to 40 % (Item 18) with percentage frequencies for 13 items between 10 % and 20 %, 10 items between (22 %) and (30 %) while the rest of items (7) had percentage frequencies between (32) and (40 %). The percentage frequencies for the option strongly agree varied between (60 %) (item 18) and (90 %) (items 7 and 8). The rest of the items were distributed among the following ranges of percentage frequencies: seven items with percentage frequencies between (60 %) and (70 %), 12 items with percentage frequencies between (71 %) and (80 %) and 11 items with percentage frequencies between (81%) and (90 %).

The interpretations of the participants' responses with respect to their views about the use of CAI in teaching selected topics yielded 12 findings. 76% and 68 % of the respondents strongly agreed that the use CAI (item 1) and the use of CAI models (Item 25) respectively helped them develop interest in the selected topics taught.

Over 80 % of the respondents strongly agreed that the use of CAI models to teach topic facilitated their understanding of difficult concepts in Biology (Item 2) and enabled them to understand the functions of the human systems (Item 4).

60% of the respondents strongly agreed that the use of CAI models in biology lessons facilitated their understanding of the concepts and they are motivated to read their notes (Item 18) while (72 %) of them strongly agreed that they are motivated to work on topics that are not interesting (Item 27). More importantly (78 %) of the respondents indicated that the use of CAI in biology lessons promote self-reflection on their understanding of the concepts being taught (Item 3) and (82 %) of them practice on the exercises on the topics taught provided in the biology textbook (Item 5).

The use of CAI in biology lessons gives the respondents confidence in their learning. Majority of the respondents (90 %) strongly agreed that the use of CAI models in biology lessons facilitate their comprehension of the concepts taught and they are confident about their comprehension of the concepts (Item 7). In the same vein, 74 %

of them strongly agreed that other students do well in Biology through the use of CAI make them believe they too would do better than the present performance (Item 19). Majority of the respondents indicated that the use of CAI promotes engagement of learners during biology lessons. (82%) of the respondents indicated that the use of CAI models in biology lessons makes it easier for teachers to interact with students (Item 11) and (72 %) indicated that it facilitates students to logically analyse and synthesise information received during instruction (Item 13). This is supported by (84 %) of the respondents strongly agreed that they try to put together (synthesise) the information from CAI, the teacher and the biology textbook (Item 30).

The use of CAI Biology lessons stimulates critical thinking among learners. A good number of the respondents (72 %) strongly agreed that CAI promotes critical thinking skills (Item 12) and the challenges posed to the learners through the CAI stimulate the learners' critical thinking (Item 26). This is likely to help them correct their misconceptions of the concepts taught, therefore promoting conceptual change. The latter was strongly agreed to by (70 %) of the respondents (Item 15).

The use of CAI models in biology lessons bring about personal fulfillment to learners as they facilitate their active participation during the lessons. A good number of respondents (68 %) strongly agreed that the models generate sense of fulfillment in them during the lesson (Item 16). This substantiated by (82 %) of the respondents who indicated that they were satisfied with their performance in exercises generated through CAI models.

The use of CAI promotes communication among learners when used in biology lessons. This strongly supported by (68 %) of the respondents that CAI approach makes it easier for them to communicate (Item 29).

Generally, the results from the responses to the questionnaire items indicated that the treatment group held positive views on the use of CAI in biology lessons on the selected topics taught. Despite these positive views expressed about the use of CAI in biology lessons, CAI has limitations as indicated by (76 %) of the respondents who agreed that CAI lessons are expensive (Item 24) due to cost of equipment while (62 %) indicated that the regular pauses of the teacher during CAI to explain concepts lead to waste of time.

In summary the data reveal overwhelmingly positive perceptions where 29 out of 30 items, 100% of respondents selected *Agree* or *Strongly Agree*. The only exception was Item 5 (voluntary practice), where 98% agreed.

The treatment group expressed exceptionally positive views on the use of CAI across cognitive, affective, and behavioural domains. These perceptions strongly align with the significant performance gains reported in Hypotheses 1 and 2, suggesting that the CAI intervention was not only effective but also highly acceptable and engaging for the students. The findings underscore CAI's potential to create a motivating learning environment that fosters deep understanding and active participation in biology.

4.3 Discussions of the Findings

The findings are discussed under three major themes:

- Effectiveness of CAI in improving biology students' performance,
- Differences in Effects of Computer Assisted Instruction and Lecture Method on biology Academic Performance and
- Students' views about the use of CAI biology lessons.

4.3.1 Effectiveness of CAI on Students' Academic Performance in Selected Topics in Biology

The results of this study demonstrate compelling evidence for the effectiveness of Computer-Assisted Instruction (CAI) in improving student performance. The statistical analysis revealed a significant and substantial increase in mean scores within the treatment group, from 8.64 in the pre-test to 18.40 in the post-test ($t(49) = 37.40$, $p < .001$). This dramatic improvement provides quantitative confirmation that the CAI intervention had a powerful, positive impact on learning outcomes for the selected biology topics.

This finding aligns robustly with the current body of research on educational technology. Meta-analytic studies have consistently shown that digital tools, particularly interactive forms of CAI, have a significant positive effect on student achievement in STEM subjects (Hillmayr et al., 2020; Saleh & Sari, 2022). The gains observed in this study corroborate these broader conclusions, suggesting that well implemented CAI is a potent strategy for addressing challenging biological concepts.

The mechanism behind this effectiveness is illuminated by the qualitative data gathered from students. Their overwhelmingly positive views provide a crucial explanatory layer for the quantitative gains. Students reported that CAI significantly boosted their interest and motivation in the subject (Items 1 & 25). This heightened engagement is a critical precursor to deep learning, as motivated students are more likely to invest cognitive effort and persist with difficult material, a factor strongly linked to improved academic outcomes (Bond et al., 2020).

Furthermore, students identified specific pedagogical strengths of CAI that contributed to their understanding. They found that CAI's interactive models and simulations made abstract and complex biological systems such as human physiology more comprehensible (Items 2, 4, 6). This perception is grounded in the Cognitive Theory of Multimedia Learning (Mayer, 2021), which posits that visualizations and interactive elements help manage cognitive load and facilitate the integration of new information with prior knowledge. By concretizing invisible processes, CAI directly addressed a primary source of difficulty in biology.

Beyond foundational knowledge, the CAI environment also fostered higher-order cognitive skills. Students reported that the approach stimulated critical thinking and problem-solving (Items 12, 26), encouraged self-regulated learning behaviours like self-questioning (Item 3), and helped them synthesize information from multiple sources (Item 30). This shift from passive reception to active knowledge construction is a hallmark of effective, student-centered learning. (Jonassen, 2000; Çakıroğlu & Öztürk, 2021).

The intervention also promoted practical benefits that enhanced learning efficiency. Students noted that CAI supported better time management (Item 28) and provided a structured yet flexible environment that kept them engaged and reduced off-task behaviour (Item 10). These factors likely contributed to the quality and focus of their learning time, thereby supporting the significant performance gains.

In conclusion, the effectiveness of CAI in this context is not attributable to a single factor but to a synergistic combination of elements: it increased student motivation, provided superior explanatory tools for complex content, actively engaged students in critical thinking, and created an efficient learning environment. This integrated impact explains the substantial improvement in academic performance. While students pragmatically noted limitations such as cost and potential disruptions (Items 17, 24), their overall experience strongly supports CAI as a valuable and effective pedagogical approach for enhancing learning in secondary school biology.

4.3.2 Comparison of Computer-Assisted Instruction and the Lecture Method on Academic Performance

Building on the evidence of CAI's effectiveness, this study further sought to compare its impact directly against the traditional lecture method. The results were unequivocal: students in the CAI treatment group significantly outperformed their peers in the lecture-based control group on the post-test. The independent samples t-test yielded a statistically significant result ($t(98) = -6.51$, $p < .001$) with a very large effect size (Cohen's $d = 1.43$). This substantial difference demonstrates that CAI is not merely effective in isolation but is a markedly superior instructional strategy for the selected biology topics when compared to conventional teaching.

This finding challenges the passive knowledge-transmission model inherent in the lecture format. While lectures can efficiently deliver information, they often fail to facilitate the deep, interactive engagement necessary for mastering complex biological systems (Schönborn & Bögeholz, 2021). In contrast, as the student perception data revealed, CAI transformed the learning environment into an active, student-centered space. Students reported that CAI promoted greater interaction with both the teacher and peers (Items 10, 11), fostered collaborative learning, and encouraged them to take ownership of their learning process. This shift from passive recipient to active investigator aligns with constructivist learning theories and explains the differential outcomes (DeCoito & Fazio, 2023; Kim et al., 2024). The CAI group's superior performance can therefore be interpreted as a direct result of this more engaging and cognitively demanding pedagogical approach.

4.3.3 Synthesis of Student Views on Computer-Assisted Instruction

The quantitative performance data is powerfully reinforced by the overwhelmingly positive perceptions of the students who experienced the CAI intervention. Their responses across 30 questionnaire items painted a consistent picture of a highly valued and impactful learning tool. Thematically, their views centered on CAI's role in enhancing engagement, comprehension, and skill development.

Students consistently linked CAI to increased motivation and interest (Items 1, 25), identifying it as a key factor that made biology more appealing. This affective benefit is critical, as interest is a known driver of sustained engagement and academic persistence. More importantly, they credited CAI with making difficult concepts accessible, citing its ability to explain complex processes through visualizations and interactive models (Items 2, 4, 6). This directly addresses a historic barrier to success in biology and supports the principles of multimedia learning (Mayer & Fiorella, 2021; Smith, 2022).

Beyond understanding, students highlighted the development of broader academic competencies. They felt CAI stimulated critical thinking and problem-solving (Items 12, 26), helped them correct misconceptions (Item 15), and improved their ability to manage time and synthesize information from various sources (Items 28, 30). These reports indicate that CAI's impact extended beyond rote memorization to foster the higher-order cognitive skills essential for scientific literacy (Mnguni, 2020; Tümay, 2021).

Conclusion of the Discussion

In summary, the findings from this study form a coherent and mutually reinforcing narrative. The significant improvement in test scores within the CAI group, its clear superiority over the lecture method, and the resoundingly positive student perceptions collectively provide robust, triangulated evidence for the value of Computer-Assisted Instruction. CAI proved to be an effective strategy not only for boosting academic performance in challenging biology topics but also for creating a more engaging, motivating, and skill-enhancing learning environment. While practical challenges such as resource cost and implementation logistics (Items 17, 24) were acknowledged, the overall evidence strongly advocates for the strategic integration of CAI as a supplemental tool in the biology classroom to promote deeper understanding and greater student success (Adnan & Ritzhaupt, 2023; UNESCO, 2021).

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.0 Overview

This chapter provides a summary of the study, synthesises the key findings, draws evidence-based conclusions, presents practical recommendations, and suggests directions for future research.

5.1 Summary of the Study

This study investigated the effectiveness of Computer-Assisted Instruction (CAI) in improving the academic performance of Senior High School (SHS) students in selected biology topics. CAI is defined as an instructional approach where the computer serves as an interactive platform to deliver content, provide adaptive feedback, and facilitate learning through tutorials, simulations, and assessments (Hwang & Chang, 2023).

Employing a quasi-experimental, non-equivalent groups design, the research involved 100 SHS 2 Biology students from Odupong Senior High School, assigned to a treatment group (CAI) and a control group (traditional lecture method).

The study was guided by two research hypotheses and one research question. A researcher-developed Biology Performance Test (BPT) was administered as a pre-test and post-test. Following a structured seven-week intervention, a questionnaire was used to capture the treatment group's perceptions of the CAI experience. Data analysis employed descriptive statistics (means, standard deviations, frequencies) and inferential statistics (paired-samples and independent-samples *t*-tests) to evaluate the hypotheses and research question.

5.2 Key Findings of the Study

The analysis yielded three principal findings:

- Significant Improvement with CAI: A paired-samples t-test revealed a statistically significant and substantial improvement in the treatment group's performance from pre-test (*M* = 8.64, *SD* = 1.31) to post-test (*M* = 18.40, *SD* = 1.82), with $t(49) = 37.40$, $p < .001$. This demonstrates a strong positive impact of the CAI intervention on learning outcomes, consistent with meta-analytic research on digital tools in STEM education (Hillmayr et al., 2020).
- Superiority of CAI over Lecture Method: An independent-samples t-test on post-test scores showed that the CAI group (*M* = 18.02, *SD* = 1.70) significantly outperformed the control group (*M* = 8.96, *SD* = 1.40), with $t(98) = -6.51$, $p < .001$ and a very large effect size (Cohen's $d = 1.43$). This provides robust evidence that CAI is more effective than the traditional lecture method for the topics studied, supporting a shift towards more interactive pedagogies (DeCoito & Fazio, 2023).
- Overwhelmingly Positive Student Perceptions: Questionnaire data revealed that students held highly favourable views of CAI. Key themes from their responses included enhanced motivation and interest, improved comprehension of complex concepts through interactive visualizations, the development of critical thinking skills, and appreciation for the self-paced, adaptive nature of the instruction, which aligns with principles of multimedia and personalized learning (Mayer, 2021; Bond et al., 2020).

5.3 Conclusion

The study conclusively demonstrates that Computer-Assisted Instruction is a highly effective pedagogical strategy for enhancing student achievement in selected biology topics, yielding significantly better results than the traditional lecture method. The profoundly positive student perceptions further validate CAI as an engaging and motivating instructional tool that supports deeper learning and the development of essential 21st-century skills. These findings align with contemporary educational research advocating for the integration of technology to create active, student-centered learning environments.

5.4 Recommendations

Based on the findings, the following recommendations are made:

- For Biology Teachers and Curriculum Planners: It is recommended that biology teachers integrate CAI as a supplemental tool within the existing curriculum. Professional development should be provided to equip teachers with the skills to design and implement effective CAI lessons that align with specific learning objectives and pedagogical best practices.
- For School Administration and Educational Authorities: School leadership and the Ghana Education Service (GES) should prioritize strategic investments in the necessary technological infrastructure (reliable hardware, software, and internet access) and establish ongoing technical and pedagogical support systems to facilitate sustainable and equitable CAI integration.
- For Teacher Training Institutions: Colleges of Education and universities should strengthen the technology integration components of their science teacher training programs. This will ensure pre-service teachers graduate with the

proficiency to critically evaluate, effectively utilize, and creatively design CAI resources.

5.5 Suggestions for Further Study

To build upon this research, the following avenues are suggested:

- Replication and Contextual Expansion: This study should be replicated in other Senior High Schools across different regions, socio-economic contexts, and with larger sample sizes to enhance the generalizability and robustness of the findings.
- Longitudinal and Transfer Impact: Future research could employ a longitudinal design to investigate the long-term retention of knowledge gained through CAI and its transfer effect on performance in subsequent science courses or standardized national examinations.
- Qualitative Depth: A complementary qualitative study using in-depth interviews or focus groups with students and teachers could provide richer insights into the specific mechanisms, contextual challenges, and pedagogical dynamics of CAI implementation.
- Subject and Pedagogical Exploration: Research could explore the effectiveness of CAI in other demanding STEM subjects (e.g., Chemistry, Physics) or investigate its impact when combined with other pedagogical frameworks, such as flipped classrooms or project-based learning.

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APPENDIX A

SECTION A (OBJECTIVES QUESTIONS ON REPRODUCTIVE SYSTEM)

INSTRUCTION: ANSWER ALL QUESTIONS SECTION A AND B

Select the best option from (A-D) that best fit each of the following sentences

1. Sperm are produced in the? a. sertoli cells b. seminiferous tubules c. Leydig cells d. graafian follicle
2. Which of the following is not found in the testis? a. Sertoli b. seminiferous tubules c. Leydig cells d. graafian follicle
3. Which structure connects the ovary to the uterus? a. fallopian tubes b. seminiferous tubules c. urethra d. ureter
4. The time taken for an embryo to develop from fertilization to birth is called? a. the menstrual cycle b. labour c. the gestation period d. approximately six weeks
5. Which of the following is a secondary sexual characteristic of human females? a. facial hair b. rounded hips c. deep voice d. broad shoulders Complete the following statements by either underlining true or false to make it meaningful.
6. Reproduction is essential because no organism can live forever. True / False
7. New individuals therefore must be produced in order for each species to continue. True/ False
8. Mammals reproduce sexually, which requires the joining of gametes from a male and a female. True/ False
9. Each gamete from each parent is haploid meaning it contains a single set of unpaired chromosomes. True/ False

10. Fusion of each haploid gametes from both parents results in a zygote which is a full complement of paired chromosomes. True/ False
11. Mammals are unisexual means their sexes are separate from each other. True /False
12. The word gonads refer to either the female ovaries or the male testes. True/ False
13. The spongy tissue of the penis contains spaces which become filled with blood making it hard during sexual excitement. True/ False
14. The fallopian funnel leads into the fallopian tube or oviduct. True/ False
15. The fallopian tube or oviduct continues downwards and inwards to the midsection and joins the uterus which has thick elastic walls. True/ False **Fill in the blank spaces with the correct answers to make the statements meaningful.**
16. The male reproductive system consists of ………….. testes, enclosed in a structure called…………………..
17. The shape of the testes found in men is described as ……………………………..
18. Explain why the testes in men hangs outside the body?..
....
19. The spermatic cord in males contains ………………… and ……………..……
20. List two hormones produced by the testes in males……………………………. and………………………………………
21. The sperm produced by males is temporary stored in a structure called………
22. State two purposes for the secretions produced by the seminiferous tubules and epididymis for the sperm?...................................... and …..……………

23. Each epididymis is connected to a tube called………………………………

24. The two sperm ducts/ vas deferens join together and open into a long tube running through the centre of the penis called?..

25. Three glands namely the seminal vesicle, the prostate and cowper's gland secrete fluid into the urethra during…………………………………………

26. Explain why the urethra is described as having urinogenital functions?..

....

....

27. State three characteristics of seminal fluids/semen?..

....

28. Two examples of hormones produced by the ovaries in females are…………………………..……… and ……………………………….………

29. State two functions of the hormones produce by ovaries.?..

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30. The muscular neck of the uterus projects into the……………………… ….and known as the…………………………

31. The seminiferous tubules join to form the……………………………………where mature…………………… are stored.

32. One of the interstitial cells located next to the seminiferous tubules inside the testicle which produces the hormone testosterone is called?…………………

33. State one clear difference between female rabbits and female in terms of their reproductive system?...
....
....
....

34. The mouth of the vagina is surrounded by an inner lips or membrane and an outer lips or membrane called the ……………………………………………...

35. The circular or rounded sensitive organ located on top of the vulva containing erectile tissues for sexual pleasure is called?..

36. The fallopian tube or oviduct continues downwards and inwards to the midsection and joins the uterus which has thick elastic walls. True/ False

QUESTIONS ON THE REPRODUCTIVE SYSTEM

SECTION B (ANSWER ALL QUESTIONS)

- Explain the term reproduction in humans?

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- State the parts of male reproductive organs and their functions?

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- State the parts of female reproductive organs and their functions?

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- Define the following terms; a) Oestrus b) Ovulation c) Menstruation d) Menstrual cycle

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MARKING SCHEME FOR OBJECTIVES QUESTIONS ON

REPRODUCTIVE SYSTEM IN HUMANS

ANSWERS TO SECTION A QUESTIONS ON REPRODUCTION IN HUMANS

1. B (seminiferous)
2. D (graafian follicle) • A (fallopian tubes)
3. C (gestation period)
4. B (rounded hips) true
5. True
6. True
7. True
8. True
9. True
10. True
11. True
12. True
13. True
14. True
15. Two testes enclosed in a structure called scrotum/scrotal sac
16. Ovoid/egg shaped
17. They are outside the body because the normal body temperature is too high for normal sperm production
18. Spermatic artery and spermatic vein
19. Testosterone and
20. Epididymis

21. To live successfully and to move or swim in it medium to fertilise the egg/ovum
22. Vas deferens or sperm duct
23. Urethra
24. Ejaculation
25. This is because the urethra serves as a passage for both urine and released of semen containing spermatozoa that fertilizes the ovum of females
26. Seminal fluids/semen—1. It forms a watery medium in which sperms swims. 2. It also contains food nutrients for the nourishment of sperm cells. 3. It also contains enzymes that make sperm cell very active
27. Oestrogen and progesterone
28. 1. The hormones control the development of female secondary sexual characteristics. 2. They also initiate the thickening of the walls of the uterus in readiness for implantation of the fertilized egg
29. Vagina and cervix
30. Epididymis, sperms
31. Leydig cells
32. In female rabbits the vagina is connected to the urethra which leads to a common passage called vestibule or which forms a common passage called vestibule for urine passage and offspring (sexual organ and birth canal) whiles in female humans the vagina is separate and the urethra is also separate.
33. Vulva (vulva consist of labia minora (inner lips) and labia majora (outer lips)
34. Clitoris
35. True

MARKING SCHEME FOR SECTION B (REPRODUCTIVE SYSTEM)

36. Reproduction- this is a biological process by which new individual organisms

(offsprings) are produced from their parents through sexual intercourse.

37. Parts of male reproductive organs include; testicles, scrotum, epididymis, sperm duct (vas deferens), prostate gland, cowper's gland, seminal vessicles, erectile tissue. etc. the testicles produce sperm and male hormones such as testosterone
38. Parts of female reproductive organs include; ovaries, oviduct, uterus, cervix, vagina. etc. the cervix is the narrow region where the uterus meets the vagina.
39. a) Oestrus-This refers to the fertile period of the female or it refers to the period when the female is fertile

b) Ovulation-This occurs about every 28 days in the life of females when one egg is released alternately by the two ovaries.

c) Menstruation- This is when there is a breakdown of the thick uterine wall lining and unfertilized eggs are discharged with a quantity of blood through the vagina mostly monthly.

d) Menstrual Cycle-This refers to the monthly hormonal cycle a female's body goes through to prepare for pregnancy. It is counted from the first day of your period up to the first day of your next period

APPENDIX B

POST INTERVENTION EXERCISE TWO

QUESTIONS ON THE NERVOUS SYSTEM

(CONTROL AND CO-ORDINATION)

SECTION A (FILL IN THE BLANK SPACES WHERE REQUIRED)

1. State the function of the soma found in the nerve cell?................................
2. The following are parts of the nerve cell or neuron except? a. dendrites
   b. axon c. Node of Ranvier d. textures
3. The………… Receives and send action potentials to the brain and returns appropriate stimulus response to target organs? a. dendrites
   b. axon c. Node of Ranvier d. textures
4. Which brain structure is responsible for the body's balance and coordination? a. thalamus b. medulla oblongata
   c. cerebrum d. cerebellum
5. State the function of the medulla oblongata?
   ………………………………………………………………………………
6. List one function of the cerebrum? ………………………………………
7. What is the function of the thalamus?………………………………………
8. Which of the following structures is not part of the central nervous system?
   a. the spinal cord b. the brain stem
   c. the spinal nerves d. the cerebral cortex
9. Which of the following is the most basic functional unit found in the nervous system? a. action potentials b. neurons c. glial cells d. the cerebellum
10. What type of cell provides support for neurons? a. glial cells

b. connective tissues c. mitochondria d. epithelial cells

11. Schwann cells, oligodendrocytes, astrocytes, and ependymal cells are few examples of? a. glia b. mitochondrion c. blood vessels d. epithelial cells

12. Schwann cells and oligodendrocytes provides myelination for neurons. True/ False

13. Astrocytes play a key role in supporting the blood-brain barrier. True/ False

14. Ependymal cells are responsible for secreting and circulating cerebrospinal fluid. True/ False

15. Blood vessels provide oxygenated blood and nutrients necessary for proper neuronal functions. True/False

16. Connective tissues are large components of the dura surrounding the brain itself, but does not provide support for neurons themselves. True/ False

17. Epithelial cells help structurally support the blood-brain barrier, but does not interact directly with neurons. true/ False

18. What are the three structural regions of a neuron? a. axon, dendrites, cell wall b. dendrites, cell body, flagellum c. cell body, cell wall, axon d. cell body, dendrites, axon

19. Which part of the neuron contains the nucleus and other organelles?
a. the axon terminal b. the cell body c. the dendrites d. the axon

20. Which of the following refers to a long projection off the cell body of the neuron that is used to conduct electrical signals to neighboring cells?
b. dentrite b. axon c. synapse d. action potential

21. Which of the following consists of spinal nerves that pass through the inferior aspect of the vertebral column? a. dura matter b. cranial nerves c. cervical nerves d. cauda equina
22. Which of the cranial nerves is associated with sense of smell? a. optic b. trigeminal c. facial d. olfactory
23. The nervous system is responsible for our thoughts, our emotions, our senses, our movements, the brain, nerves, and the spinal cord are all members of this important process. True/ False
24. The three main problems that can affect the nervous system are blood supply problems, injuries to organs, problems that are present at birth (congenital). True/ false

SECTION B, ANSWER ALL QUESTIONS NERVOUS SYSTEM (CONTROL AND COORDINATION)

1. Explain control and coordination of body activities.
2. Describe the general plan of the nervous system.
3. Identify the parts of the brain and state their functions

MARKING SCHEME TO SECTION A QUESTIONS ON NERVOUS SYSTEM (CONTROL AND COORDINATION)

1. Soma of the nerve cell- The soma is the cell body of the neuron. it is the site of neuron metabolism and protein synthesis.

   Dendrites of the nerve cell-It receives incoming action potential signals and gives an appropriate feedback stimulus

   Axon of the nerve cell-This sends the action potential outwards from the soma to the axon terminal.

   Vesicles of the nerve cell- They are neurotransmitters released from the axon terminal to the dendrites of other nearby neurons. neurons can have numerous dendrites but will have only one soma and one axon.
2. D (texture)
3. A (dendrites)
4. D (cerebellum)
5. Medulla oblongata—is responsible for maintaining subconscious body functions such as heart rate and breathing
6. Cerebrum—is responsible for higher level functions such as movement and memory
7. Thalamus—is responsible for mediating survival instincts such as hunger, thirst, sexual instincts. Etc.
8. C (the spinal nerves)
9. B (neurons)
10. A (glial cells)
11. A (glia)
12. True

13. True

14. True

15. True

16. True

17. True

18. D (cell body, dendrites, axon)

19. B (cell body)

20. B (axon)

21. D (cauda equina)

22. D (olfactory)

23. True

24. True

MARKING SCHEME TO SECTION B,

QUESTIONS ON THE NERVOUS SYSTEM

1. This is when mammals respond to stimulus in many ways. Example responding to cold weather by wearing appropriate clothes to avert the effects of cold weather. This ability of an individual is only possible when his/her nervous and hormonal systems are working and well-coordinated.
2. The nervous system consists of two (2) major parts, namely, the central nervous system and the peripheral nervous system. the central nervous system consists of the brain and spinal cord, while the peripheral nervous system consists of the cranial nerves and the spinal nerves. The autonomic nervous system is concerned with the internal coordination of the body.
3. The brain consists of three main regions
4. forebrain which extends to form the cerebrum and responsible for controlling all voluntary activities of the body such as reasoning, will power, vision, speech, taste, smell. Etc
5. midbrain which extends to form brainstem also has the pons and medulla. It connects to the cerebrum and spinal cord.
6. hindbrain forms the cerebellum and responsible for receiving impulses from the semi-circular canals of the ear and involved in balancing and posture of individuals.

APPENDIX C

POST INTERVENTION EXERCISE THREE ON THE RESPIRATORY SYSTEM

SECTION A (ANSWER ALL QUESTIONS)

1. In which part of the respiratory system does gaseous exchange takes place?

   a. alveoli b. pharynx c. larynx d. trachea

2. ………………………….. Is located between two pleural sacs and is the central compartment of the thoracic cavity? a. hilum b. pleura c. mediastinum d. thoracic cage

3. Which of the following statements is true about involuntary breathing?

   a. it is controlled by the bronchioles b. it is controlled by the pulmonary arterioles c. it is controlled by the alveolar-capillary network d. it is controlled by the neurons, located in the medulla and pons

4. Which of the following are parts of the human respiratory system?

   a. trachea b. diaphragm c. the lungs d. all the above

5. Which of the following gas is released out during the process of respiration? a. oxygen b. hydrogen c. carbon dioxide d. none of the above

6. The tiny air sacs present in human lungs is called? a. alveoli b. bronchus c. bronchioles d. all of the above

   Which of the following functions by filtering and keeping the mucus and dirt away from our lungs? a. cilia b. bronchioles c. hairs in the lungs d. all of the above

7. The total number of alveoli present in the human lungs is estimated to be around….? a. 1 billion b. 800 million c. 500 million d. 1500 million

8. The exchange of gases between the external environment and the lungs is called ….? a. respiration b. external respiration c. cellular respiration d. none of the above

9. Which one of the following statements is false about the trachea?

   a. has C-shaped rings b. it is covered by epiglottis c. it splits into the right and left lungs d. none of the above

10. The maximum volume of air contained in the lung by a full forced inhalation is called…………..? a. tidal volume b. vital capacity c. ventilation rate d. total lung capacity

11. Which one of the following is correct regarding larynx? a. it houses the vocal cords b. it prevents the invading pathogens into the trachea

    c. it is an organ made of cartilage and connects the pharynx to the trachea

    d. all of the above

12. Which of the following is the function of the trachea? a. gaseous exchange b. filters the air we breathe c. exhales the air from the body d. all of the above

13. Which of these statements is true about internal respiration?

    a. production of ATP b. exchange of gases between the bloodstream and tissue cells c. exchange of gases between alveoli and the bloodstream d. breathing between the atmosphere and the alveoli Which of the following organs functions as an air conditioner?

    a. larynx b. pharynx c. nasal chambers d. all of the above

14. The normal breathing process is controlled by…………...? a. lungs

    b. ventral respiratory group c. dorsal respiratory group d. both (b) and (c)

15. In Aves, the exchange of gases occurs within the ……? a. lungs

b. air sacs and lungs c. none of the above

16. Which of the following statements is true about the entry of air into the lungs?

 a. air enters the body and travels to the lungs through the mouth and the nose

 b. air enters the body and travels to the lungs through the oesophagus and gullet

 c. air enters the body and travels to the lungs through the windpipe and the pores d. air enters the body and travels to the lungs through the nose and the nervous system

17. The windpipe is also called the ……………..? a. larynx

 b. lungs c. trachea d. oesophagus

18. In earthworms, the process of respiration is through……………….? a. skin

 b. head c. lungs d. pores on its anterior end

MARKING SCHEME TO SECTION A, QUESTIONS ON RESPIRATORY SYSTEM EXERCISE THREE

1. A (alveoli)
2. C (mediastinum)
3. D (it is controlled by the neurons, located in the medulla and pons)
4. D (all of the above)
5. C (carbon dioxide)
6. A (alveoli)

   A (cilia)
7. C (500 million)
8. B (external respiration)
9. B (it is covered by epiglottis)
10. D (total lung capacity)
11. D (all of the above)
12. B (filters the air we breathe)
13. B (exchange of gases between the bloodstream and tissue cells)
14. C (nasal chambers)
15. D (both (b) and (c)
16. A (lungs)
17. A (air enters the body and travels to the lungs through the mouth and the nose)
18. C (trachea)
19. A (skin)

APPENDIX D

POST INTERVENTION EXERCISE FOUR ON THE EXCRETORY SYSTEM

SECTION B, ANSWER ALL QUESTIONS

By the end of the lesson the student will be able to;

1. explain excretion and identify organs of the mammalian excretory system.
2. explain the term homeostasis
3. list four excretory organs of humans and the wastes they excrete.

MARKING SCHEME FOR SECTION B POST INTERVENTION EXERCISE FOUR ON THE EXCRETORY SYSTEM

1. Excretion is the process whereby living organisms eliminates metabolic waste substances from the body either in liquid form as urine or solid form as feacal matter. Excretory organs of humans are; kidneys, liver, skin and lungs.
2. Homeostasis is the ability of a living organism to maintain a stable internal body temperature despite the changes present in the external environment temperature.
3. The lungs- excretes, carbon dioxide, water vapour.

   The kidneys-excretes, urine, urea, uric acid, ammonia, creatinine.

   The skin-excretes sweats, excess water, mineral salts, urea.

   The liver-excretes, urea, bilirubin, and some drugs toxins.

APPENDIX E

POST INTERVENTION EXERCISE FIVE, SECTION A, ON SKELETAL SYSTEM

ANSWER ALL QUESTIONS

1. The following are functions of the skeleton except a. protection of delicate internal organs b. maintenance of the shape of the body c. providing attachment for muscles d. controlling growth rate in animals
2. Muscles are attached to bones by means of? a. ligament b. synovial membrane c. tendons d. connective tissue
3. When happens when the biceps muscle contracts? a. the forearm straightens b. the triceps muscle contracts c. the scapula moves towards the sternum d. the forearm bends
4. When a person accidentally steps on hot object, he withdraws his foot quickly, this is an example of? a. co-ordination b. involuntary action c. reflex action d. voluntary
5. The explanation in question 4 is a good example of? a. irritability b. respiration c. reproduction d. nutrition

SECTION B: ANSWER ALL

1. Explain the concept skeleton and mention the types of skeletons
2. Identify the different vertebrae in the vertebral column
3. Define the term joint and identify the different types of joints in humans

MARKING SCHEME ON POST INTERVENTION EXERCISE FIVE ON SKELETAL SYSTEM QUESTIONS, SECTION A

1. D (controlling growth rate in animals)
2. C (tendons)
3. D (the forearm bends)
4. C (reflex action)
5. A (irritability/ sensitivity)

MARKING SCHEME TO SECTION B, POST INTERVENTION EXERCISE FIVE ON THE SKELETAL SYSTEM

1. Skeleton refers to the hardest part of the body which provides point of attachment for muscles. There are two types of skeletons in humans, these are Endoskeleton and Exoskeleton
2. Name of Vertebra in Human Number of Vertebrae in Human

Name of Vertebra in Human	Number of Vertebrae in Human
Cervical	7
Thoracic	12
Lumbar	5
Sacral	5
Coccynx	4 fused

3. Joint refers to a spot or a junction where two or more bones meet and bring about movement.

Types of joints in the body include;

4. Ball and socket joint
5. Hinge joint
6. Gliding joint. Etc.

APPENDIX F

POST INTERVENTION EXERCISE SIX ON BODY SYMMETRY AND ORIENTATIONS, SECTION A

1. In bilateral symmetry, which of the following divides the body into left and right mirror images? a. axis b. line c. bone d. muscle
2. The jellyfish has a body that radiates outward from a central point. It has a mouth to take in food. Which type of body symmetry does the jellyfish displays? a. asymmetry b. bilateral symmetry c. radial symmetry d. spherical symmetry
3. Which type of symmetry can be found in complex animals that have wellformed heads? a. spherical b. radial symmetry c. asymmetry d. bilateral symmetry
4. Animals whose body parts are arranged the same on both sides have? a. radial symmetry b. asymmetry c. bilateral symmetry d. spherical symmetry
5. Most sponges have? a. radial symmetry b. bilateral symmetry c. spherical symmetry d. asymmetry

MARKING SCHEME FOR POST INTERVENTION EXERCISE SIX (6) ON BODY SYMMETRY AND ORIENTATIONS, SECTION A

1. A (axis/ sagittal plane)
2. C (radial symmetry)
3. D (bilateral symmetry)
4. C (bilateral symmetry)
5. D (asymmetry)

APPENDIX G

QUESTIONNAIRE OF STUDENTS' VIEWS ON THE TEACHING OF SELECTED BIOLOGY TOPICS USING COMPUTER ASSISTED INSTRUCTIONS.

Dear Students,

This Study is purely for academic purposes. You will be contributing to its success, if you provide the right responses to the items as honestly as possible.

Your response will be kept confidentially. Kindly read through each of the items carefully and indicate the opinion that is the nearest expression of your view on each of the issue raised.

The aim of the Study is to improve the performance of biology students in senior high school Form 2 Science, Home Economics 2a & 2b on selected biology topics at Odupong Senior High School.

Section A: Background Information of Respondents

General Instructions

Please tick { } the appropriate column or bracket

Sex: Male

Female

Form: SHS 2 SCI SHS 2H.E A SHS 2H.E B

Age: below 15yrs { } 16yrs { } 17yrs { } 18yrs { } 19yrs { }

Above 19yrs { }

Form:

Section B: Questionnaire on Students' Views about the use of Computer Assisted Instruction to improve Biology Students' Academic Performance

Statement	Strongly Agree	Agree	Not certain	Disagree	Strongly Disagree
1. I am interested in selected biology topics taught using CAI.					
2. CAI models explain difficult concepts on selected biology topics better.					
3. After studying selected biology topics with CAI, I ask myself questions to make sure I know the material I have been studying.					
4. CAI models has helped me understood how the various systems (digestive system, respiration system, nervous system,					
reproductive system). Etc. functions appropriately.					
5. I work on practice exercises and answer end of the chapter questions on selected biology topics with CAI even when I am not required to do so.					
6. CAI models' approach of teaching has made it easier for me to understand concepts better.					
7. CAI models' approach help students to better comprehend lesson confidently.					
8. CAI models help teachers to also teach very confidently.					

9. CAI models help teachers to explain concepts better to the understanding of students.					
10. CAI models' approach makes it easier for me not to misbehave during lesson.					
11. CAI models' approach makes it easier for teachers to interact to students.					
12. CAI model lessons stimulate the critical thinking skills of students.					
13. CAI models' approach gives enough time for students to analyse and synthesise information being received logically.					
14. CAI models' approach gives enough time for class discussion.					
15.CAI model lessons helps me to correct my misconceptions on previous concepts taught.					
16. CAI model lessons generates sense of fulfillment in me during lesson.					
17. The regular pausing of CAI model lessons by the teacher to explain concepts to students leads to time wasting.					
18. I have understood the concepts taught in selected biology topics using CAI models, therefore I'm happy reading my notes.					
19. Observing others do well through CAI lessons makes me believe that I can do much better than my current performance without CAI models.					

20. When I study selected biology topics through CAI, I jot down important points in my own words.					
21. I am satisfied with my performance in current exercises through CAI models' approach.					
22. Ghana Education Service policy encourages teachers to use CAI models to teach.					
23. The use of CAI models' approach in teaching selected biology topics stimulates students to unearth their talents.					
24. CAI models lessons are expensive and needs sponsorship from other corporate organization.					
25. The use of CAI models makes me develop more interest in studying selected biology topics.					
26. I like the challenge of CAI lessons because it stimulates my critical thinking skills.					
27. Even when a topic is dull and non-interesting, I keep working till I finally					
comprehend it using CAI models' approach.					
28. I have learnt to manage my time much better in doing assignments using CAI models' approach than previous years.					
29. CAI models' approach of teaching makes it easier for me to communicate better in class.					
30. When I am studying, I try to put together the information from CAI, the teacher and the biology text book.					

APPENDIX H

INTERVENTION WEEKLY LESSON NOTES FOR TREATMENT GROUP USING C.A.I
WEEK ONE LESSON NOTES ON REPRODUCTION IN HUMANS

DAY/ DURATION	TOPIC/SUB-TOPIC/ASPECT	OBJECTIVES/ R.P.K	TEACHER-LEARNER ACTIVITIES	TEACHING-LEARNING MATERIALS	CORE POINTS	EVALUATIONS
DAYS MONDAY TUESDAY WEDNESDAY DURATION 2 HOURS CLASSES SCIENCE 2 HOME ECONOMICS 2A & 2B	TOPIC REPRODUCTION SUB-TOPIC/ASPECTS; Definition of term The parts of male reproductive organs and their functions The parts of female reproductive organs and their functions	R.P.K STUDENTS ARE FAMILIAR WITH THEIR SEXUALITY TYPE OBJECTIVES BY THE END OF LESSON THE STUDENT WILL BE ABLE TO; • Explain the term reproduction in humans • State the parts of male reproductive organs and their functions. • List the parts of female reproductive organs and their functions	INTRODUCTION A CHART OF MARRIED COUPLES AND THEIR CHILDREN Guide students to explain the term reproduction Guide students to state the parts of male reproductive organs and their functions. Guide students to list the parts of female reproductive organs and their functions.	CHARTS WITH VIDEO CLIPS video clips Charts video clips Charts video clips Charts	• Reproduction- this is a biological process by which new individual organisms (offsprings) are produced from their parents through sexual intercourse. • Parts of male reproductive organs include; testicles, scrotum, epididymis, sperm duct (vas deferens), prostate gland, cowper's gland, seminal vessicles, erectile tissue. etc. the testicles produce sperm and male hormones such as	LET STUDENTS Explain the term reproduction in humans State the parts of male reproductive organs and their functions. • List the parts of the female reproductive organs and their functions

			CLOSURE Teacher summarises lesson with more video clips.		testosterone • Parts of female reproductive organs include; ovaries, oviduct, uterus, cervix, vagina. etc. the cervix is the narrow region where the uterus meets the vagina.	**REMARKS** Lesson was successfully taught.

WEEK TWO LESSON NOTES ON NERVOUS SYSTEM (CONTROL AND COORDINATION)

DAYS/ DURATION	TOPIC/ SUB-TOPIC/ ASPECTS	OBJECTIVES/ RPK	TEACHER LEARNER ACTIVITIES	TEACHING-LEARNING MATERIALS	CORE POINTS	EVALUATION
DAYS MONDAY TUESDAY WEDNESDAY	TOPIC CONTROL AND COORDINATION	R.P.K Students are able to respond to stimulus appropriately when they touch a hot object because their nervous system is working.	INTRODUCTION Teacher showed a short video of a woman cooking and accidentally touching a hot sauce pan lid.	A video clip, hot sauce pan lid, ice block	This is when mammals respond to stimulus in many ways. example responding to cold weather by wearing appropriate clothes to avert the effects of cold weather. this ability of an individual is only possible when his/her nervous and hormonal systems are working and well coordinated. The nervous system consists of two (2) major	Let students; explain control and coordination of body activities
DURATION 2 HOURS CLASSES SCIENCE 2 HOME ECONOMICS 2A & 2B	SUB-TOPIC DEFINITION OF TERMS AND BODY ACTIVITIES	By the end of lesson, the student will be able to; • Explain control and coordination of body activities. • Describe the general plan of the nervous system. • Identify the parts of the brain and state their functions	Guide students to explain control and coordination of body activities Guide students to describe the general plan of the nervous system Guide students to identify the parts of the brain and state their functions	Charts Charts Charts		describe the general plan of the nervous system identify the parts of the brain and state their functions

					parts, namely, the central nervous system and the peripheral nervous system. The central nervous system consists of the brain and spinal cord, while the peripheral nervous system consists of the cranial nerves and the spinal nerves. The autonomic nervous system is concerned with the internal coordination of the body. The brain consists of three main regions forebrain which extends to form the cerebrum and responsible for controlling all	

			Closure Summarises lesson with more video clips.		voluntary activities of the body such as and responsible for receiving impulses from the semi-circular canals of the ear and involved in balancing and posture of individuals.	**Remarks** Lesson was successfully taught

WEEK THREE (3) LESSON NOTES ON EXCRETION SYSTEM OF MAMMALS

DAYS/DURATION	TOPIC/SUB-TOPIC/ ASPECT	OBJECTIVES/ R.P.K	TEACHER LEARNER ACTIVITIES	TEACHING LEARNING MATERIALS	CORE POINTS	EVALUATION
DAYS MONDAY TUESDAY WEDNESDAY	TOPIC THE EXCRETORY SYSTEM IN MAMMALS	R.P.K Students can relate to how humans get rid of waste products from their body such as urine, feaces, urea, sweats. Etc	INTRODUCTION Teacher asked students to give examples of wastes products they had eliminated from their body upon waking up?	video clips A chart of excretory organs of the body		Let students
DURATION 2 HOURS CLASSES	SUB-TOPIC/ASPECTS Definition of term Examples of excretory organs in humans	By the end of the lesson the student will be able to; • explain excretion and identify organs of the	• Guide students to explain excretion and	video clips A chart of excretory	• Excretion is the process whereby living	• Explain excretion and identify organs of

SCIENCE 2 HOME ECONOMICS 2A & 2B	Examples of wastes excreted by excretory organs	mammalian excretory system. • explain the term homeostasis	identify organs of the mammalian excretory system. • Guide students to explain the term homeostasis	organs of the body video clips	organisms eliminates metabolic waste substances from the body either in liquid form as urine or solid form as feacal matter. Excretory organs of humans are; kidneys, liver, skin and lungs. • Homeostasis is the ability of a living organism to maintain a stable internal body temperature despite the changes present in the external environment temperature	the mammalian excretory system

				A chart of excretory organs of the body	• The lungs- excretes, carbon dioxide, water vapour.	
		• list four excretory organs of humans and the wastes they excrete.	• Guide students to list four excretory organs of humans and the wastes they excrete	video clips	The kidney sexcretes, urine, urea, uric acid, ammonia, creatinine.	• Explain the term homeostasis
				A chart of excretory organs of the body	The skin-excretes sweats, excess water, mineral salts, urea.	• List four excretory organs of mammals and the wastes they excrete.
					The liver-excretes, urea, bilirubin, and some drugs toxins.	
			Closure Summarises lesson by showing more videos on topic taught.			**Remarks** Lesson was successfully taught.

WEEK FOUR (4) LESSON NOTES ON THE SKELETAL SYSTEM

DAYS /DURATION	TOPIC/SUB-TOPIC/ASPECT	R.P.K/OBJECTIVES	TEACHER LEARNER ACTIVITIES	TEACHING LEARNING MATERIALS	THE CORE POINTS	EVALUATION
MONDAY TUESDAY WEDNESDAY	TOPIC: THE SKELETAL SYSTEM	R.P.K STUDENTS CAN RELATE THE IMPORTANCE OF SKELETON IN HUMANS	INTRODUCTION Teacher showed a video of the skeletal system	video clips A chart of skeletal system		LET STUDENTS
DURATION 2 HOURS CLASSES SCIENCE 2 HOME ECONOMICS 2A & 2B	SUB-TOPIC/ASPECT Definition of term Types of vertebrae in the vertebral column Joints and types of joints	BY THE END OF LESSON, THE STUDENT WILL BE ABLE TO; • Explain the concept skeleton and mention the types of skeletons	• Guide students to explain the concept of skeleton and mention the types of skeletons	video clips A chart of skeletal system	• Skeleton refers to the hardest part of the body which provides point of attachment for muscles There are two types of skeletons in humans, these are	• Explain the concept of skeleton and mention the types of skeletons

<table>
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<td>Guide students to identify the different vertebrae in the vertebral column</td>
<td>video clips A chart of skeletal system</td>
<td>Endoskeleton and Exoskeleton
<table>
<tr><td>Name of vertebra in human</td><td>Number Of vertebrae in human</td></tr>
<tr><td>Cervical</td><td>7</td></tr>
<tr><td>Thoracic</td><td>12</td></tr>
<tr><td>Lumbar</td><td>5</td></tr>
<tr><td>Sacral</td><td>5</td></tr>
<tr><td>Coccynx</td><td>4 fused</td></tr>
</table>
</td>
<td>• Identify the different vertebrae in the vertebral column</td>
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<td>Identify the different vertebrae in the vertebral column

Define the term joint and identify the different types of joints in humans</td>
<td>Guide students to define the term joint and identify the different types of joints in humans</td>
<td>video clips

A chart of skeletal system</td>
<td>• Joint refers to a spot or a junction where two or more bones meet and bring about movement.
Types of joints in the body include; Ball and socket joint, Hinge joint, gliding joint Etc.</td>
<td>• Define the term joint and identify the different joints in humans</td>
</tr>
</table>

			Closure Teacher summarises lesson with more examples			**Remarks** Lesson was successfully taught

WEEK FIVE (5) LESSON NOTES ON CIRCULATORY SYSTEM

DAYS/DURATION	TOPIC/SUB-TOPIC/ASPECTS	R.P.K/ OBJECTIVES	TEACHER LEARNER ACTIVITIES	TEACHING LEARNING MATERIALS	THE CORE POINTS	EVALUATIONS
DAYS MONDAY TUESDAY WEDNESDAY DURATION 2 HOURS CLASSES SCIENCE 2 HOME ECONOMICS 2A & 2B	TOPIC CARDIOVASCULAR SYSTEM	R.P.K Students are familiar with the functions of the cardiovascular system serving as the main transport of blood, fluids and electrolytes of the body BY THE END OF THE LESSON THE STUDENT WILL BE ABLE TO; Define what blood vessels are ?	INTRODUCTION Teacher presented a chart showing the pattern of blood flow in humans. Guide students to define what blood vessels are ? Guide students to state the types of blood vessels Guide students to list the composition of blood	Charts video clips video clips A chart of different blood vessels in humans video clips A chart of different blood vessels in humans	Blood vessels are channels through which blood flows around the body. There are three types of blood vessels these are; arteries, veins, and capillaries The composition of blood are;	LET STUDENTS Define what blood vessels are ? State the types of blood vessels List the composition of blood ?

		State the types of blood vessels List the composition of blood	**Closure** Summarises lesson by posing oral questions to students and they answered it correctly	video clips A chart of different blood vessels in humans	plasma which contains red blood cells, white blood cells and platelets. It also contains water, blood proteins, dissolved food nutrients, mineral salts, gases, hormones and waste substances example urea.	**Remarks** Lesson was successfully taught

WEEK SIX LESSON NOTES ON BODY SYMMETRY AND ORIENTATION

DAY /DURATION	TOPIC/SUB-TOPIC/ASPECT	OBJECTIVE/R.P.K	TEACHER LEARNER ACTIVITIES	TEACHING LEARNING MATERIALS	CORE POINTS	EVALUATION
DAYS MONDAY TUESDAY WEDNESDAY DURATION 2 HOURS CLASSES SCIENCE 2 HOME ECONOMICS 2A & 2B	TOPIC: BODY SYMMETRY AND ORIENTATION SUB-TOPIC: DEFINITION OF SYMMETRY, TYPES OF SYMMETRY.	R.P.K STUDENTS CONTINUE TO DIVIDE ITEMS SUCH AS ORANGES, PAWPAW INTO TWO EQUAL HALVES OR MORE PARTS IN THEIR HOMES. BY THE END OF LESSON THE STUDENT WILL BE ABLE TO; Explain the term body symmetry State the main types of body symmetry	INTRODUCTION TEACHER ASKS STUDENTS TO DEMONSTRATE HOW TO DIVINE FRUITS?	FRUITS, KNIVES, TRAYS, NAPKINS, GLASS CUPS and video clips video clips video clips video clips	Body symmetry- refers to how an object/body can be divided into two equal halves or more than two equal halves with exact mirror images Two types of body symmetry are; bilateral symmetry and radial symmetry Sectioning- refers to how an object or specimen can be divided to show its internal structures. examples. seeds in	LET STUDENTS EXPLAIN THE TERM Body symmetry State the main types of body symmetry Define sectioning and list their types

		Define sectioning and list their types	**Closure** Teacher summarises lesson by giving more examples.		oranges, placentation in oranges. Examples of sectioning include vertical, transverse, and longitudinal section.	**Remarks:** Lesson was successfully taught.