

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

**EFFECT OF THE IMMERSION, STRUCTURING AND APPLYING MODEL ON
STUDENTS' PERFORMANCE AND DISPOSITION IN GENETICS IN SENIOR
HIGH SCHOOLS**

ISAAC KWAME BOAFO

2025

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HIGH SCHOOLS**

BY

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requirements for the award of a Master of Philosophy degree in Science Education.

SEPTEMBER, 2025

DECLARATION

Candidate's Declaration

I hereby declare that this thesis, with the exception of quotations and references contained in published works which have been duly acknowledged; is the result of my own original work, and that no part of it has been presented for another degree at this university or elsewhere.

Isaac Kwame Boafo

Signature: Date:

Supervisors' Declaration

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

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ABSTRACT

This study investigated the effect of the Immersion, Structuring, and Applying (ISA) model on Senior High School students' academic performance and disposition (perception and attitudes) towards genetics. A sequential explanatory mixed-method design was employed, involving 170 biology students from two public schools in Ghana's Sekyere Central District. Intact classes were assigned to an experimental group (taught with the ISA model) and a control group (taught with traditional methods). Data were collected using a Genetics Concept Test (GCT), a questionnaire, and semi-structured interviews. Quantitative data were analysed with Wilcoxon Signed-Rank and Mann-Whitney U tests, while qualitative data underwent reflexive thematic analysis. Findings revealed a statistically significant improvement in the experimental group's performance (Wilcoxon $Z = 7.98$, $p = .001$, $r = 0.87$), with mean scores rising from 3.1 to 16.4. The ISA group significantly outperformed the control group ($U = 516$, $p = .001$, $r = -0.74$). No significant gender differences were found, indicating the model's inclusivity. Qualitative data showed high levels of student interest, understanding, and motivation. The study concludes that the ISA model is highly effective and gender-inclusive for teaching genetics. It is recommended that the Ghana Education Service integrates the ISA model into in-service teacher training programs and that curriculum developers incorporate its principles into the senior high school biology syllabus.

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DEDICATION

I dedicate this work to my Mum, late Dad, sisters, and all my lovely friends for their prayers and support.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter presents the foundation of the study by introducing the background and context of the research problem. It begins with a discussion of the challenges associated with teaching and learning of science, particularly at the senior high school level in Ghana. The chapter outlines the purpose and objectives of the study, which is to assess the effect of the Immersion, Structuring and Applying (ISA) model of teaching on students' performance and their dispositions (perception and attitudes) towards the study of genetics at the senior high school. Additionally, the chapter explains the significance of the study, highlighting its relevance to teachers, students, school administrators, and curriculum developers. It concludes with the scope of the study and limitations of the study. This chapter sets the stage for the subsequent chapters, which detail the literature review, research methodology, data analysis, and findings.

1.1 Background to the Study

To teach is to impart knowledge, sound judgement, and mature wisdom to a learner through a learning process. The main goal of teaching is to develop students' performance, abilities, and conduct to have a better life (Dorgu, 2015). A solid teaching approach must be employed to accomplish this since teaching strategies have been shown to significantly influence student performance (Munna & Kalam, 2021). According to Van Geel et al. (2019), because of the uniqueness of each student and his or her environment, teachers

should employ various teaching strategies to engage, encourage, and improve students' learning outcomes. Effective teaching strategies are tailored to the learners' requirements, as each learner understands and responds to events and experiences differently (Franklin & Harrington, 2019). Several approaches and strategies have been developed to guarantee that teachers give excellent education that allows students to comprehend topics quickly and meaningfully (Wilson & Conyers, 2020). Multiple ideologies underpin the beliefs that serve as the foundation for instructional approaches. Methods of teaching are divided into two types. These are the teacher-centred and student-centred strategies, which focus on the instructor and the learner, respectively. Teacher-centred strategies are founded on the idea of behavioural learning, which emphasises the necessity of providing appropriate stimuli that result in the expected and desired outcomes for learners (Agyei, 2022).

Traditional teaching techniques that place the instructor as the sole authority and primary source of knowledge in the classroom are known as teacher-centred approaches. In this model, the instructor determines the lesson's pace and organisation, while students are supposed to passively absorb the material presented (Massouleh & Jooneghani, 2012). This style frequently stresses direct instruction, lectures, and rote memorisation, with the teacher giving material and the students following along. The emphasis is mainly on transmitting factual knowledge from instructor to student, with evaluations often measuring retention of the given material (Darling-Hammond et al., 2020). Several studies suggest that a progression from a teacher-centred to a student-centred approach may be optimal for learning novel concepts in science, particularly at the senior high school (SHS) level

(Dervić et al., 2018; Ubulom & Ogwunte, 2017; Emaliana, 2017), which positively improves students' performance.

Today, science education strives to educate students for lifelong learning by engaging them in practical application, reflection, and discovery worldwide. Learners are immersed in real-world sustainability challenges and interdisciplinary teamwork, which allows them to develop independent learning attitudes capable of applying scientific ideas to real-world situations (Singha & Singha, 2024). This is essential in today's society, for which teacher-centred approaches have been criticised over the years for failing to adequately develop these skills since they are frequently characterised by rote memorisation and passive reception of knowledge (Darling-Hammond et al., 2020). One notable shift during the late 1950s science curriculum revisions was the role of the student in teaching and learning, termed "constructivism" (Matthews, 2024). The learner's role is associated with applying their prior knowledge and real-world experiences, learning to hypothesise, testing their theories, trying things that may not work, asking questions, sharing with others, and reflecting on their experiences (Rannikmäe et al., 2020). This new way of teaching and learning through numerous instructional models and approaches has been shown over time to have a positive impact on student performance in various topics in the sciences, particularly biology worldwide (Manishimwe et al., 2023; Cheronon et al., 2021; Adonu et al., 2021; Manishimwe et al., 2022).

Additionally, the idea of "students' disposition", which includes a person's beliefs, passions, and attitude toward science, is crucial in determining how they will learn.

According to Osborne and Dillon (2008), a good attitude toward science can improve engagement, motivation, and eventually academic achievement. Conversely, negative dispositions may hinder learning and teaching efficacy (Osborne & Dillon, 2008). Understanding the interplay between students' disposition and genetics education is therefore vital for effective teaching and learning. In Ghana, as in many parts of the world, there is a growing emphasis on improving students' dispositions to meet the demands of a rapidly evolving global landscape (Annan, 2020).

This study primarily looks at how students feel about studying genetics and how they perceive and feel about it, popularly termed as 'perception'. According to Aivelo and Uitto (2021), perception is the way in which students understand and value genetics as a topic, influenced by their past experiences, the classroom setting, and the teaching strategies employed. More readiness to interact with the material and actively participate in learning is linked to positive perception, such as considering genetics to be fascinating, relevant, and useful to daily life (Westerlund & Chapman, 2017). Negative perception, on the other hand, may result in low motivation, disengagement, and a preference for rote memorisation over conceptual comprehension (Yuldasheva, 2025).

Students' emotional and behavioural inclinations towards genetics, as well as their degree of interest, enjoyment, and willingness to put in the work necessary to become proficient in the subject, are all included in their attitude (Aivelo & Uitto, 2021). While negative attitudes can lead to science anxiety, avoiding difficult assignments, and limited success, positive attitudes are frequently associated with more perseverance in problem-solving,

greater involvement, and enhanced academic performance (Sturm & Bohndick, 2021). Promoting positive attitudes and views is essential in genetics teaching to increase student interest in difficult subjects like genetic diversity, inheritance, and DNA structure. Teachers can maintain students' interest in genetics, foster curiosity, and enhance comprehension by implementing excellent teaching practices (Aivelo & Uitto, 2021).

Additionally, studies show that male and female students perform differently in various scientific domains (Sonnert & Fox, 2012). Efforts to identify effective and inclusive teaching methods in science, technology, engineering, and mathematics (STEM) education have led to the adoption of numerous student-centred approaches to teaching STEM topics (Aguillon et al., 2020). Although more girls are encouraged to pursue STEM courses, only a few have been successful (Cheryan et al., 2017). To solve this difficulty, educators have discovered innovative strategies to entice student engagement and improve performance for a successful STEM career using the constructivist approach (Taconis & Bekker, 2023).

One such model is the Immersion, Structuring, and Applying model (ISA). It consists of three phases (Immersion, Structuring, and Applying), each phase with two sub-phases that highlight specific roles for the teacher and the students (Singer & Moscovici, 2008). It begins with an Immersion phase, in which students immerse themselves in the topic, using their prior knowledge, gathering additional information, organising experiments, and detecting tentative patterns. The teacher's responsibility is to encourage students' interest, assist in formulating learning objectives, and scaffold research. The Immersion phase is divided into two interconnected subphases: Evoking and Exploring. Evoking sub-phase

entails students applying prior knowledge to the problem, discussing and criticising ideas with classmates, and finding resources. Students explore in the next sub-phase by organising, carrying out, and assessing investigations while addressing an issue. Students learn how to pick relevant knowledge, correlate variables and experimental outcomes, recognise experiment constraints, and apply higher-order thinking abilities. They alternate between concrete and abstract experiences, allowing them to explain and generalise patterns while separating abstract information from concrete experimental/trial stages (Singer & Moscovici, 2008; Singer, 2004; Singer, 1995).

The Structuring Phase is a crucial stage in the learning process, where students interpret and adjust their experiential results. They explain their claims using examples and counter-examples and create new situations to challenge them. The teacher plays a facilitator role, helping students synthesise observations, summarise findings, and explore inferences during the Systematization sub-phase. The Conceptualization sub-phase helps students use new terminology, generalise conclusions, and expand their findings beyond specific problems. The Structuring phase teaches students to differentiate between opinion and fact, understand experiment limitations, and use appropriate language (Singer & Moscovici, 2008).

In the Applying phase, students create abstract patterns and apply them to related and unrelated circumstances. They tweak and adjust these patterns to make them broader and more functional. They apply these notions to new settings by resolving current difficulties and developing hypothetical or actual scenarios in the extended sub-phase. This technique produces a more generic pattern for recognising restricting components. Teachers assess

students' comprehension of ideas and the inquiry process by using concrete examples from the same or related/unrelated domains to demonstrate relationships or raise complexity. They may also encourage students to evaluate areas of their daily lives for future learning in the evaluate sub-phase (Singer & Moscovici, 2008).

Unlike traditional teaching approaches, in which teachers offer content through lectures and students passively absorb information, the ISA model challenges students to actively participate in learning through inquiry, problem-solving, and collaboration. This active participation not only keeps students involved but also allows them to have a better comprehension of the subject. For example, when students are encouraged to investigate concepts through hands-on activities, experiments, or discussions, they are more likely to connect the information to past knowledge, resulting in a more meaningful learning experience (Chen et al., 2020). Building on prior knowledge is essential to the constructivist approach and has been related to higher academic achievement. Constructivism encourages higher levels of cognitive engagement by requiring students to think critically and apply concepts, which leads to improved learning results (Van Riesen et al., 2022). It also promotes comprehension over memorisation, which helps students retain and apply their knowledge. It allows students to build their understanding by creating mental models for new situations. This knowledge transmission is crucial for academic and professional success (Larison, 2022).

In Ghana, science is valued as the most debated subject in our educational system, with a strong emphasis on biology (Amoah et al., 2023). Biology, as a science, teaches us how to describe and comprehend natural processes in our surroundings via observation and

investigation (Abdussemiu, 2022). It is an essential subject in Ghana's senior high school curriculum, helping shape students' understanding of life science and preparing them for medical, agricultural, environmental science, and biotechnology jobs. As a science elective, biology provides students with the scientific understanding and practical skills required to address the country's health and environmental concerns (Annan et al., 2019). It is a distinct subject with its own teaching and learning contexts. Despite this, it is typically taught with minimal interaction and passive student participation (Mccomas et al., 2018). Genetics, physiology, and ecology are examples of biology topics that need hands-on laboratory and practical experiences. Genetics is a crucial topic of biology that studies DNA, genes, inheritance, and genetic diversity in living creatures. However, due to their complexity, students frequently need help understanding and applying genetic concepts (Gupta, 2019). According to Fauzi and Mitalistiani (2018), the most challenging topic in biology at the senior high school (SHS) level was genetics. Genetic concepts including DNA structure, gene expression, Mendelian inheritance, genetic linkage, and mutations are difficult for students to visualise and comprehend. Many students struggle with these issues because they include unready observable processes, making it difficult to understand how genetic material is passed down from generation to generation or how it influences features (Kumandaş et al., 2019). This has had enormous consequences on students' performances in genetics and biology as a subject, per the chief examiner's report of the West African Examination Council [WAEC] (WAEC chief examiner's report, 2021, 2020, 2019, 2018, and 2017). This is due to the series of no practical teaching of genetics from most teachers in Ghana (Wilmot, 2020).

Furthermore, the Ghanaian Senior High School Biology syllabus, both old and new, suggests that teachers adopt constructivist teaching approaches to ensure that biology ideas are fully understood. The biology syllabus explicitly promotes learner-centred, constructivist teaching approaches, such as inquiry, problem-based learning, and differentiated instruction, to ensure deep conceptual understanding, development of 21st-century competencies, and alignment with social, emotional, and Ghanaian values (CRDD, 2010; National Council for Curriculum and Assessment [NaCCA], 2023).

As a result, it stands to reason that, to solve the issue of students' low performance in genetics, successful constructivist teaching methodologies that have been proven elsewhere should be used when teaching biology concepts. Students will benefit from this by performing better academically in the topic. Research on science education has demonstrated that student-centred constructivist teaching methods greatly enhance students' performance in the subject (Bara & Xhomara, 2020; Precious & Feyisetan, 2020; Dada et al., 2023). As a result, this study aims to examine the effect of the ISA model in teaching genetic concepts in the Ghanaian senior high school biology class.

1.2 Statement of the Problem

Numerous factors, including cognitive challenges, a lack of laboratory resources, student motivation, instructor competency, instructional strategies, and curriculum design, can all contribute to the poor performance of students in genetics (Chifwa, 2015). However, because teaching methods have a direct and adjustable influence on students' learning outcomes, this study focuses on the influence of the teaching approaches on students' performance. According to research, teaching strategies have a big impact on students'

understanding and involvement, especially when it comes to difficult subjects like genetics (Van Geel et al., 2019). Compared to the other external elements mentioned above, teaching methods are easier to adapt and apply within the current educational systems (Davis, 2003).

Globally, there is enough evidence of the difficulties in teaching and understanding genetics in senior high schools, and Ghana is no exception (Asare, 2020). As a crucial component of the biology curriculum, genetics deals with complex concepts such as DNA structure, inheritance patterns, gene expression, and mutations. However, students in Ghana need help with these abstract concepts, as reflected in their poor performance in the WAEC biology exams, particularly in genetics (WAEC Chief Examiner's Report, 2019; 2020; 2021; 2022; 2023). More specifically, the Chief Examiners' Report for the 2019 WASSCE asserted that most applicants failed to fully articulate the distinctions between DNA and RNA. Similarly, the WAEC Chief Examiners Report (2020) found that the applicants' biology coursework was poor, citing genetic diagrams as an example of incorrect construction. Candidates had trouble explaining recombinant DNA technology and its applications. Students often perform poorly in genetics, which affects their overall biology performance. This issue is primarily attributed to the traditional methods of teaching, which rely heavily on rote memorisation and passive learning. Teachers often provide content through lectures without engaging students in the hands-on activities and inquiry-based learning necessary for a deep understanding of genetic concepts (Wilmot, 2020).

Additionally, the case of Sekyere Central District is no different, as available data indicate challenges in science education within the district. The Sekyere Central District Assembly's 2019 report highlights that their WASSCE performance in science subjects ranged from 25.5% to 30%, suggesting difficulties in science education, which likely encompass genetics topics (Sekyere Central District Assembly report, 2019).

Despite the well-documented challenges in teaching genetics, the potential impact of constructivist approaches, particularly the Immersion, Structuring, and Applying (ISA) model, on students' knowledge and performance in genetics remains unclear. It appears this model, known for its success in enhancing learning outcomes in other scientific fields (Singer & Moscovici, 2008), has not been thoroughly explored in the context of genetics education in Ghanaian senior high schools.

Nevertheless, a student with a favourable attitude toward science, high self-efficacy, and positive reinforcement from peers and the instructional approach is more likely to exhibit constructive learning behaviours and dispositions as found in the ISA model (Sasway & Kelly, 2021). Modern educational models increasingly recognise disposition as a mediating factor in learning. For example, the Dispositional Learning Theory developed by Costa and Kallick (2000) identifies "Habits of Mind" such as persistence, managing impulsivity, and thinking flexibly as critical to academic success. This makes it critical to investigate how the ISA model may be used to teach genetics since genetics is a fundamental subject in biology that underlies numerous jobs in health, agriculture, and biotechnology (Black, 2020). Improving student genetics performance is crucial for academic achievement and

creating a scientifically literate population capable of solving national and global health and environmental challenges (Vandiver et al., 2022). This will allow for evidence-based solutions to improve biology teaching in Ghana. In order to achieve this, this study intends to evaluate the effect of the ISA model on students' genetics performance at the senior high school level.

1.3 Purpose of the Study

The main purpose of this study was to assess the effect of the Immersion, Structuring and Applying model of teaching on students' performance and their dispositions (perceptions and attitudes) towards the study of genetics in senior high schools in the Sekyere Central district of Ghana.

1.4 Objectives of the Study

The study seeks to;

1. Assess the effect of incorporating the ISA model on students' performance in genetics at the Senior High School.
2. Compare the academic performance in genetics of students exposed to the ISA model with those taught using traditional methods in the senior high school.
3. Evaluate the difference in performance of boys and girls taught genetics at the Senior High School using the ISA model.
4. Find the attitude and perception of students after the study of genetics.

1.5 Research Questions

1. What is the effect of incorporating the ISA model on students' performance in genetics at the Senior High School?
2. What is the difference in academic performance between students taught genetics using the ISA model and those taught with the traditional approach at the SHS level?
3. What is the difference in performance between boys and girls taught genetics using the ISA model at the Senior High School?
4. What is the attitude and perception of students after the study of genetics at the senior high school level?

1.6 Significance of the Study

The importance of the study is to address the following:

1. To provide practical insights into using the ISA model to enhance teaching practices and potentially influence teaching strategies of teachers across biology and other science subjects in the Sekyere Central district. This contributes to sustainable professional development by equipping teachers with a replicable, effective pedagogical skill.
2. To inform educational policy in Ghana by offering evidence on the effectiveness of the ISA model, guiding curriculum developers, educational authorities, and teacher training institutions to modernise science education and improve teaching quality nationwide.

1.7 Delimitation of the Study

The study's delimitations define the scope and boundaries to keep the research manageable.

This study focused on the following:

Senior high schools in the Sekyere Central District of Ghana's Ashanti Region, targeting third-year students studying biology, particularly those in General Science and Home Science programs.

The research specifically addressed the teaching and learning of genetics within the biology curriculum, limiting its scope to topics like heredity, DNA structure, and replication.

The study utilised the Immersion, Structuring, and Applying (ISA) model, a constructivist teaching approach, to evaluate its impact on students' genetics performance, chosen for its structured stages and proven effectiveness in other educational settings.

1.8 Limitations of the Study

A key limitation of the study was that the use of non-parametric tests; while appropriate for the data characteristics, it may have reduced the sensitivity to detect subtle differences.

The sample was also drawn from only two Senior High Schools in one district, limiting the generalizability of the findings.

1.9 Organisation of the Study

The study is divided into five chapters, each covering a distinct facet of the subject. The first chapter discusses the study's background, problem statement, purpose, research objectives, research questions, research hypotheses, significance, delimitation, limitation, and the organisation of the study. Chapter two focuses on the study's literature review, the

theoretical framework, the conceptual framework of the study, a review of empirical studies, teaching methodologies, the concept of the ISA instructional model, and the problems associated with the teaching and learning of genetic concepts. The third chapter examines the study's research methods. It will describe the study area, research paradigm, type of research design, overall research design, the conceptual framework of the study design, the study population, population sample and sampling technique, research instruments, data collection procedure, and data analysis procedure. The findings of the research are presented and discussed in Chapter 4. Chapter five includes a summary of the findings, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter presents relevant theoretical, conceptual, and empirical literature that supports the study. It includes the theoretical underpinnings, reviews of the ISA model, teaching strategies in genetics education, students' academic performance and disposition, gender-related differences, and previous studies aligned with the use of constructivist approaches in science education.

2.1 Theoretical Framework

The Immersion, Structuring, and Applying (ISA) model is rooted in the constructivist theory of learning, which emphasises the active role of learners in constructing knowledge through experience, reflection, and interaction. Constructivism, as a pedagogical philosophy, underlines that the learner does not passively receive information but instead actively engages in the meaning-making process, drawing upon their prior knowledge, environment, and social interactions (Renninger, 2024).

One of the foundational proponents of constructivism, Jean Piaget, proposed the theory of cognitive development, which explains how learners progress through developmental stages by actively interacting with their environment. According to Piaget (1952), learning occurs through processes of assimilation and accommodation, which enable learners to adjust their mental models to incorporate new information. Within the ISA model, this is

evident in the Immersion phase, where students activate prior knowledge and confront new experiences, leading to cognitive conflict and eventual restructuring of ideas. This theory supports the design of instructional models like ISA that encourage exploration, problem-solving, and reflection.

Lev Vygotsky, another influential theorist, introduced the sociocultural theory of cognitive development. His concept of the Zone of Proximal Development (ZPD) highlights the importance of guided learning, where learners can achieve more with the assistance of a more knowledgeable other than they could independently (Vygotsky, 1978). The ISA model aligns well with Vygotsky's perspective, particularly in its structured phases where teachers guide and scaffold while learners interact and share ideas with peers, allowing knowledge to be co-constructed.

Jerome Bruner also made significant contributions to constructivist learning through his advocacy for discovery learning. Bruner (1961) emphasised that students learn best when they discover principles for themselves, especially when instruction is organised around inquiry, categorisation, and sequencing. These ideas resonate with the ISA model's emphasis on student-led investigations, interpretation of findings, and application of concepts. The Applying phase of the ISA model reflects this orientation, encouraging learners to apply knowledge to new problems, thus reinforcing and deepening their conceptual understanding, which influences their learning outcome.

Collectively, these theoretical foundations justify the ISA model as an effective instructional approach for science education. By engaging students in active, scaffolded, and inquiry-driven learning experiences, the model leverages constructivist principles to enhance both cognitive and affective learning outcomes in complex subjects like genetics.

2.2 Conceptual Framework

The conceptual framework for this study is rooted in the constructivist learning paradigm, which asserts that learners actively construct knowledge through experiences, interaction, and reflection. This framework has been operationalised in the present study through the application of the ISA model—Immersion, Structuring, and Applying—developed by Singer and Moscovici (2008). It is designed around the core phases of the Immersion, Structuring, and Applying (ISA) model and their expected influence on students' performance, perceptions, and attitudes in genetics.

At the heart of the framework is the assumption that the ISA model, grounded in constructivist principles, creates more opportunities for active engagement, collaboration, and real-life application than traditional teacher-centred methods. By immersing learners in authentic problems, helping them structure and clarify concepts, and then applying knowledge in new contexts, the ISA model is expected to foster deeper understanding and improved performance.

In addition to cognitive gains, the framework recognises that the ISA model influences student dispositions. By making genetics relevant, interactive, and learner-centred, it is

anticipated to enhance positive perceptions (how students view the subject) and attitudes (their feelings, motivation, and willingness to engage). These affective outcomes are critical, as positive dispositions can sustain long-term interest and achievement in science.

Gender functions as a moderating variable within this framework. Prior research in Ghana and elsewhere suggests that male and female students may experience and respond differently to teaching approaches due to socialisation patterns, self-concept, and classroom dynamics (Eddy & Brownell, 2016; Wang & Degol, 2017). The framework therefore accounts for possible variations in how ISA influences performance and dispositions across genders.

In the context of the ISA model, gender differences may manifest in students' levels of engagement, confidence in handling practical activities, or willingness to collaborate during group tasks. For example, some studies have shown that female students may exhibit stronger collaborative skills and prefer interactive learning settings, while male students may engage more competitively, potentially affecting their perception of and attitude toward the subject (Almasri, 2021; Dewi & Muhid, 2021). Similarly, differences in prior exposure to scientific concepts could influence how quickly each group adapts to the inquiry-based and application-focused elements of the ISA model.

By examining gender as a moderator, this study aims to determine whether the instructional benefits of the ISA model are consistent across male and female students or whether targeted adjustments may be necessary to ensure equitable learning outcomes.

Understanding such differences is crucial for developing inclusive teaching strategies that cater to diverse learners in genetics education.

In summary, the conceptual framework positions the ISA model as an intervention expected to influence both cognitive (performance) and affective (perceptions and attitudes) outcomes, with gender acting as a potential moderator of these relationships. The conceptual framework is represented graphically below in figure 2.1.

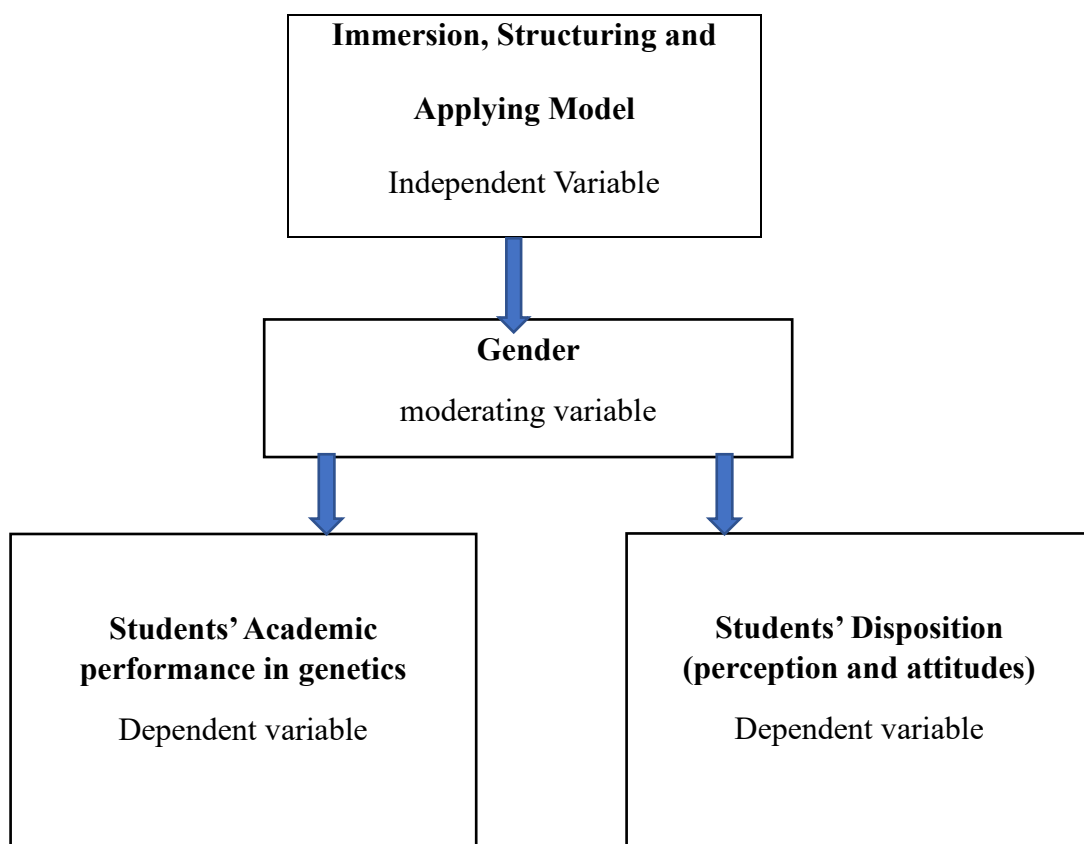


Figure 2.1: Conceptual Framework of the Study

2.3 Teaching and Learning of Genetics in Ghana

Genetics, a core component of the Senior High School (SHS) biology curriculum in Ghana, has long been identified as one of the most conceptually challenging topics for students.

The abstract nature of its concepts—such as DNA structure, replication, protein synthesis, and Mendelian inheritance—often poses difficulties for learners to visualize and apply meaningfully (Abdussemmi, 2022; Mbah, 2019). For instance, students are expected to understand microscopic and molecular processes, which require high levels of reasoning and abstraction. Consequently, many learners develop misconceptions about basic concepts, such as confusing dominance with frequency of traits or misinterpreting the structure and function of nucleic acids (Tsui & Treagust, 2010).

Evidence from the West African Examinations Council (WAEC) Chief Examiners' Reports consistently indicates that genetics is one of the poorest-performing sections in biology examinations. For example, the 2018 and 2021 reports highlighted students' difficulties in applying Mendelian principles, analysing genetic crosses, and interpreting Punnett squares (WAEC Chief Examiner's report, 2018; 2021). Examiners frequently report that students provide memorized definitions but fail to apply them in problem-solving contexts, suggesting that instruction often emphasizes rote learning rather than conceptual understanding. This trend is concerning given that genetics forms the foundation for more advanced studies in biology, medicine, and biotechnology.

Several contextual factors account for these persistent difficulties. One major issue is the dominance of teacher-centred instructional methods in SHS biology classrooms (Baah, 2021). Teachers often rely on lectures, dictation of notes, and limited demonstrations, leaving students as passive recipients of information. While such methods enable coverage of the syllabus within time constraints, they provide little opportunity for learners to engage

with concepts actively. This is problematic for genetics, where meaningful learning depends on visualization, experimentation, and the application of abstract concepts to real-life examples.

In addition, resource limitations in many Ghanaian schools exacerbate these challenges. Laboratory facilities, molecular models, and visual aids necessary for genetics instruction are often unavailable or inadequate (Asante, 2022). Without these tools, students struggle to concretise abstract concepts, making genetics appear overly theoretical. Teachers also face large class sizes, sometimes exceeding 60 students per class, which constrains their ability to implement activity-based or inquiry-centred lessons effectively (Akyeampong, 2017).

Curriculum reforms in Ghana have attempted to address these issues. The Standards-Based Curriculum introduced by the National Council for Curriculum and Assessment (NaCCA) emphasises learner-centred, constructivist approaches, including inquiry-based learning, problem solving, and contextualisation of concepts (NaCCA, 2023). These changes are in line with international trends in science education, which support the idea that students should learn science by doing it rather than merely memorising it (DeBoer, 2011). However, the effective translation of these policies into classroom practice has been inconsistent. Many teachers report inadequate training and professional development to implement innovative pedagogies, leaving a gap between policy intentions and actual classroom practice (Popova et al., 2022).

Another critical factor is the perception of difficulty and relevance associated with genetics among Ghanaian students. Studies show that when students perceive a subject as difficult and irrelevant to their daily lives, their attitudes and motivation toward learning decline (Owusu-Fordjour et al., 2024; Opoku et al., 2021). Genetics is often perceived as highly abstract and disconnected from students' socio-cultural contexts, which affects their engagement and performance. In many cases, teachers do not adequately contextualise lessons to students' everyday experiences—such as family traits, agriculture, or health issues—missing opportunities to make the subject more relatable. Gender disparities also influence the teaching and learning of genetics (Bueno, 2019). While evidence suggests that male and female students perform comparably in science globally (Hyde, 2014), local studies in Ghana indicate that female students often exhibit lower self-confidence and higher anxiety in science classrooms compared to their male counterparts (Asomah et al., 2025; Gyan & Mensah, 2025). These differences can be attributed to socio-cultural expectations and stereotypes that shape how boys and girls engage with science subjects, potentially affecting their interest and performance in challenging areas like genetics.

Despite these challenges, there are emerging opportunities for improvement. The push for learner-centred pedagogy, combined with the availability of ICT tools and simulation software, has created possibilities for innovative genetics instruction. Digital tools such as interactive simulations and animations can help bridge the gap between abstract genetic processes and concrete visualisation (Korkut & Surer, 2023). However, their use remains limited in Ghanaian schools due to infrastructure and training constraints.

In all, the teaching and learning of genetics in Ghana is constrained by persistent challenges, including abstract content, reliance on teacher-centred methods, limited resources, and negative student perceptions. While curriculum reforms advocate constructivist approaches, implementation gaps remain. Gender disparities and contextual irrelevance further compound the problem. These issues justify the exploration of innovative instructional models such as the ISA model, which emphasises active participation, contextualisation, and learner engagement, offering a promising approach to improving genetics education in Ghana.

2.4 Constructivist Approaches in Science Education

The constructivist view of learning holds that learners actively construct knowledge through interaction with their environment, rather than passively receiving information from teachers. Rooted in the theories of Piaget, Vygotsky, and Bruner, constructivist approaches emphasise that knowledge is built when learners engage in inquiry, problem-solving, collaboration, and reflection (Montecillo, 2024). Science education, in particular, has embraced constructivism because its focus on discovery and experimentation mirrors the nature of scientific inquiry itself (Bybee, 2015). In Ghana, the National Council for Curriculum and Assessment (NaCCA) has endorsed constructivist principles in the Standards-Based Curriculum, calling on teachers to adopt learner-centred, inquiry-driven instruction that fosters critical thinking and creativity (NaCCA, 2023).

One of the most widely used constructivist models in science education is inquiry-based learning (IBL). Inquiry learning requires students to ask questions, design investigations,

collect and analyse data, and build explanations based on evidence (Pedaste et al., 2015). This mirrors the process of doing science and encourages learners to develop higher-order thinking skills. Evidence from both developed and developing contexts indicates that IBL promotes deeper understanding of scientific concepts, better retention, and stronger attitudes toward science (Bremner, 2021; Baidoo-Anu, 2023). However, implementing inquiry effectively can be challenging in resource-limited classrooms, such as those in Ghana, where large class sizes and limited materials restrict active experimentation.

Another important constructivist strategy is problem-based learning (PBL), in which learners tackle complex, real-world problems that do not have single correct answers. Through collaborative problem-solving, learners construct knowledge that is both meaningful and transferable (Chen, 2024). In science education, PBL has been shown to enhance students' problem-solving skills, critical thinking, and ability to apply knowledge to new contexts (Razak et al., 2022). For Ghanaian students learning genetics, PBL can situate abstract content within familiar contexts such as agriculture, health, and family traits, thereby enhancing relevance and motivation. However, teachers require strong facilitation skills to guide discussions without reverting to traditional lecture methods, which remains a common challenge.

Cooperative and collaborative learning approaches also represent key constructivist strategies. In cooperative learning, students work in small groups to achieve shared goals while being individually accountable for their contributions (Ramsook, 2018). Collaborative learning, on the other hand, emphasises joint construction of knowledge

through dialogue and negotiation of meaning. Research has shown that these approaches improve not only achievement but also social and communication skills (Theng & Mai, 2013). In the Ghanaian context, where students are accustomed to competitive, exam-driven learning environments, cooperative methods can promote inclusivity and mutual support, especially in mixed-gender classrooms.

The 5E instructional model—Engage, Explore, Explain, Elaborate, and Evaluate—is another structured constructivist framework widely applied in science education. Developed by Bybee (2009), the 5E model provides a sequence that mirrors cognitive processes of learning. It begins with engaging learners' prior knowledge, followed by exploration of phenomena, teacher-guided explanation, application of new concepts, and evaluation of understanding. Studies have demonstrated the effectiveness of the 5E model in enhancing conceptual understanding in biology, including genetics (Awortwe, 2020; Ylostalo, 2020). Its stepwise nature makes it accessible for teachers, but implementation may be constrained by time and assessment pressures in Ghanaian SHSs.

In addition, context-based and experiential learning approaches are essential in constructivist science education. These approaches situate scientific concepts within students' everyday experiences and local contexts, thereby increasing relevance and motivation (Agyei, 2022). For example, teaching genetics through case studies on sickle cell disease, crop improvement, or family traits makes abstract processes more tangible and meaningful for Ghanaian learners. Studies indicate that when science is contextualised, students not only perform better but also develop positive attitudes toward the subject

(Agyei, 2022; Kazeni & Onwu, 2013). However, context-based teaching requires teachers to have creativity and flexibility, which may be limited by exam-orientated practices.

Despite the promise of constructivist approaches, scholars caution against assuming that they are universally superior to teacher-centred methods. Some critics argue that minimally guided approaches, such as open inquiry or unguided discovery, can overwhelm novice learners and result in misconceptions (Dalgarno et al., 2014; Kirschner et al., 2006). To be effective, constructivist methods must balance student autonomy with appropriate teacher scaffolding. This insight reinforces the importance of models like the ISA, which combine guided immersion, structured clarification, and application, offering a balanced approach suitable for diverse classrooms.

In Ghana, the integration of constructivist approaches has been uneven. While curriculum policies strongly advocate learner-centred methods, classroom practices often remain teacher-dominated (Agyei, 2022; NaCCA, 2023). Factors such as teacher beliefs, limited professional development, large class sizes, and resource scarcity hinder widespread adoption. Yet, evidence from localised interventions demonstrates that constructivist strategies can be successfully adapted when teachers receive adequate support and resources (Baah, 2021).

Overall, constructivist approaches in science education—including inquiry-based learning, problem-based learning, cooperative learning, the 5E model, and context-based instruction—offer powerful tools for enhancing student learning and dispositions.

However, their effectiveness depends on thoughtful implementation, teacher capacity, and contextual adaptation. This sets the stage for exploring the Immersion, Structuring and Applying (ISA) model, which draws from these constructivist traditions while simplifying their application into three manageable phases tailored to classroom realities in Ghana.

2.5 Empirical Review

Empirical studies conducted globally and locally provide evidence on the impact of constructivist-based instructional models such as the Immersion, Structuring and Applying (ISA) model on students' academic achievement and attitudes in science education. Although few studies have directly investigated the ISA model in Ghana, related models such as inquiry-based learning, problem-based learning, cooperative learning, and the 5E model have been extensively studied and provide useful comparison points.

Singer and Moscovici (2008), in one of the earliest empirical investigations of the ISA model, conducted a quasi-experimental study in the United States involving middle school students learning physical science concepts. Their findings showed that students exposed to the ISA model performed significantly better on post-tests compared to those receiving traditional instruction. The study also reported increased student engagement, suggesting that the hands-on, inquiry-driven nature of ISA supports deeper conceptual understanding.

Similarly, a study by Zudaire and Napal Fraile (2021) in Spain used an inquiry-structured ISA-like model to teach biological systems. Their results indicated improved student reasoning skills and conceptual retention, highlighting that, instructional models involving immersion and application enhance long-term understanding. Similarly, Renninger's

(2024) study also shows that activity-based, learner-centred approaches significantly enhance student achievement compared to traditional lecture methods. Although not labelled as ISA, their models shared similar stages and demonstrated positive learning outcomes.

In Africa, empirical research on constructivist models has also shown improved learning outcomes. Manishimwe et al. (2023) conducted a quasi-experimental study in Rwanda using activity-based, learner-centred teaching approaches in biology. Their findings revealed significant gains in students' genetics achievement compared to those taught through lecture methods. This aligns with the core assumption of the ISA model that active involvement enhances comprehension of abstract scientific concepts.

A study by Ahiaba (2023) in Ghana investigated the effect of cooperative and inquiry-based methods on SHS students' performance in biology. The findings showed that students taught with learner-centred methods outperformed their peers taught with traditional approaches. The study also revealed that female students particularly benefited from the interactive learning environment, reducing the gender performance gap. These findings support the argument that models like ISA can promote gender-inclusive learning.

In another Ghanaian study, Baah (2021) examined the effect of problem-based learning on SHS students' understanding of genetics. The results showed significant improvement in students' achievement and a decrease in common misconceptions. The study also revealed increased student confidence and interest in genetics. These results are consistent with the

Structuring and Applying phases of the ISA model, where students synthesise ideas and apply knowledge to new situations.

Several studies have also documented the effects of constructivist teaching approaches on student attitudes. For example, Russo-Tait (2023) found that inquiry-based teaching significantly improved students' attitudes toward genetics by making the subject more relevant and engaging. Similarly, Aivelo and Uitto (2021) reported that students developed more positive perceptions of genetics when learning involved exploration, discussion, and real-world applications. These findings suggest that the ISA model, which emphasises immersion and relevance, may enhance students' dispositions toward genetics.

Research on gender differences further shows that constructivist approaches reduce disparities. Cotner et al. (2020) demonstrated that active learning environments narrow gender achievement gaps in science because they promote collaboration and reduce performance anxiety. This is relevant to the present study, which examined whether the ISA model benefits male and female students equally.

Despite the documented success of constructivist approaches, empirical studies specifically examining the ISA model in African or Ghanaian contexts remain limited. Most studies in Ghana focus broadly on inquiry or cooperative learning, with few targeting the specific phases of the ISA model. Moreover, little empirical work has investigated how such models influence both performance and dispositions in genetics, a topic consistently reported as difficult for SHS students.

2.6 Gender, Disposition, and Performance in Science

The relationship between gender and performance in science has been widely debated in educational research. Globally, meta-analyses suggest that gender differences in science achievement are relatively small, with performance outcomes being more influenced by contextual factors such as teaching methods, classroom climate, and socio-cultural expectations than by inherent ability (Hyde, 2014). Despite these findings, stereotypes about boys excelling in science and girls performing better in languages persist in many contexts, shaping students' confidence, participation, and achievement (Napp & Breda, 2022). In Ghana, these stereotypes are reinforced by cultural expectations, which often discourage girls from pursuing science-related careers, thereby influencing their self-concept and engagement in science classrooms (Gyan & Mensah, 2025).

Dispositions, which include students' perceptions and attitudes toward science, play a critical role in shaping achievement across genders. According to Osborne and Dillon (2008), students with positive attitudes toward science demonstrate greater motivation, persistence, and long-term interest, while negative dispositions hinder engagement and achievement. In the Ghanaian context, students often perceive biology—and particularly genetics—as difficult and abstract, leading to negative attitudes that impact performance (Asare, 2020). These perceptions can be further shaped by gender, as girls may internalise beliefs that science is less suitable for them, thereby reducing their confidence and willingness to engage in complex problem-solving tasks (Sibisi et al., 2025).

Research indicates that teaching approaches significantly interact with gender to influence performance and dispositions. Active, learner-centred strategies such as cooperative learning, inquiry, and problem-based approaches have been shown to reduce gender disparities by providing inclusive and supportive environments (Annan et al., 2019; Russo-Tait, 2023). In Ghana, Ahiaba (2023), found that activity-based biology instruction not only improved overall performance but also enhanced female students' participation and confidence. This suggests that instructional models such as ISA, which emphasise immersion, structuring, and applying, may mitigate gender-related performance gaps while improving students' perceptions of genetics.

Evidence also suggests that gender differences in performance may not be in raw achievement but in engagement and self-efficacy. For example, girls often report higher levels of science anxiety and lower confidence, even when their achievement matches or exceeds that of boys (Cotner et al., 2020). This mismatch between competence and confidence indicates that improving dispositions is as important as addressing performance. In Ghanaian SHSs, female students frequently report perceiving genetics as overly abstract and disconnected from their everyday lives, which influences their classroom participation and exam outcomes (Annan et al., 2019). Thus, improving dispositions through contextualised and student-centred models like ISA is crucial for equity.

The role of gender in science performance must also be understood within the framework of socialisation and classroom dynamics. Studies suggest that boys are often encouraged

to take leadership roles in group work, participate more actively in class discussions, and take risks in answering questions, while girls may adopt more passive roles (Hyde & Deal, 2003). These patterns are visible in many Ghanaian classrooms, where teacher expectations and peer interactions subtly reinforce gendered participation. Without deliberate strategies to ensure equal participation, these dynamics can perpetuate differences in performance and attitudes between boys and girls.

Importantly, gender differences in science education are context-dependent rather than universal. For example, in some studies, girls outperform boys in biology due to their diligence and interest in health-related topics, while boys outperform in physics and chemistry (Kiernan et al., 2023). This suggests that gender effects are shaped not by inherent ability but by the alignment of teaching methods, curriculum relevance, and student dispositions. In genetics, where abstract reasoning and problem-solving are required, teaching methods that fail to contextualise content may disproportionately disadvantage female students, who already report lower confidence in tackling abstract science problems (Marsh et al., 2019).

Dispositions are also a key mediator between gender and performance. Positive attitudes toward science can buffer against stereotypes and low self-efficacy, enabling students to persist in challenging tasks (Osborne & Dillon, 2008). Conversely, negative dispositions can amplify gender gaps, as girls with low confidence may disengage more quickly when faced with difficult genetics concepts. Instructional strategies that emphasise relevance,

collaboration, and student agency have been shown to strengthen dispositions for both genders, leading to more equitable outcomes (Freeman et al., 2014).

In Ghana, promoting gender equity in science education is also tied to broader educational policy goals, including the push to increase female participation in STEM fields (Boateng, 2025). The integration of constructivist approaches like ISA into the SHS biology curriculum offers one pathway to achieve this goal by enhancing both performance and dispositions across genders. By situating genetics within real-life contexts and actively engaging students in collaborative learning, the ISA model has the potential to narrow gender differences while improving overall achievement.

In summary, gender, disposition, and performance are deeply interconnected in science education. While global evidence shows minimal inherent gender differences in science achievement, socio-cultural factors, dispositions, and classroom practices significantly shape outcomes. In the Ghanaian SHS context, these influences are particularly pronounced in challenging topics such as genetics. The ISA model provides a promising framework for addressing these challenges by improving both cognitive outcomes (performance) and affective outcomes (dispositions), while creating more equitable learning opportunities for male and female students alike.

2.7 Gaps in the Literature and Research Justification

A review of the literature reveals significant challenges in the teaching and learning of genetics in Ghana and beyond. Despite the inclusion of genetics as a core component of

the Senior High School (SHS) biology curriculum, students consistently perform poorly in this area, as highlighted by successive WAEC Chief Examiners' Reports (WAEC Chief Examiners' Reports, 2018; 2019; 2021; 2022; 2023). Studies attribute this poor performance to the abstract nature of genetics concepts, heavy reliance on rote memorisation, and the dominance of teacher-centred instruction in Ghanaian classrooms (Abdussemiu, 2022; Baah, 2021). While such findings are well-documented, limited research has explored innovative instructional models specifically designed to make genetics more concrete, engaging, and accessible to Ghanaian SHS students. This leaves a gap in identifying and testing pedagogical strategies that can effectively address the persistent learning difficulties in genetics.

Although constructivist teaching approaches such as inquiry-based learning, problem-based learning, and the 5E model have been widely studied globally (Bybee, 2015; Chen, 2024), their implementation in Ghanaian SHSs remains limited. Research shows that contextual challenges—including large class sizes, limited laboratory resources, and inadequate teacher training—hinder the practical application of these approaches in local classrooms (Akyeampong, 2017; Asante, 2022). Consequently, there is insufficient evidence on how constructivist frameworks can be adapted to fit the realities of Ghanaian classrooms. The ISA model, with its simplified phases of immersion, structuring, and applying, offers a potentially viable alternative, but empirical studies assessing its effectiveness in Ghanaian SHS settings are scarce.

Furthermore, existing literature on science education in Ghana has paid limited attention to the dual dimensions of learning: cognitive outcomes (performance) and affective outcomes (dispositions). While performance data from WAEC and other studies highlight persistent achievement gaps, much less is known about how students' perceptions and attitudes toward science, especially genetics, shape their learning. This is a critical gap, as negative attitudes have been shown to reduce motivation, persistence, and willingness to engage with challenging content (Osborne & Dillon, 2008). Research that integrates both performance and dispositions is therefore necessary to provide a holistic picture of student learning outcomes in genetics.

Another underexplored area is the role of gender in moderating learning outcomes in genetics education. While global research shows minimal inherent gender differences in science achievement (Hyde, 2014), local studies suggest that socio-cultural expectations and classroom dynamics may disadvantage female students in Ghana (Gyan & Mensah, 2025; Ahiaba, 2023). Yet, few empirical studies have examined how innovative instructional models like ISA might reduce gender disparities by creating more inclusive and engaging learning environments. Addressing this gap is essential for informing educational policy goals of promoting gender equity in STEM education in Ghana (Singer & Moscovici, 2008).

Additionally, most Ghanaian studies on biology instruction have focused on general performance outcomes without examining specific topics such as genetics in detail. Genetics presents unique learning challenges due to its abstract, molecular nature and its

reliance on probabilistic reasoning (Agyei, 2022; Tsui & Treagust, 2010). While broader studies on biology instruction provide useful insights, they often fail to capture the particular difficulties students face in genetics, such as misconceptions about inheritance, DNA replication, and genetic crosses. This lack of topic-specific research leaves a gap in designing interventions tailored to the unique demands of genetics education.

There is also limited evidence on how innovative instructional models can be effectively scaled or adapted within resource-constrained Ghanaian schools. Although studies have reported the benefits of constructivist methods (Abdussemiu, 2022; Annan et al., 2019), implementation challenges remain poorly understood. For example, few studies have investigated how large class sizes, exam-orientated teaching, and teacher capacity affect the adoption of learner-centred approaches. Without such evidence, educational reforms risk remaining at the policy level without practical impact in classrooms. The ISA model's structured yet flexible design offers an opportunity to explore these implementation dynamics systematically.

Moreover, research in Ghana has rarely examined how instructional interventions influence both immediate academic performance and long-term student dispositions. Studies often focus on short-term test scores without investigating how teaching approaches affect students' attitudes, confidence, and interest in science. Yet, improving dispositions is critical for sustaining student engagement beyond examinations and for nurturing interest in STEM careers (Osborne & Dillon, 2008). By addressing both cognitive and affective domains, studies on the ISA model can provide more comprehensive evidence on its effectiveness.

In summary, the literature reveals several critical gaps: (a) limited topic-specific studies on genetics instruction in Ghana, (b) inadequate exploration of dual outcomes (performance and dispositions), (c) insufficient attention to gender as a moderating factor, (d) scarce empirical evidence on the ISA model in Ghanaian SHSs, and (e) a lack of focus on implementation challenges in resource-limited classrooms. This study seeks to fill these gaps by investigating the effectiveness of the ISA model in improving both performance and dispositions in genetics, while also examining gender differences and contextual feasibility. By doing so, it contributes to the advancement of science education research in Ghana and informs curriculum reforms aimed at enhancing both equity and quality in secondary education.

2.8 Summary of the Literature Review

The review of related literature has provided a comprehensive foundation for understanding the teaching and learning of genetics, the theoretical underpinnings of the Instructional Student Activity (ISA) model, and the role of gender and student dispositions in shaping science education outcomes. Globally, genetics is recognised as one of the most conceptually demanding topics in biology, requiring abstract reasoning and higher-order problem-solving (Tsui & Treagust, 2010). In Ghana, consistent evidence from WAEC Chief Examiners' Reports (2017; 2018; 2019; 2021; 2022) highlights students' persistent underperformance in genetics. Scholars attribute this challenge to the abstractness of the concepts, inadequate teacher preparation, and the dominance of teacher-centred pedagogies (Abdusseminu, 2022; Baah, 2021). These issues underscore the urgent need for innovative

instructional approaches that make genetics more accessible, engaging, and meaningful for senior high school students.

Constructivist approaches, including inquiry-based learning, problem-based learning, cooperative learning, and the 5E instructional model, have been identified as effective in promoting deep learning, engagement, and transfer of knowledge (Bybee, 2015; Chen, 2024). These approaches are grounded in the works of Piaget, Vygotsky, and Bruner, who emphasised active learner participation, scaffolding, and knowledge construction. Although the Ghanaian curriculum (NaCCA, 2023) encourages such learner-centred methods, classroom practice often remains teacher-dominated due to systemic barriers such as large class sizes, inadequate resources, and exam-orientated teaching (Asante, 2022). This gap between policy and practice highlights the need for models that can operationalise constructivist principles in a simplified, practical manner for Ghanaian classrooms.

The ISA model provides such an opportunity. Organised around three phases—Immersion, Structuring, and Applying—the model builds on constructivist theory by enabling learners to connect prior knowledge with new concepts, organise understanding through scaffolding, and apply learning to novel contexts. Evidence suggests that activity-based models such as ISA improve not only performance but also attitudes and perceptions toward science, making learning more engaging and relevant (Freeman et al., 2014; Singer & Moscovici, 2008). The model is particularly well suited to genetics instruction, as it contextualises abstract concepts, fosters collaborative inquiry, and encourages problem-

solving. However, empirical studies on the ISA model in Ghanaian SHSs remain limited, creating a gap this study seeks to fill.

Gender and student dispositions emerged as critical factors influencing science learning. While global research suggests minimal inherent gender differences in science performance (Hyde, 2014), socio-cultural factors in Ghana often reinforce stereotypes that disadvantage female learners (Gyan & Mensah, 2025; Ahiaba, 2023). Dispositions—including perceptions and attitudes toward science—play a mediating role, influencing motivation, confidence, and persistence (Osborne & Dillon, 2008). Research shows that learner-centred, activity-based instruction can help reduce gender disparities and foster positive dispositions, thereby creating more equitable learning opportunities (Russo-Tait, 2023). These findings provide a strong rationale for including gender and disposition in the present study's conceptual framework.

The literature also highlighted several gaps that justify the present study. First, there is a lack of topic-specific research focused on genetics instruction in Ghana, despite its consistent status as a high-difficulty area in WAEC assessments. Second, while constructivist approaches have been studied, their adaptation to resource-limited Ghanaian classrooms is underexplored. Third, existing research has often focused on cognitive outcomes (performance) without integrating affective outcomes (dispositions), leaving a partial understanding of student learning. Fourth, there has been insufficient attention to gender as a moderating variable in evaluating instructional models. Finally, little empirical

evidence exists on the ISA model in Ghanaian SHSs, particularly in relation to its impact on genetics learning.

In conclusion, the literature establishes that genetics is a persistently challenging area for SHS students in Ghana, largely due to the dominance of teacher-centred instruction and the abstractness of concepts. Constructivist approaches offer viable solutions but require context-sensitive adaptation. The ISA model, grounded in constructivist theory and structured around practical phases, emerges as a promising pedagogical framework to enhance performance, improve dispositions, and promote gender equity in genetics education. This study is therefore justified in its aim to investigate the impact of the ISA model on performance, gender differences, and student perceptions in genetics at the SHS level in Ghana.

CHAPTER THREE

METHODOLOGY

3.0 Overview

The study area is explained in this chapter. It also discusses the strategy and design of the research. The demographic, sample, and sampling methods that will be employed to ascertain the research sample size are also covered in this chapter. Additionally, it gives a thorough explanation of the research tool that will be used to collect data for the study as well as its validity and reliability. The data collection method and the analysis of the findings are in the final sections.

3.1 Study Area

The study will be conducted in the Sekyere Central District in the Ashanti region of Ghana. It is one of the twenty-four (24) administrative districts in the Ashanti Region of Ghana; it is located in the northern part of the region and shares boundaries with Mampong Municipal, Atebubu District, Sekyere East, Sekyere South, and Ejura-Sekyeredomasi. The land size of the district is 1,631.1 sq. km, and it is located within longitudes of 0.05 degrees and 1.30 degrees west, with latitudes of 6.55 degrees and 7.30 degrees north, as cited in Figure 3.1. It has about 150 settlements, with about 70 percent being rural. The Afram Plains areas in the district have the most rural areas with less than 50 people, with an average annual rainfall of 1270 mm. The climate is dry, hot, and dusty from December to February, with mean monthly temperatures ranging from 22 to 30 degrees Celsius. The district is in the wet semi-equatorial forest zone, but due to human activities and bushfires,

the forest vegetation has been reduced to savannah, particularly in the northeastern part. Primary forest vegetation can only be found within the Kogyae Nature Forest Reserve, covering 115 square kilometres. The district has three (3) senior high schools: Ghana Muslim Mission SHS in Beposo, Nsutaman Catholic SHS in Nsuta, and Presby SHTS in Kwamang. They are all mixed schools that offer biology as an elective subject (Ghana Statistical Service, 2022).

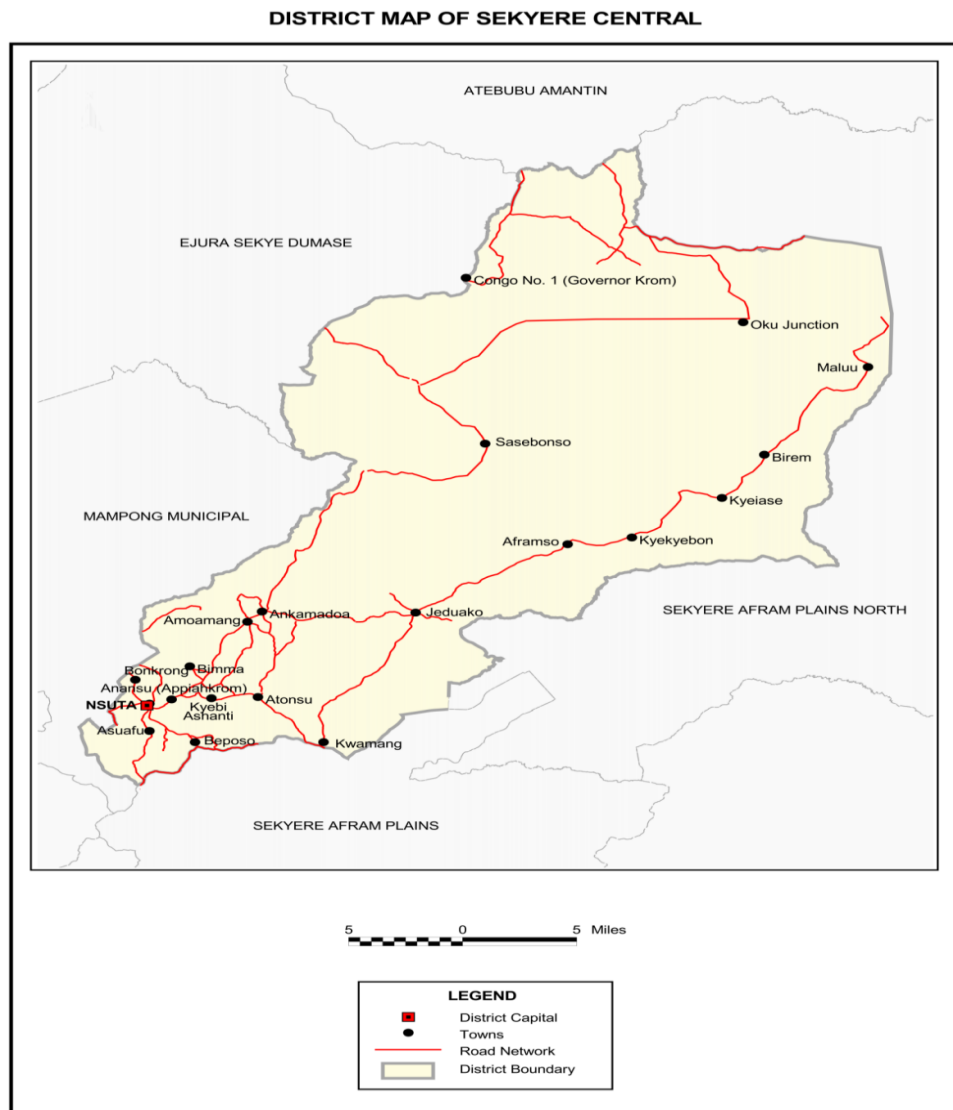


Figure 3.1: The map of Sekyere Central District

3.2 Research Paradigm

A paradigm refers to the philosophical assumptions or fundamental ideas that influence the researcher's work and shape his or her worldview (Kaushik & Walsh, 2019). The word paradigm, coined by Thomas Kuhn (1970), refers to a community of specialists' common generalisations, beliefs, and ideals about the nature of reality and knowledge. "Worldview" is a synonym for paradigm. According to Creswell (2009), a researcher adopts this "worldview", which serves as the foundation for the study's research and practice. It guides each stage of the inquiry process, such as selecting a research topic, developing research questions, determining the nature and variations of reality, knowledge, procedures, and the significance of the research attempt.

Moreover, as stated by Chilisa and Kawulich (2012), no particular paradigmatic or theoretical framework is 'right', and it remains up to the researcher to determine their paradigmatic view and how it influences their research designs to address the subject under study effectively. Research is conducted from several perspectives, including positivism, post-positivism, interpretivism, pragmatism, constructivism, and transformative paradigms. Among these, Pragmatist is synonymous with this study. The pragmatist paradigm is particularly suitable for mixed-methods research because it focuses on using the most effective methodological approach to answer research questions, rather than being restricted to either positivist (quantitative) or interpretivist (qualitative) worldviews (Creswell & Plano Clark, 2023). Pragmatism acknowledges that both objective, measurable outcomes and subjective, experiential insights are necessary to comprehensively understand a research problem (Omodan, 2024). In this study, the quasi-

experimental pre-test, post-test, non-equivalent control group design was used to provide empirical evidence of the ISA Model's effect on student performance. At the same time, focus group interviews explore students' attitudes and perceptions toward genetics, capturing their lived experiences. The integration of both perspectives reflects a pragmatic approach to educational research. Because it integrates quantitative and qualitative approaches to provide a thorough understanding of how the ISA Model affects students' performance in genetics, the pragmatic paradigm is especially suitable. Studies that need both quantitative data and a more in-depth contextual interpretation are ideally suited for pragmatic approaches, which encourage the application of several approaches to difficult educational issues (Omodan, 2024).

The pragmatic viewpoint also encourages data triangulation, which improves the reliability and validity of study conclusions. To give a more thorough picture of student learning and engagement, triangulation will take place in this study by comparing focus group talks and questionnaire responses (Omodan, 2024). This study was best suited to the pragmatic research paradigm, as it permits a thorough, adaptable, and application-focused methodology. A more thorough assessment of the ISA Model's efficacy in genetics at the senior high school level is provided by the study's integration of quantitative data on student performance with qualitative insights into student attitudes and perspectives.

3.3 Research Design

A Sequential Explanatory Mixed-Method Design was used in this study to examine how the ISA model affects senior high school students' performance in genetics. With focus

group interviews serving as the qualitative component and a quasi-experimental pre-test, post-test, and non-equivalent control group design serving as the main quantitative component in addition to the dispositions, this design combines both quantitative and qualitative methodologies. While the sequential method enables a deeper investigation of students' attitudes and perspectives after their questionnaire replies, the explanatory design guarantees that qualitative data complements and strengthens the understanding of the quantitative findings.

A quasi-experimental pre-test, post-test, and non-equivalent control group design was used for the study's quantitative component. An experimental group and a control group are used in this design to assess how the Immersion, Structuring, and Applying (ISA) model affects senior high school students' performance in genetics. Students in the experimental group will study genetics using the ISA model, a constructivist teaching methodology that prioritises practical experience, teamwork, and idea application. To compare the efficacy of the ISA model, the control group was instructed in genetics using the conventional lecture-based methods.

In order to assess the students' initial genetics knowledge, a pre-test was given prior to the intervention, and a post-test was given following the intervention to gauge any performance improvements. The efficacy of the ISA model may be evaluated by contrasting each group's pre-test and post-test results.

It is a research design commonly used to evaluate the effects of an intervention when random assignment to groups is not feasible. This design uses two or more pre-existing groups (intact classes or natural groups). One group, known as the experimental group, receives the intended intervention, while the other serves as a control group and does not receive the intended intervention to be assessed. The effectiveness of the intervention is assessed by comparing the outcomes of both groups before and after the intervention, using pre-test and post-test measurements. This design is beneficial in educational settings where random assignment may be impractical or unethical (Cook, 1979).

The use of intact classes means that the groups were not randomly assigned to the experimental or control group. This approach is practical and often necessary in educational research, where students are already organised into specific classes or schools. The lack of random assignment is referred to as using "intact class" because the groups may differ in ways that could influence the outcomes. However, using pre-test scores helped clear the initial doubt of differences by providing a baseline measure, improving the study's internal validity (Creswell & Creswell, 2017).

There are several reasons why a quasi-experimental approach is appropriate for this investigation. First, practical issues are important, as randomly assigning students to various teaching groups in a school context may need to be more practical owing to ethical concerns and administrative limitations. It would be difficult and disruptive to move students from their usual classrooms to separate groups only for the sake of the research.

Using entire classes as non-equivalent groups was a feasible and viable approach that adheres to the existing educational system (Campbell & Stanley, 2015).

Finally, the quasi-experimental approach ensures ecological validity, which is critical for assessing the impact of an intervention in a real-world educational environment. By investigating the impacts of the ISA model in its natural classroom setting, the findings are more likely to represent the natural consequences of adopting the model in other similar educational environments. This realistic environment increases the data's relevance and application, making them more effective in shaping educational practices and policies (Cook, 1979).

In addition to the quasi-experimental study, a 5-point Likert scale was used to gauge students' attitudes and perceptions on genetics. This assessed their perceived difficulty, interest, and confidence. Following the analysis of the questionnaire data, qualitative focus group interview was conducted. In order to provide a more comprehensive picture of students' perception and attitudes about studying genetics, the focus groups were used to validate, expound upon the results of the questionnaire. By combining these qualitative observations with the quantitative findings, a thorough grasp of students' attitudes and perceptions regarding genetics was possible.

The Sequential Explanatory Mixed-Methods Design is the best fit for this study because it allowed for a sequential integration of data, where quantitative data was collected first, followed by qualitative data to deepen and refine the findings (Creswell & Plano Clark,

2023). In addition, methodological triangulation was made possible by this design, which guarantees that the findings from focus group interviews and Likert-scale responses complement each other and improve the study's overall validity and reliability. (Denzin, 2012). By considering students' actual learning experiences as well as quantifiable academic improvements, this method guaranteed a thorough assessment of the ISA Model's efficacy.

3.4 Population

All senior high school students enrolled in biology classes in the Sekyere central district in Ghana's Ashanti Region made up the study's target population, while all Form Three (3) biology students in the district's SHSs made up the accessible population. The study focused on this group of students because they have the prerequisite knowledge needed to be engaged in genetics classes in order to assess the influence of the Immersion, Structuring, and Applying (ISA) model on students' genetics performance and their dispositions, with the ultimate goal of enhancing educational results in this tough topic.

3.4.1 Sampling and Sampling Techniques

A multi-stage sampling procedure was utilised in this study; for the first stage, two (2) senior high schools from the district were selected using a simple random sampling. One (1) school was chosen to be the experimental group, while the other became the control group using simple random sampling. In the next stage, a purposive sampling strategy was utilised to choose four (4) intact classes of biology students (general science or home science), two from each of the schools. The unit of analysis was 170 biology students.

Additionally, a stratified sampling technique was used to choose eight students for the focus group, guaranteeing a fair representation of participants with a range of backgrounds and academic achievement levels. Eight students were a reasonable group size that allowed for rich and varied qualitative insights, which is in line with best practices for focus group research (Krueger & Casey, 2015). In order to ensure equitable representation, stratified sampling was suitable as it enables the researcher to separate the population into two important strata: students from the experimental group (ISA Model) and those from the control group (Traditional Teaching) (Creswell & Creswell, 2017).

Lastly, to capture a variety of viewpoints on genetics studies, four (4) students representing a range of academic abilities (high and poor performance) were purposively chosen from each stratum using a purposive sampling technique (Etikan et al., 2016).

3.5 Research Instrument

The research instruments used are a standardised test known as the Genetic Concepts Test (GCT), a questionnaire and a semi-structured interview guide to collect data on the attitudes and perceptions of the students.

3.5.1 Genetic Concept Test (GCT)

The researcher developed the GCT, which consisted of five (5) essay-type questions covering genetics topics like heredity, DNA structure, and replication in their syllabus. This was used to evaluate the performance of SHS biology students before (pre-test) and

an equivalent one after (post-test) the intervention. The students' responses to the test items were graded polytomously.

3.5.2 Questionnaire

A questionnaire was used to collect information about the students' perceptions and attitudes on the study of genetics. The questionnaire was made of a Likert scale question, which is a type of survey that measured their perceptions and attitudes by asking respondents to indicate their level of agreement or disagreement with a series of statements about the students' expressions of the teaching and learning of genetics; the Likert scale consisted of statements and a range of responses, such as 'Strongly Disagree', 'Disagree', 'Neutral', 'Agree' and 'Strongly Agree'. The questionnaire was developed by the researcher with the help of experts in the science faculty at the university. It consisted of twenty (20) statements, ten (10) each on perception and attitudes on the study of genetics. A semi-structured interview guide consisting of six (6) questions was used to solicit their perception and attitudes on the study of genetics using the focus group.

3.6 Validity of Instrument

Clark and Watson (2019) define an instrument's validity as whether it correctly measures what it is designed to measure. To establish the validity of the research instruments, the GCT and interview questions were sent to experts in biology and science education to assess the suitability of each item on the instruments; this is also known as face validity. Cohen et al. (2002) define face validity as a kind of content validity. Five experts were then asked to evaluate the GCT questions to determine their correctness and capacity to assess

students' performance in the genetic topics covered in the study. Following the professional evaluations, the content validity of the instrument's items (GCT) was determined using Lawshe's (1975) content validity ratio (CVR).

The Content Validity Index (CVI) was computed for every item on the instrument in order to determine the CVR. The CVI is calculated by dividing the number of experts who ranked the items as vital by the total number of experts who evaluated the items (Ayre & Scally, 2014). The CVI for the entire instrument is computed once the CVI for each item has been determined. This represents the average of every single CVI (Almanasreh et al., 2019). The CVRs of the GCT and interview guide were then determined by dividing the overall CVI by the total number of items. Tables 3.1 and 3.2 present the Content Validity Ratio and Content Index for both the GCT and interview guide, respectively.

Table 3.1: Content validity index and content validity ratio of GCT

Item	Panel 1	Panel 2	Panel 3	Panel 4	Panel 5	Agreement	CVI
1	X	X	X	X	X	5	1.00
2	X	X	X	X	X	5	1.00
3	X	X	X	X	X	5	1.00
4	X	X	X	X	X	5	1.00
5	X	X	0	X	X	4	0.80
6	X	X	X	X	X	5	1.00
CVR							0.96

O=non-essential

X= essential

$$CVI = \text{Content Validity Index} = \frac{NE}{N}$$

$$CVR = \text{Content Validity Ratio} = \frac{CVI}{\text{total number of items}}$$

N = total number of experts

N_E = Number of experts indicating items as essential.

Almanasreh et al. (2019) stated that CVR ranges from -1 to 1, with high values signifying expert agreement over the significance of an item in the instrument. Consequently, the CVR value for GCT was 0.96, as shown in Table 3.1, indicating a viable instrument. The interview guide's CVI and CVR are also included in Table 3.2.

Table 3.2: Content validity index and content validity ratio of interview guide

Item	Panel1	Panel 2	Panel 3	Panel 4	Panel 5	Agreement	CVI
1	X	X	0	X	X	4	0.80
2	X	X	X	0	X	4	0.80
3	X	X	X	X	X	4	0.80
4	0	X	X	X	X	4	0.80
5	X	X	0	X	X	4	0.80
CVR							0.80

Table 3.2 shows that the interview guide's CVR value was 0.80, indicating that it was a valid instrument (Almanasreh et al., 2019).

3.7 Pilot-Study of the Instruments

The GCT was first used in a pilot study to assess the reliability of the instruments. The pilot study was done at Presby SHTS in Kwamang, an unselected SHS in the Sekyere Central District, with a sample of 32 third-year biology students who had similar characteristics comparable to those of the research participants but did not participate in the main study. The pre-test and post-test were administered to an intact class before and after the intervention of the ISA model, respectively, followed by the questionnaire.

3.7.1 Reliability of Instrument

Reliability relates to the uniformity of assessment outcomes. In other words, if we measure the same construct several times, would the results be almost identical as long as the underlying phenomena remain constant? (Stemler, 2019). Ross (2019) discovered that reliability necessitates consistency but not accuracy. As a consequence, the genetic concept test's (GCT) internal consistency or reliability was assessed using inter-rater reliability, especially Cohen's Kappa. Inter-rater reliability measures the amount of agreement between two or more raters evaluating the same item or performance. It is especially critical when subjective judgements are involved, such as evaluating essays, making clinical diagnoses, or tracking behaviour. Cohen's Kappa is a prominent statistic for analysing inter-rater reliability since it takes into consideration the agreement that would be predicted by chance alone. Gwet (2014) categorises values < 0 as no agreement, values from 0.01 to 0.20 as none to slight, 0.21 to 0.40 as fair, 0.41 to 0.60 as moderate, 0.61 to 0.80 as significant, and 0.81-1.00 as practically perfect agreement. This means that a high Kappa value shows substantial agreement among raters, implying that the test results are reliable across several assessors.

Cronbach's alpha (α) was utilised to evaluate the study questionnaire's internal consistency. A commonly used statistical metric called Cronbach's alpha assesses the degree of group relatedness among a collection of items and provides an indication of the scale's reliability (Vaske et al., 2017). Greater internal consistency is indicated by higher Cronbach's alpha values, which range from 0 to 1. According to Taber (2018), an alpha value of 0.70 or

above is generally regarded as satisfactory, whereas values over 0.80 imply strong reliability, and those above 0.90 suggest outstanding reliability.

The questionnaire in this study used Likert-scale items to gauge students' attitudes and views about studying genetics. A pilot test was carried out on a sample group that is comparable to the research participants in order to guarantee its reliability. Following data collection, Cronbach's alpha was used to assess the students' responses' internal consistency. The Tables below presents the reliability of the instruments.

3.7.2 Inter-rater Reliability of the GCT

The inter-rater reliability of the GCT was examined using Cohen's Kappa's agreement metric. The result is presented in Table 3.3.

Table 3.3: Inter-rater reliability of GCT-pre-test

		Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Measure of Agreement	Kappa	0.70	0.09	9.72	.001
No of Valid Cases		32			

Table 3.3 indicates, the value of Kappa's measure of agreement for the pre-test is 0.70, which is a substantial agreement, as per Gwet (2014). Therefore, the GCT-pre-test was deemed reliable to be used.

Following the reliability of the Pre-test the Post-test was also tested using the Kappa's agreement between the two raters the reliability. Its findings are also presented in Table 3.4.

Table 3.4: Inter-rater reliability of GCT-post-test

		Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Measure of Agreement	Kappa	0.82	0.07	12.89	.001
No of Valid Cases		32			

Table 3.4 indicates the value of Kappa's measure of agreement for the post-test is 0.82, which is a strong agreement, as per Gwet (2014). Therefore, the GCT post-test was also deemed reliable to be used.

3.7.3 Internal Consistency of the Questionnaire

Cronbach's alpha (α) was used to assess the internal consistency of the questionnaire. The findings are presented in Table 3.5.

Table 3.5: Internal consistency of the questionnaire

Scale	Number of Items	Cronbach's alpha (α)
Students' Perception	10	0.70
Students' Attitudes	10	0.72

From Table 3.5, the values of the Cronbach's alpha (α), the internal consistencies of both questionnaires, are 0.70 and 0.72 for the perception and attitude, respectively. This indicates a satisfactory or acceptable reliability of the instrument (Taber, 2018).

3.8 Data Collection Technique

The study included the gathering of quantitative data in two stages. These are the pre-intervention and post-intervention stages.

3.8.1 Pre-intervention Stage

At this phase, the first stage of data collection, formal authorisation was requested from the district education office, the headmaster, the head of the science department, and biology instructors from the school chosen for the study. The pre-test was taken by the students at our first engagement. While ensuring the confidentiality of the results and information supplied by the students, students were not permitted to write their names on their answer sheets throughout the pre-test and post-test. Instead, students were assigned identity numbers for identification and data input throughout the study. The study was conducted during regular school time. The pre-test served one primary function in this investigation. It was used to assess students' entrance characteristics before the intervention. Students were allowed 40 minutes to complete the test items.

3.8.2 Intervention Stage

The instructional approaches (ISA model and conventional method) were deployed at this stage, which served as the study's independent variables. The researcher taught the subject matter to the students (participants) in order to account for teacher differences. The intervention stage, which lasted for a period of four (4) weeks, involved teaching the same topics (genetics) and using different treatment activities (the ISA instructional model and

the traditional instructional approach) for all the intact classes. Table 3.6 provides a summary of the various contents that were covered during the research.

Table 3.6: Content of genetics taught to students

Period	Content Taught
Week 1	Heredity
Week 2	Nucleic Acids
Week 3	DNA Structure
Week 4	DNA Replication

3.8.3 Intervention Activities

Both intact classes in the experimental group were exposed to the ISA model's teaching and learning approach during the teaching and learning of genetic concepts. Table 3.7 gives a description of how the ISA model was implemented.

Table 3.7: Stages of the ISA model for intervention implementation

PHASE	ISA STRATEGIES		ACTIVITY
	Teacher	Student	
Immersion	Anticipation	Evoking	Stimulating curiosity through real-life problems, questions, or demonstrations. Activating prior knowledge. Introducing context through stories, images, or videos.
	Problem Construction	Exploring	Eliciting students' initial ideas, questions, or experiences related to the topic.
Structuring	Systematization	Synthesizing	Guiding students to identify patterns, relationships, and concepts from their observations. Concept mapping or guided group discussions.
	Conceptualization	Explaining	Formally constructing knowledge; teacher introduces core ideas based on student exploration. Use of charts, models, or concept summaries.
Applying	Transfer	Extending	Students apply learned concepts to new contexts, solve problems, or design tasks. Case studies, simulations, or practical exercises.
	Reinforcement	Evaluating	Assessment of conceptual understanding and application skills through quizzes, presentations, or reflective journals.

The implementation of the ISA instructional model in this study followed a structured, phased approach consisting of Immersion, Structuring, and Applying, each designed to support students' cognitive and affective engagement in learning genetics. This model was applied over a series of carefully planned lessons with activities aligned to each phase.

Immersion Phase

The goal in the first phase was to stimulate curiosity, activate prior knowledge, and engage students in the learning process through real-life contexts. At the beginning of each lesson, students were introduced to real-world problems or scenarios relevant to genetics, such as why family members look alike or how genetic disorders are inherited. The teacher employed visual aids, short video clips, and storytelling to make these scenarios relatable and thought-provoking. This stage emphasised student-centred strategies such as brainstorming and concept cartoons to elicit learners' prior knowledge and misconceptions. By encouraging learners to share their experiences and initial ideas in groups or whole-class discussions, the phase aimed to create a supportive atmosphere for inquiry and reflection.

Structuring Phase

It focused on helping students organise, refine, and conceptualise their knowledge based on their exploration in the immersion stage. Here, students engaged in structured learning activities such as analysing genetic crosses using Punnett squares, identifying inheritance patterns, and interpreting simple pedigrees. They worked collaboratively in small groups to examine case studies, conduct simulations, and identify patterns in data. During this phase, the teacher scaffolded student learning by guiding discussions, introducing formal terminology (such as 'genotype', 'phenotype', 'homozygous', and 'heterozygous'), and using tools like concept maps and graphic organisers. These supports enabled students to integrate new ideas with prior knowledge and construct scientifically accurate explanations. The structuring phase was critical in transitioning students from initial exploration to deeper conceptual understanding.

Applying Phase

Students were guided to transfer their newly constructed knowledge to novel or real-life situations, thereby reinforcing learning and promoting critical thinking. For example, students were asked to analyse hypothetical family histories to determine the likelihood of inheriting specific traits or disorders. They also designed models, engaged in group presentations, and solved real-life genetics problems that required them to apply what they had learnt. In addition to applying content knowledge, students completed reflective writing tasks and participated in discussions that encouraged them to evaluate their own learning. Assessment activities, including quizzes, oral presentations, and exit tickets, were used to measure both conceptual understanding and the ability to transfer knowledge. This phase not only consolidated learning but also enhanced students' motivation, confidence, and scientific reasoning skills.

Together, these phases of the ISA model created a cohesive and learner-centred instructional process that engaged students cognitively and emotionally. By moving from immersion in relevant problems, through structured knowledge building, to application in meaningful contexts, the ISA model supported both the performance and disposition outcomes targeted in the study. The model's structured yet flexible nature allowed for differentiated instruction, peer interaction, and deep engagement, addressing the common challenges associated with teaching abstract genetics concepts in traditional settings.

3.8.4 Post-intervention Stage

Following the intervention stage, students were given a two-day revision break to review their notes before taking the post-test (GCT). Students were allowed forty (40) minutes to complete the test items. Following that, the students were given the questionnaires to answer relating to their attitudes and perceptions of the study of genetics, and the focus group were informed and interviewed the next day. The section was recorded for easy analysis.

3.9 Data Analysis Technique

The data analysis for this study involved quantitative and qualitative techniques to comprehensively evaluate the effectiveness of the ISA model on students' performance and their dispositions in genetics (Table 3.8).

Table 3.8: Data analysis techniques representation

Research Questions	Type of Data	Type of Test	Description
Research Questions 1	Scores of GCT (post-test scores)	Wilcoxon sign rank Test	To assess the effectiveness of the ISA Model.
Research Questions 2	Scores of GCT	Mann-Whitney U test	To compare the significant differences between the two groups.
Research Questions 3	Scores of GCT	Mann-Whitney U test	To compare the difference in performance based on gender.
Research Questions 4	Students' responses from questionnaire and the Interview	Descriptive Statistics (mean and standard deviations), Reflexive thematic analysis and Triangulation	To describe their perception and attitudes towards the study of genetics.

3.10 Ethical Considerations

According to Israel (2014), ethical norms embody the desire and efforts to respect the rights of others, carry out obligations, avoid damage, and provide benefits to the subjects. To ensure the complete involvement of the selected respondents and their respective schools, the researcher maintains the confidentiality and anonymity of their responses. This was accomplished by instructing respondents to refrain from writing their names or indicating their schools on the paper. The head teachers of the schools chosen and the head of the Science Department were informed that the research is completely anonymous, and they were familiar with the study's specifics. The test items were administered during normal school hours, in the usual school environment, and under the supervision and authority of the teachers. The study also received ethical clearance from the Committee on Human Research, Publication and Ethics at Kwame Nkrumah University of Science and Technology (KNUST) Kumasi to conduct this research. A copy of the ethical clearance certificate is included in Appendix E.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The chapter presents results and discussions on the effectiveness of the ISA model on senior high school students' performance in genetics at the Sekyere central district, Ashanti Region. The findings are presented based on the following research questions:

1. What is the effect of incorporating the ISA model on students' performance in genetics at the Senior High School?
2. What is the difference in academic performance between students taught genetics using the ISA model and those taught with the traditional approach at the SHS level?
3. What is the difference in performance between boys and girls taught genetics using the ISA model at the Senior High School?
4. What is the attitude and perception of students after the study of genetics at the senior high school level?

4.1 Demographics of Respondents

The study included 2 public senior high schools within the district, comprising 170 biology students who were selected. The Figure 4.1 below indicates the distribution of their gender.

GENDER DISTRIBUTION OF PARTICIPANTS

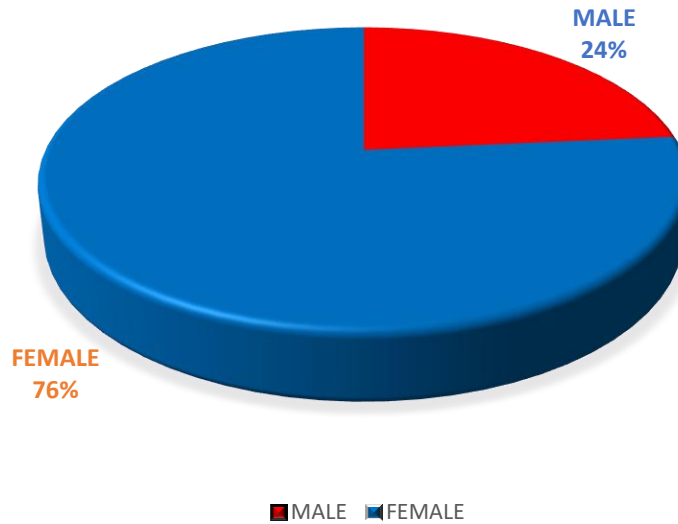


Figure 4.1: Gender distribution of participants

The pie chart in Figure 4.1 shows that most of the students who took part in the study were female, 130, representing 76% of the total sample size, while only 40 were male, also representing 24%. This means that more girls than boys participated in the research. This difference depicts the natural settings of biology classes, dominated by female students, especially in Ghana (Annan et al., 2019).

4.2 Data Suitability

To make sure the data was appropriate, normality tests were conducted before the study's results were analysed. This section presents the findings. To decide whether to apply parametric or non-parametric tests, the study's student results were put through a normality test. Using the numerical method, normality checks were performed. The Shapiro-Wilk and Kolmogorov-Smirnov tests were thus conducted quantitatively. According to the "null

hypothesis that the data sets are normally distributed", normality tests were conducted (Khatun, 2021). This means that when the p-value from the Kolmogorov-Smirnov or the Shapiro-Wilk tests is more than 0.05, the null hypotheses are rejected; hence, the data are not normal. The outcomes of the normalcy tests are shown in Table 4.1.

Table 4.1: Results of normality tests for students' scores

Groups	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test of Control Group	.139	84	.001*	.944	84	.001*
Post-test of Control Group	.107		.018*	.966		.024*
Pre-test of Experimental Group	.214		.001*	.916		.001*
Post-test of Experimental Group	.118		.006*	.964		.019*

a. Lilliefors Significance Correction

***Significant since $p < 0.05$**

The results of the Kolmogorov-Smirnov and Shapiro-Wilk tests indicate that the students' pre-test and post-test scores for both the control and experimental groups are not normally distributed, as all significance values (p-values) are less than 0.05. This violation of the assumption of normality justifies the use of non-parametric statistical tests for further analysis. The Shapiro-Wilk test, which is more appropriate for smaller sample sizes, confirmed the non-normality across all test groups. Therefore, statistical analyses such as the Wilcoxon Signed Rank Test and Mann-Whitney U Test were appropriately used in this study.

4.3 The Effect of the ISA Model on Student's Performance in Genetics

To assess the effect of the ISA model on students' performance in genetics, the pre-test and post-test scores of the experimental group were analysed using the Wilcoxon signed-rank

test. This non-parametric test was chosen because the data did not meet the normality assumption required for a paired-samples t-test, as indicated by the Shapiro–Wilk test results. The Wilcoxon signed-rank test is appropriate for comparing two related samples when the measurement scale is at least ordinal and the distribution of differences is non-normal (Pallant, 2020). The results are presented in Table 4.2.

Table 4.2: Wilcoxon signed rank test results on the effect of the ISA model

Groups	N	Test Statistic	Mean	<i>z</i>	<i>r</i>	<i>p</i>
Pretest	84	3570	3.1	7.98	0.87	.001*
Posttest			16.4			

***Significant since $p < 0.05$**

The Wilcoxon Signed Rank Test assessed the effectiveness of the ISA instructional model by comparing students’ pre-test and post-test scores in the experimental group. The test shown in Table 4.2 indicates a statistically significant increase in scores after the intervention, with a Z-value of 7.98 and a p-value of .001. The pre-test mean was 3.1, while the post-test mean improved dramatically to 16.4. The effect size ($r = 0.87$) is considered very large, suggesting that the ISA model had a strong and meaningful impact on improving students’ performance in genetics (Fritz et al., 2011).

4.4 The Difference in Academic Performance between Students Taught Genetics Using the ISA Model and Those Taught with the Traditional Approach in Genetics

In determining the difference between the control and experimental groups, the Mann–Whitney U test was used to compare their pre-test scores first, to establish whether any

significant variation existed prior to the intervention, followed by an analysis of their post-test scores. This non-parametric test was selected because the data violated the assumption of normality required for an independent-samples t-test, as indicated by the Shapiro–Wilk test results. The Mann–Whitney U test is appropriate for comparing the central tendencies of two independent groups when the dependent variable is measured at least on an ordinal scale and the distribution is non-normal (Pallant, 2020). The results are presented in Tables 4.3 and 4.4.

Table 4.3: Mann-Whitney U test on the pre-test of both groups

Groups	N	<i>U</i>	Mean rank	<i>Z</i>	<i>r</i>	<i>p</i>
Experimental Group	84	4035	80.46	1.33	0.11	.183
Control Group	86		90.42			

The Mann-Whitney U Test results for the pre-test scores of the experimental and control groups reveal no statistically significant difference ($p = .183$). The mean ranks for the experimental and control groups were 80.46 and 90.42, respectively, with the control group slightly better than the experimental group. This finding indicates that both groups were relatively equal in their understanding of genetics prior to the intervention. Therefore, any differences observed in the post-test scores can be reasonably attributed to the instructional intervention rather than pre-existing disparities in knowledge.

Table 4.4: Mann-Whitney U test on the post-test of both groups

Groups	N	<i>U</i>	Mean Rank	<i>Z</i>	<i>r</i>	<i>p</i>
Experimental Group	84	516	122.36	-9.697	0.74	.001*
Control Group	86		49.5			

***Significant since $p < 0.05$**

In contrast to the pre-test results, the post-test analysis shows (Table 4.4) a statistically significant difference between the experimental and control groups ($p = .001$). The experimental group, which was taught using the ISA model, had a higher mean rank of 122.36, compared to the control group's mean rank of 49.5. The U-value of 516 and large effect size ($r = 0.74$) further underscore the effectiveness of the ISA model in enhancing student performance (Fritz et al., 2011). These results strongly support the claim that the ISA model's approach is superior to the traditional method in teaching genetics at the SHS level.

4.5 The Effect of the ISA Model between the Performance of Boys and Girls in Genetics

In determining the difference between male and female students in the experimental group, the Mann-Whitney U test was run on their pre-test first to establish if there was any significant variation prior to the interventions, followed by the post-test results. The results are presented in Tables 4.5 and 4.6.

Table 4.5: Mann-Whitney U test on the pre-test of both gender

Groups	N	<i>U</i>	Mean Rank	<i>Z</i>	<i>r</i>	<i>p</i>
Female	58	587	39.62	-1.64	0.18	.102
Male	26		48.92			

Table 4.5 compares pre-test scores between male and female students from the experimental group. The Mann-Whitney U Test revealed no statistically significant difference ($p = .102$) between the genders. Female students had a mean rank of 39.62, and males had a mean rank of 48.92. This suggests that gender did not play a role in students' baseline understanding of genetics before the intervention, indicating a level playing field for analysing post-intervention effects across genders.

Table 4.6: Mann-Whitney U test on the post-test of both gender

Groups	N	U	Mean Rank	Z	r	p
Female	58	570	39.33	-1.8	0.2	.072*
Male	26		49.58			

Indication from Table 4.6: the post-test results by gender also showed no statistically significant difference ($p = .072$), even though males had a slightly higher mean rank (49.58) compared to females (39.33). Though the Z-score was -1.8, and a small effect size ($r = 0.2$). This indicates that both male and female students may have benefited equally from the ISA model, further confirming that the intervention was gender-neutral in its effectiveness.

4.6 The Perception and Attitude of Students After the Study of Genetics at the SHS

As stipulated in survey analysis literature, the common practice for interpreting means and standard deviation on a 5-point Likert scale is as represented in Table 4.7, with standard deviation used to indicate response consistency; a lower standard deviation ($SD < 0.50$) reflects a stronger agreement, while a higher standard deviation ($SD > 0.50$) also reflects lower agreement or highly varied responses. Although individual Likert items are ordinal, aggregates are treated as approximating interval data for descriptive and inferential purposes (Sullivan & Artino, 2013; Yin et al., 2016).

Table 4.7: A Five-point Likert scale interpretation

Scale	Responses
1.00–1.79	Strongly Disagree
1.80–2.59	Disagree
2.60–3.39	Neutral
3.40–4.19	Agree
4.20–5.00	Strongly Agree

A descriptive statistic (mean and standard deviation) was conducted to examine the perception and attitude of students towards the study of genetics after the intervention at the SHS. All participants (N = 170) in the study completed the questionnaire.

Table 4.8: A descriptive table on the perception of students after the study of genetics

Statements	Mean	Standard Deviation
I find genetics to be an interesting and engaging subject.	3.81	1.05
I believe genetics is relevant to my everyday life and future career.	4.25	0.7
The concepts in genetics are easy to understand when taught effectively.	3.49	1.3
I feel confident in my ability to apply genetic principles to solve real-world problems.	4.08	1.1
Learning genetics is more difficult compared to other biology topics.	3.16	1.3
I believe genetics helps me understand the biological basis of inheritance and diversity.	4.24	0.79
Studying genetics increases my curiosity about scientific discoveries and medical advancements.	3.94	0.81
I feel that genetics is a subject that requires too much memorization rather than understanding.	3.3	1.0
I think genetics should be integrated more with other subjects like chemistry and mathematics.	3.45	1.44
The knowledge of genetics helps me make informed decisions about my health.	4.2	0.89
OVERALL	3.79	1.04

Table 4.8 presents students’ perceptions across ten statements measured on a 5-point Likert scale. The overall mean score was 3.79, indicating that, on average, students agreed with most positive statements about genetics. The highest mean score (4.25) was for the statement “I believe genetics is relevant to my everyday life and future career”, with a low standard deviation (0.70), reflecting both strong agreement and consistency among students. Similarly, students strongly agreed that genetics helps them make informed health decisions (M = 4.20, SD = 0.89) and understand inheritance and diversity (M = 4.24, SD = 0.79). These responses suggest students perceive genetics as practical, relevant, and scientifically important in real-life contexts.

Students also found genetics to be interesting and engaging ($M = 3.81$), and studying it increased their curiosity about scientific discoveries and medical advancements ($M = 3.94$). While most agreed that the concepts are understandable when taught effectively ($M = 3.49$), the high standard deviation (1.30) reveals diverse experiences, likely depending on teaching quality. Students were neutral about the subject being difficult ($M = 3.16$), and their views on whether genetics requires too much memorisation were mixed ($M = 3.30$). The statement about integrating genetics with chemistry and mathematics received a mean of 3.45 with a high SD of 1.44, suggesting mixed responses. Overall, the data indicates that students value and appreciate genetics, particularly when it is taught well and connected to real-life issues, indicating a positive perception towards the study of genetics.

Table 4.9: A descriptive table on the attitudes of students after the study of genetics

Statements	Mean	Standard Deviation
I enjoy participating in genetics-related class activities, such as experiments and discussions.	4.06	1.03
I feel motivated to study genetics even when I face challenges in understanding the concepts.	3.76	1.05
I prefer interactive and hands-on learning approaches when studying genetics.	3.96	1.22
I am likely to pursue further studies or a career that involves genetics.	3.56	1.34
I believe genetics should be taught using real-life examples to improve understanding.	4.48	0.66
I feel anxious when learning genetics because of the complexity of the concepts.	2.97	1.27
I am more engaged in genetics lessons when practical activities or case studies are used.	3.94	1.25
I believe everyone should have a basic understanding of genetics to make informed life choices.	4.23	0.8
I enjoy learning about genetic disorders and how they affect individuals and families.	4.23	0.92
If given the opportunity, I would like to participate in a genetics-related research project.	4.28	0.96
OVERALL	3.95	1.05

Table 4.9 evaluates student attitudes through ten statements. The overall mean score was 3.95, which is higher than the perception score in Table 4.8, showing a generally positive and active attitude toward genetics. The highest-rated statement was “I believe genetics should be taught using real-life examples to improve understanding” (M = 4.48, SD = 0.66), indicating that students not only value practical relevance but also believe it enhances learning. Similarly, students expressed strong interest in participating in genetics-related research projects (M = 4.28) and learning about genetic disorders (M = 4.23), reflecting high engagement and curiosity.

Moreover, students agreed that interactive and hands-on approaches make genetics more enjoyable (M = 3.96), and they preferred lessons that involved experiments and discussions

(M = 4.06). Many also said they felt more engaged when practical activities or case studies were used (M = 3.94), supporting the use of inquiry-based learning methods. Interestingly, the only item with a mean below 3.0 was “I feel anxious when learning genetics because of the complexity of the concepts” (M = 2.97), suggesting that genetics can cause anxiety for some students, though it does not dominate their overall attitude. Motivation remained relatively high even when students faced challenges (M = 3.76), and about two-thirds of students were open to pursuing further studies or careers in genetics (M = 3.56). Overall, the findings show that students not only enjoy studying genetics but are also eager to explore it beyond the classroom when taught in an engaging, applied, and relatable manner, indicating a positive attitude towards the study of genetics.

4.6.1 Students’ Interview on Their Perception and Attitude after the Study of Genetics at the SHS

This section presents the findings from the qualitative data gathered through focus group interviews with senior high school students regarding their perception and attitudes toward the study of genetics. The data were analysed using Braun and Clarke’s reflexive thematic analysis framework (Braun et al., 2023). The six phases of the analysis include familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. This process was used to identify key patterns and shared meanings in the responses of the students. Therefore, to achieve this, a face-to-face, semi-structured focus group interview was conducted with eight (8) students. Students’ views were recorded with their permission and transcribed for

thematic analysis. The interview transcripts revealed four main themes presented in Table 4.10 (all names are pseudonyms).

Table 4.10: Thematic presentation of student’s perception and attitude towards the study of genetics

Themes	Topic
Theme 1	Perceptions and Attitudes Toward Genetics
Theme 2	Motivational and Personal Learning Experiences
Theme 3	Impact of Teaching Methods on Learning
Theme 4	Real-Life Application and Relevance of Genetics

4.6.2 Theme 1: Perceptions and Attitudes toward Genetics

Students generally expressed positive attitudes toward the study of genetics. Emelia and Emmanuella highlighted that genetics was interesting, particularly because of concepts like genotype, phenotype, dominance, and chromosomes.

Emelia, a student in the control group said:

“Okay, I feel good studying genetics compared to other topics, the most interesting part of genetics is the basic terms used in it: we have the genotype, the phenotype, dominance and recessiveness. I also feel good about the genetics and the importance of it that, one is paternity test, production of improved breed in agriculture, blood transfusions, marriage counselling and production of useful chemicals such as insulin.”

Emmanuella from the experimental group also said:

“Okay, the interesting part I liked in genetics is the significance of the chromosome number, it determines the characteristics of an individual species, it also determines the sex of an individual and the types of chromosomes, the autosomal and sex chromosomes. Another thing I found interesting about genetics is the mono-hybrid inheritance so according to Mendel’s law considers one construct character, it is therefore explained as the inheritance involving one pair of character, so for example tall pure pea plant against dwarf pea plant, so it will be like we have capital ‘TT’ plant and we have small ‘tt’. So, the representation will be like, the parental genotype which is the tall plant times the short plant. So, this experiment will be like, the genotype will be $T \times t$, so their random fertilisation will be in that F_1 , which is the genotype and we have the F_1 the phenotype, so the matching will be like the Tt ”

4.6.3 Theme 2: Motivational and Personal Learning Experiences

Students’ motivation to learn genetics was greatly influenced by specific classroom experiences.

Mensah from the experimental group remarked that:

“Okay, so my experience in genetics was, how Sir, you used, the straw, we all know straw and you used it to form a double stranded helix, which looks like a ladder and you told us about the components in it. This motivated me into learning more about the topic. You also used Gregor Mendel’s method of inheritance to explain, in the monohybrid crossing and dihybrid crossing, it was interesting. Sometimes also you used some app on your laptop about the types of nucleotides to teach us. We realised it was beneficial to most of us”.

Latif from the control group had a contrasting opinion:

“Okay, my experience with genetics – the negative aspect was when you were teaching us, it was a little bit confusing, and I didn’t understand it well. You were not able to make it practical, and it was confusing; because of that, I didn’t get the concept. Everything was just scattered, and I didn’t think I would understand it because of that.”

4.6.4 Theme 3: Impact of Teaching Methods on Learning

Students noted that the way genetics is taught greatly affects their engagement and understanding.

Fatima from the experimental class praised her teacher:

“When you were teaching, everybody was participating so it was good and interesting; yes, it boosted my interest. Okay, the method that Sir you used was nice even before the class kraa, you gave us some work to do so that before you start the class, we get the understanding well. It very nice and you used the pea plants to explain the determination of the laws of inheritance. It was very interesting and nice. You also brought your own laptop to the class and explained things further to us, then it boosted our understanding and then I think learning genetics would be useful in our careers.”

Gestina shared similar opinion with Fatima though from the control group:

“Yes, like we were answering questions here and there. It has affected me in a positive way, because the lectures and the discussions in the class has help me about understanding. Okay, you were so nice, to us because, when you came to the class, we were so wondering what topic you were about to teach us and finally I now know something about the topic. It

was so nice, and we had a good time we spent with you. The strategies the teacher used were also nice.”

4.6.5 Theme 4: Real-Life Application and Relevance of Genetics

Students clearly recognized the relevance of genetics in their everyday lives.

Latif from the experimental group stated that:

“So, through genetics we are able to inherit some traits from our parents, such as hair texture, blood type, eye colour and also height. So, in relating to real-life situations, we have genetic disorders. Is a condition caused by mutation and variation in an individual’s DNA; examples are chromosomal disorders caused by changes in chromosomes and a number of structures, etc. It helps us a lot, yes; it has helped us in the detection of criminals by using fingerprints in places like banks, malls and supermarkets.”

Abdul agrees with what Latif said:

“Yes, because with genetics we have been able to know that offspring can acquire or inherit some characteristics from their parents, for example, the height and the size of my nose, eyes and mouth. It has improved in the production of useful chemicals, such as insulin, and also marriage counselling. Learning genetics has been useful in my life. This is because it has a great impact on my daily life. I know that the food we eat, the cloths we wear and anything that we just do can be associated with genetics like transfusion of blood. Yes, it also helps doctors to determine the kind of blood a donor should transmit to his/her receptor. It is very useful yes.”

4.6.6 Main Findings of Students Interview

This reveals that high school students generally hold positive perceptions and attitudes toward the study of genetics, especially when it is taught through engaging, hands-on, and context-based approaches like the ISA model.

4.7 Discussion

This section discusses the findings presented earlier based on the respective research questions.

4.7.1 Effect of Incorporating the ISA Model on Student's Performance in Genetics at the Senior High School

The ISA model had a statistically significant impact on students' academic performance in genetics, as demonstrated by the results of the Wilcoxon Signed Rank Test (Table 4.2). The mean score for the experimental group increased from 3.1 (pre-test) to 16.4 (post-test), with a Z-value of 7.98 and a highly significant p-value ($p = .001$). The effect size ($r = 0.87$) was large, indicating not just statistical significance but also practical relevance (Fritz et al., 2011). This substantial improvement confirms that the ISA instructional model, designed to be interactive, scaffolded, and application-based, had a meaningful impact on students' understanding of genetics.

The improvement aligns with findings by Russo-Tait (2023), who reported that active and inquiry-based instructional methods in science classrooms enhanced students' mastery of abstract topics by allowing them to explore, question, and apply knowledge in meaningful contexts. Similarly, Asante (2022) found that the integration of real-life examples and

collaborative group work in biology lessons in Ghanaian senior high schools significantly boosted students' ability to transfer theoretical knowledge to problem-solving tasks. In the current study, the ISA model's immersion and application phases provided such opportunities, thereby enabling students to connect theoretical genetics principles to real-world examples.

The results also resonate with the arguments of Baah (2021), who stressed that linking classroom content to learners' lived experiences deepens conceptual understanding and supports long-term retention. By engaging students in structured inquiry and encouraging them to apply concepts in varied contexts, the ISA model bridged the gap between abstract genetic content, such as Mendelian inheritance and gene expression, and the students' daily experiences, making learning more relevant and memorable.

In addition, the findings are supported by Freeman et al. (2014), who demonstrated that cooperative and interactive instructional approaches improved not only students' comprehension of science concepts but also their confidence in applying those concepts to novel situations. In the ISA model, collaborative activities in the "Structuring" phase allowed students to co-construct understanding, consistent with the social constructivist perspective that learning is optimised through dialogue, peer explanation, and shared problem-solving (Singer & Moscovici, 2008; Vygotsky, 1978).

Taken together, the findings indicate that incorporating the ISA model into Senior High School genetics instruction can yield substantial learning gains. The strong performance

outcomes observed in the experimental group reaffirm theoretical claims from constructivist and inquiry-based learning frameworks, as well as empirical evidence from previous studies in both Ghana and other contexts. The consistency between the present findings and the reviewed literature reinforces the conclusion that learner-centred, contextually relevant instructional models offer a powerful alternative to traditional methods, especially for teaching complex scientific topics like genetics.

4.7.2 Differences in Academic Performance between Students Taught Genetics Using the Isa Model and Those Taught with the Traditional Approach at The SHS Level

Comparison of post-test results between the experimental and control groups, presented in Table 4.4, shows a statistically significant difference in favour of the experimental group. While both groups started at a similar level, as confirmed by the non-significant pre-test results ($p = .183$; Table 4.3), the post-test results revealed a stark contrast. The experimental group, taught using the ISA model, had a much higher mean rank (122.36) than the control group (49.5), with a highly significant p-value ($p = .001$) and a large effect size ($r = -0.74$). These strongly suggest that the instructional strategy used made a major difference in the students' performance results.

The gains observed in this study also address one of the limitations associated with traditional teacher-centred methods highlighted in the literature review (Renninger, 2024). Osborne and Dillon (2008) noted that such approaches often promote rote memorisation without equipping learners with higher-order cognitive skills. By contrast, the ISA model's application-focused design appears to have strengthened students' academic gains, which is critical for success in both academic and real-world contexts. In Ghanaian contexts,

Baah (2021), reported similar results, noting that biology students exposed to interactive, real-life examples demonstrated significantly higher achievement scores than those taught through lectures alone. The present study mirrors this trend, as the ISA model's active learning phases encouraged student engagement, peer discussion, and problem-solving, which are largely absent in traditional methods. These interactive elements likely contributed to the experimental group's higher scores.

The performance gap between the groups also supports the findings of Freeman et al. (2014), who argued that practical, inquiry-orientated activities not only improve students' understanding of science concepts but also enhance retention and application skills. In the current study, the ISA model's "Immersion" and "Application" phases gave students direct opportunities to apply genetic principles in contextualised situations, deepening their grasp of complex concepts such as dihybrid crosses, genetic variation, and inheritance patterns. By contrast, the control group primarily engaged in note-taking and listening to teacher explanations, consistent with Renninger's (2024) critique that teacher-centred methods foster passive learning and limit opportunities for higher-order thinking.

Moreover, Renninger (2024) further highlighted that contextualising learning to students' lived experiences enhances both motivation and achievement. In this study, the ISA model incorporated examples from Ghanaian cultural and environmental contexts, such as local agricultural practices and hereditary traits common in the population, which may have made the subject matter more relatable and memorable for the experimental group. This kind of contextualisation is often missing from traditional lecture formats, which can appear abstract and disconnected from students' realities.

The findings also align with Zudaire and Napal Fraile (2021) conclusion that cooperative and collaborative learning environments create conditions for students to learn from one another, fostering peer support and reinforcing understanding through discussion and shared problem-solving. These dynamics were present in the ISA model but largely absent in the control group, further explaining the observed performance differences. Overall, the statistically significant advantage of the ISA model over the traditional approach reinforces the reviewed literature's claim that active, learner-centred, and contextually relevant teaching methods are more effective for developing both conceptual understanding and practical application skills in science subjects. The results of this study therefore provide strong empirical support for adopting the ISA model in Senior High School genetics instruction as a means of improving students' learning outcomes beyond what is achievable through conventional methods.

4.7.3 Differences in Performance between Boys and Girls Taught Genetics Using the ISA Model at the Senior High School

There were no statistically significant differences between male and female students in the experimental group's pre-test ($p = .102$) or post-test ($p = .072$) scores, according to the gender-based performance analysis displayed in Tables 4.5 and 4.6. Although male students had slightly higher mean ranks in both tests (48.92 for males vs. 39.62 for females in the pre-test and 49.58 vs. 39.33 in the post-test), the differences were not large enough to be statistically meaningful. This suggests that the ISA model was equally effective across

gender lines, providing both boys and girls with similar opportunities to grasp genetic concepts and succeed academically.

The results are also consistent with studies where both male and female biology students benefited equally from inquiry-based and cooperative learning activities (Annan et al., 2019; Russo-Tait, 2023). In the current study, the ISA model's structuring phase ensured that all students, regardless of gender; actively participated in the learning process, collaborated with peers, and applied concepts in real-life scenarios. Such equitable engagement is likely to have contributed to the lack of performance disparity.

From a constructivist perspective, learning occurs most effectively when students are actively involved in constructing their own knowledge through meaningful interaction with content, peers, and teachers (Vygotsky, 1978). The ISA model's design, which incorporates immersion, structured guidance, and application, appears to have provided balanced opportunities for male and female students to engage with the material in ways that matched their abilities and interests. This supports Russo-Tait (2023) argument that well-designed, collaborative science instruction can bridge traditional participation gaps between genders.

While some earlier studies have reported gender differences in science achievement due to factors such as prior exposure, confidence, and societal expectations (Sibisi et al., 2025), the absence of such differences in the present study may be attributed to the ISA model's emphasis on cooperative group work, peer discussion, and hands-on learning tasks. Though

the effect size for the gender comparison in this study was small, further reinforcing the conclusion that the ISA model worked equally well for male and female students (Fritz et al., 2011). This has practical implications for science teaching in Ghanaian Senior High Schools, suggesting that adopting student-centred, contextually relevant instructional models like the ISA can promote gender equity in learning outcomes for complex subjects such as genetics.

In summary, the findings demonstrate that the ISA model not only improved overall academic performance but also supported equitable learning gains across genders. This supports the reviewed literature's assertion that when pedagogy is active, engaging, and inclusive, traditional gender gaps in science achievement can be minimised or eliminated (Russo-Tait, 2023).

4.7.4 The Attitude and Perception of Students After the Study of Genetics at the Senior High School Level

The quantitative findings presented in Tables 4.8 and 4.9 indicated that students generally hold positive perceptions and attitudes toward the study of genetics. The overall mean perception score was 3.79, suggesting that students agreed with key positive statements concerning the subject. The highest-rated perception item, "I believe genetics is relevant to my everyday life and future career" ($M = 4.25$), reflects a strong appreciation for the practical application of genetics in real-world contexts. This aligns with previous studies indicating that students are more engaged with scientific content when it is seen as meaningful and connected to their personal lives (Freeman et al., 2014; Osborne & Dillon, 2008). Additionally, students showed strong agreement that genetics enhances their

understanding of inheritance and diversity ($M = 4.24$), which supports the idea that science education should emphasize conceptual relevance to promote comprehension (Marsh et al., 2019). While there were some challenges; particularly in the ease of understanding complex concepts ($M = 3.49$), students generally expressed confidence in their ability to apply genetic knowledge to real-life situations ($M = 4.08$).

In terms of student attitudes, Table 4.9 revealed an even stronger overall mean score of 3.95, confirming students' enthusiasm and positive disposition toward learning genetics. The item with the highest mean; "I believe genetics should be taught using real-life examples to improve understanding" ($M = 4.48$), highlights the importance of contextual and applied instruction. Research by Annan et al. (2019) supports this view, emphasising that science learning becomes more effective when connected to everyday experiences and societal challenges. Furthermore, students reported strong motivation to engage in genetics research ($M = 4.28$) and a keen interest in learning about genetic disorders ($M = 4.23$), echoing findings by Ahiaba (2023), who observed that personal interest and perceived relevance significantly influence science learning motivation. Though some anxiety was observed ($M = 2.97$) due to the complexity of the subject, most students remained motivated and engaged when practical activities and case studies were used, reinforcing the value of inquiry-based and student-centred pedagogy in science education (Freeman et al., 2014).

According to Osborne and Dillon (2008), disposition is a significant factor in predicting students' interest, academic perseverance, and accomplishment, especially in disciplines

like genetics that call for critical thinking and long-term conceptual comprehension. The quantitative insights were triangulated with rich qualitative data from student interviews, providing deeper context for the survey results. Students described genetics as “interesting”, “useful”, and “important,” citing real-life applications such as paternity testing, agricultural improvements, and blood transfusions. Emelia and Fatima highlighted their fascination with Mendelian inheritance and chromosomal functions, while others like Latif and Abdul linked genetics to crime detection, marriage counselling, and healthcare. These insights mirror the findings of Ahiaba (2023), who argued that students' engagement increases when they can connect scientific knowledge to societal issues and personal experiences. Additionally, many students pointed to specific classroom strategies; such as modelling DNA with straws and using digital apps; that enhanced their understanding, which supports Piaget's (1952) assertion that effective learning environments include multiple representations and scaffolds to support concept development.

The integration of both qualitative and quantitative results demonstrates effective methodological triangulation, strengthening the credibility and richness of the findings (Denzin, 2012; Fusch et al., 2018). While the surveys provided general trends in students' dispositions, the interviews uncovered the underlying reasons behind those attitudes; namely the influence of engaging, real-life teaching strategies and the relevance of genetics to everyday life. The convergence of data confirms that when taught with student-centred approaches like the ISA model, genetics becomes not just an academic topic but a personally meaningful subject. Therefore, the findings underscore the need for science instruction that is relevant, practical, and actively engaging, as these characteristics

significantly contribute to positive student attitudes and long-term interest in science learning (Freeman et al., 2014).

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.0 Overview

This chapter provides a comprehensive summary of the key findings from the study, draws conclusions based on the research objectives, and offers practical recommendations for educators, curriculum planners, and policymakers. The study explored the effectiveness of the Immersion, Structuring, and Applying (ISA) model on students' academic performance, as well as their attitudes and perceptions toward the study of genetics at the Senior High School level. By integrating both quantitative and qualitative data, the chapter discusses the implications of the findings in relation to the four research questions that guided the study.

5.1 Summary of Findings

This study investigated the effectiveness of the Inquiry-Scaffold-Application (ISA) model on senior high school students' performance, perception, and attitude towards the study of genetics. A mixed-methods approach was employed, involving both quantitative and qualitative data collection and analysis. Quantitative data were obtained through pre- and post-tests, as well as structured questionnaires using Likert-scale items, while qualitative insights were gathered from focus group interviews. The study addressed four core research questions:

For Research Question One, the results from the Wilcoxon Signed Rank Test showed a statistically significant improvement in student performance within the experimental group. The mean score increased from 3.1 in the pre-test to 16.4 in the post-test, with a large effect size ($r = 0.87$), indicating that the ISA model was highly effective in enhancing students' academic performance in genetics.

Research Question Two explored differences in performance between students taught using the ISA model and those taught through traditional methods. The Mann-Whitney U Test revealed no significant difference in pre-test scores but a significant difference in post-test scores in favour of the experimental group ($p = .000$), with a large effect size ($r = -0.74$). This confirmed that the ISA model was more effective than conventional teaching methods.

Research Question Three examined gender-based performance. The Mann-Whitney U tests revealed no statistically significant differences between male and female students in both pre- and post-tests ($p = .102$ and $p = .072$, respectively), suggesting that the ISA model equally benefitted both genders and supported gender equity in science education.

For Research Question Four, both quantitative (Tables 4.8 and 4.9) and qualitative (interviews) data revealed that students had positive perceptions and attitudes toward genetics. Students found genetics interesting, relevant, and important to real life and future careers. They preferred interactive, real-life-based teaching strategies. Triangulated findings indicated that the ISA model's hands-on, contextual, and scaffolded teaching methods increased students' motivation, engagement, and conceptual understanding.

5.2 Conclusions

Based on the findings, it can be concluded that:

The ISA instructional model is highly effective in improving students' academic performance in genetics. The model's strength lies in its structured approach beginning with immersion, followed by Structuring instruction, and concluding with application through real-life problems. This approach facilitates deeper understanding and long-term retention of complex scientific concepts, which translates to students' learning outcomes.

Moreover, the ISA model proved inclusive and equitable, offering equal learning benefits to both male and female students. It also positively shaped students' attitudes and perceptions toward genetics. When learners find a subject interesting and relevant, and when it is taught through interactive and relatable methods, their engagement and academic achievement significantly improve.

These outcomes are consistent with constructivist learning theory and existing research supporting student-centred pedagogies in science education. Overall, the study affirms the ISA model as a transformative instructional approach that bridges the gap between theory and application in genetics education.

5.3 Recommendations

Based on the outcomes of this study, the following recommendations are made:

1. Educational stakeholders, especially biology teachers at the SHS level in Sekyere Central, should consider adopting the ISA model in teaching abstract topics like genetics. Its inquiry-based and applied approach promotes better understanding and learner engagement.

2. Teachers in the Sekyere central district should design genetics lessons that are grounded in real-life contexts, using models, experiments, and digital tools to simplify complex concepts and stimulate interest.
3. Given the equitable results across genders, teachers in the Sekyere central district should continue to use inclusive and participatory strategies that create safe and supportive learning environments for both male and female students.

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APPENDICES

APPENDIX A

PRE-TEST ON GENETICS

CODE:

AGE:

DURATION: 40 Minutes

GENDER:

INSTRUCTIONS:

- **Read the scenario carefully and answer all questions.**
- **Use diagrams where necessary to support your explanations.**
- **Answer the questions at the back of the question paper.**

QUESTIONS

In a small town, a family has noticed an interesting pattern in their inherited traits. The father has brown eyes, while the mother has blue eyes, and their two children have different eye colours; one has brown eyes, and the other has blue. Meanwhile, their neighbours, who are identical twins, share exactly the same physical traits. Curious about genetics, the family visits a genetic counsellor, who explains how **heredity, DNA structure, and replication** influence these traits.

1. Explain the concept of heredity and how it determines inherited traits like eye colour. **[4 marks]**
2. Using Mendel's First Law (Law of Segregation), illustrate how eye colour is inherited when a heterozygous brown-eyed father (Bb) and a homozygous blue-eyed mother (bb) have children. Use a simple crossing to support your answer. **[4 marks]**

3. Describe the **double-helix structure of DNA**. [4 marks]
4. The genetic counsellor explains to the family that **genotype** and **phenotype** play a role in determining their children's traits. Differentiate between these two terms with an example each. [4 marks]
5. Before a cell divides, its DNA must be copied. In a single paragraph, briefly explain the steps involved in DNA replication. [4 marks]

APPENDIX B

POST-TEST ON GENETICS

CODE:

AGE:

DURATION: 40 Minutes

GENDER:

INSTRUCTIONS:

- **Read the scenario carefully and answer all questions.**
- **Use diagrams where necessary to support your explanations.**
- **Answer the questions at the back of the question paper.**

QUESTIONS

In a small town, two families are curious about how **genetic traits** are passed from one generation to another. In the first family, the father has dimples while the mother does not, yet only one of their two children has dimples. Meanwhile, their neighbours are studying how **genetic disorders** run in their family after learning that a cousin was diagnosed with **sickle cell disease**. At school, students are also learning about **DNA structure and replication**, conducting experiments to understand how DNA stores and transfers genetic information.

1. Explain the concept of heredity and how they influence the inheritance of dimples in the first family. **[4 marks]**
2. If the father is heterozygous for dimples (Dd) and the mother does not have dimples (dd), use a simple crossing to predict the possible genotypes and phenotypes of their children. **[4 marks]**

3. Describe the **structure of DNA**, citing the significance of the nitrogenous **base pairing (A-T, G-C)**. [4 marks]
4. DNA replication ensures that genetic information is accurately passed to new cells. Describe the **major steps of DNA replication**, highlighting the role of **helicase, DNA polymerase, and ligase**. [4 marks]
5. The neighbor's family is investigating the inheritance of sickle cell disease. Explain the difference between **genotype and phenotype**, using **sickle cell disease (SS, Ss, and ss)** as an example. [4 marks]

APPENDIX C

RESEARCH QUESTIONNAIRE

This questionnaire is intended to solicit for your perception and attitude towards the study of genetics at the senior high school in the Sekyere central District of the Ashanti Region of Ghana. All information provided will be treated as strictly confidential and for academic purpose only and has no prejudices for future endeavours.

(Scale: Strongly Agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly Disagree =1)

Please tick [] where necessary.

Section A: Socio-Demographic Characteristics and Living Conditions

1. Age

I. 15-18 []

II. 19-22 []

III. 23-26 []

IV. 27 Above []

2. What is your gender?

I. Male []

II. Female []

Section B: Perception of Students toward the Study of Genetics

ITEMS	RESPONSES				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I find genetics to be an interesting and engaging subject.					
2. I believe genetics is relevant to my everyday life and future career.					
3. The concepts in genetics are easy to understand when taught effectively.					
4. I feel confident in my ability to apply genetic principles to solve real-world problems.					
5. Learning genetics is more difficult compared to other biology topics.					

<p>6. I believe genetics helps me understand the biological basis of inheritance and diversity.</p>					
<p>7. Studying genetics increases my curiosity about scientific discoveries and medical advancements.</p>					
<p>8. I feel that genetics is a subject that requires too much memorization rather than understanding.</p>					
<p>9. I think genetics should be integrated more with other subjects like chemistry and mathematics.</p>					
<p>10. The knowledge of genetics helps me make informed</p>					

decisions about my health.					
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Section C: Attitudes of Students toward the Study of Genetics

ITEMS	RESPONSES-Frequency (Percentage %)				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
11. I enjoy participating in genetics-related class activities, such as experiments and discussions.					
12. I feel motivated to study genetics even when I face challenges in understanding the concepts.					
13. I prefer interactive and hands-on learning approaches when studying genetics.					

<p>14. I am likely to pursue further studies or a career that involves genetics.</p>					
<p>15. I believe genetics should be taught using real-life examples to improve understanding.</p>					
<p>16. I feel anxious when learning genetics because of the complexity of the concepts.</p>					
<p>17. I am more engaged in genetics lessons when practical activities or case studies are used.</p>					
<p>18. I believe everyone should have a basic understanding of genetics to make informed life choices.</p>					

<p>19. I enjoy learning about genetic disorders and how they affect individuals and families.</p>					
<p>20. If given the opportunity, I would like to participate in a genetics-related research projects.</p>					

APPENDIX D

SEMI-STRUCTURED INTERVIEW GUIDE ON PERCEPTION AND ATTITUDES ON THE STUDY OF GENETICS

1. How do you feel about studying genetics compared to other topics in biology, and what aspects do you find most interesting or challenging?
2. Describe any experiences (positive or negative) that have influenced your interest or motivation in learning genetics?
3. In what ways do you think the teaching methods used in genetics affect your understanding and engagement with the subject?
4. How do you relate genetics concepts to real-life situations?
5. Do you think learning genetics is useful for your future career or daily life?
6. What changes or improvements would you suggest to make genetics lessons more engaging and easier to understand?

THEMES

Theme 1. Perceptions and Attitudes toward Genetics

1. "How do you feel about studying genetics compared to other topics in biology, and what aspects do you find most interesting or challenging?"

Theme 2. Motivational and Personal Learning Experiences

2. "Describe any experiences (positive or negative) that have influenced your interest or motivation in learning genetics?"

Theme 3. Impact of Teaching Methods on Learning

3. "In what ways do you think the teaching methods used in genetics affect your understanding and engagement with the subject?"
6. "What changes or improvements would you suggest to make genetics lessons more engaging and easier to understand?"

Theme 4. Real-Life Application and Relevance of Genetics

4. "How do you relate genetics concepts to real-life situations?"
5. "Do you think learning genetics is useful for your future career or daily life?"

APPENDIX E

ETHICAL CLEARANCE



Kwame Nkrumah
University of Science
and Technology, Kumasi

College of Health Sciences
SCHOOL OF MEDICINE AND DENTISTRY

COMMITTEE ON HUMAN RESEARCH, PUBLICATION AND ETHICS

Our Ref: CHRPE/AP/929/25

5th September 2025

Mr. Isaac Kwame Boafo
Department of Integrated Science Education
Faculty of Science Education
AMMUSTED-MAMPONG

Dear Sir,

LETTER OF APPROVAL

Protocol Title: *“Effect of the ISA Model on Students' Performance and Disposition in Genetics at the Senior High School.”*

Proposed Sites: *Sekyere Central District-Ashanti Region.*

Sponsor: *Self-Sponsored.*

Students: Mr. Isaac Kwame Boafo.

Supervisor: Dr. Charles Amoah Agyei.

Your submission to the Committee on Human Research, Publications, and Ethics on the above-named protocol refer.

- A notification letter of 12th November, 2024 from the Ghana Education Service, Nsuta-Ashanti (study site) indicating approval for the conduct of the study in the district.
- Completed CHRPE Application Form.
- Participant Information Leaflet and Consent Form.
- Research Protocol.
- Questionnaire and Interview Schedule.

The Committee has considered the ethical merit of your submission and approved the protocol. The approval is for one year, renewable after that, from **5th September 2025 to 4th September 2026**. The Committee may, however, suspend or withdraw ethical approval at any time if your study is found to contravene the approved protocol.

Data gathered for the study should be used for the approved purposes only. Permission should be sought from the Committee if any amendment to the protocol or use, other than that submitted, is made of your research data.

The Committee should be notified of the actual start date of the project and would expect a report on your study, annually or at the close of the project, whichever one comes first. It should also be informed of any publication arising from the study.

Thank you for your application.

Yours faithfully,

Rev. Prof. John Appiah-Poku.

Honorary Secretary
FOR: CHAIRMAN

APPENDIX F

OVERALL SPSS OUTPUTS OF RESULTS

Reliability test results (Kappa's inter-rater)-GCT-Pre-test

Symmetric Measures

		Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Measure of Agreement	Kappa	.672	.090	9.716	.000
N of Valid Cases		32			

- a. Not assuming the null hypothesis.
 b. Using the asymptotic standard error assuming the null hypothesis.

Reliability test results (Kappa's inter-rater)-GCT-Post-test

Symmetric Measures

		Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Measure of Agreement	Kappa	.822	.072	12.899	.000
N of Valid Cases		32			

- a. Not assuming the null hypothesis.
 b. Using the asymptotic standard error assuming the null hypothesis.

Reliability test results (Cronbach's Alpha)-Perception

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.692	.704	10

Reliability test results (Cronbach's Alpha)-Attitudes

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.719	.756	10

Normality Test Results

Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest of Experimental group	.214	84	.000	.916	84	.000
Posttest of Experimental Group	.118	84	.006	.964	84	.019
Pretest of Control Group	.139	84	.000	.944	84	.001
Posttest of Control Group	.107	84	.018	.966	84	.024

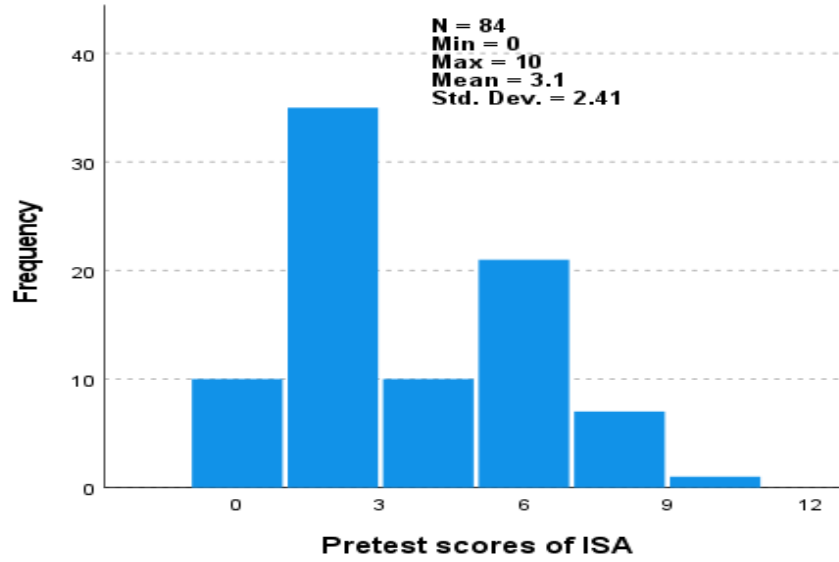
a. Lilliefors Significance Correction

Research Question 1-Pre-test/Post-test

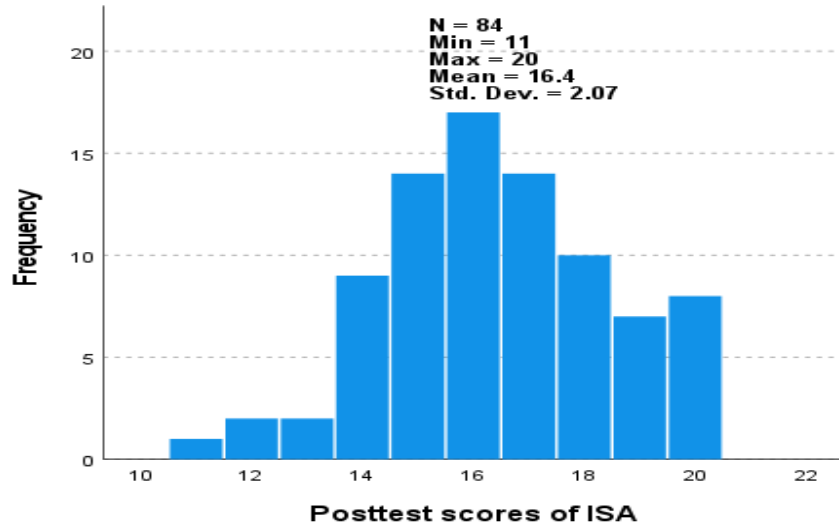
Related-Samples Wilcoxon Signed Rank Test Summary

Total N	84
Test Statistic	3570.000
Standard Error	223.612
Standardized Test Statistic	7.983
Asymptotic Sig.(2-sided test)	.000

Continuous Field Information Pretest scores of ISA



Continuous Field Information Posttest scores of ISA

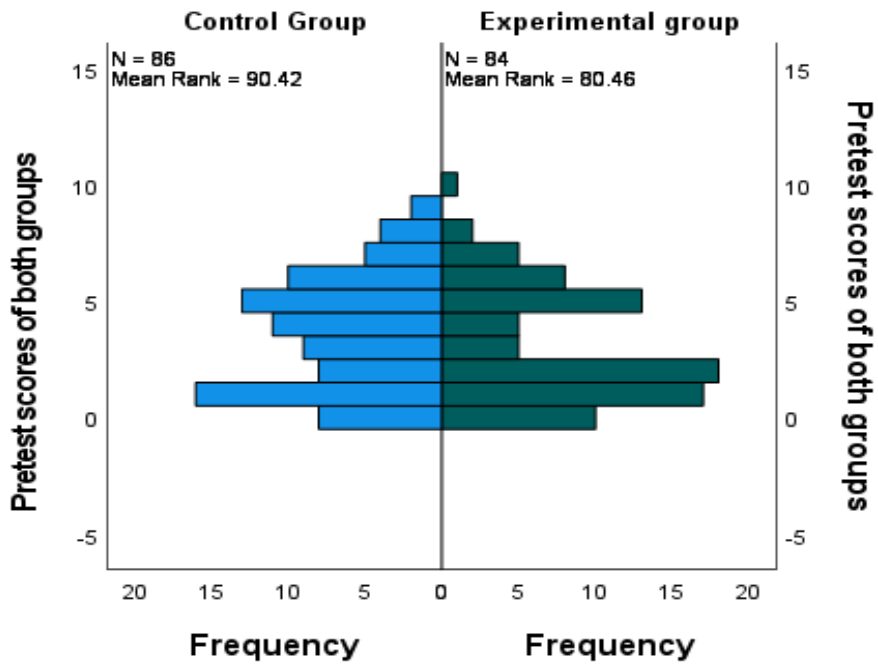


Research Question 2-Pre-test (ISA vs Traditional)

Independent-Samples Mann-Whitney U Test Summary

Total N	170
Mann-Whitney U	4035.000
Wilcoxon W	7776.000
Test Statistic	4035.000
Standard Error	317.872
Standardized Test Statistic	1.331
Asymptotic Sig.(2-sided test)	.183

**Independent-Samples Mann-Whitney U Test
Experimental and Control Groups**

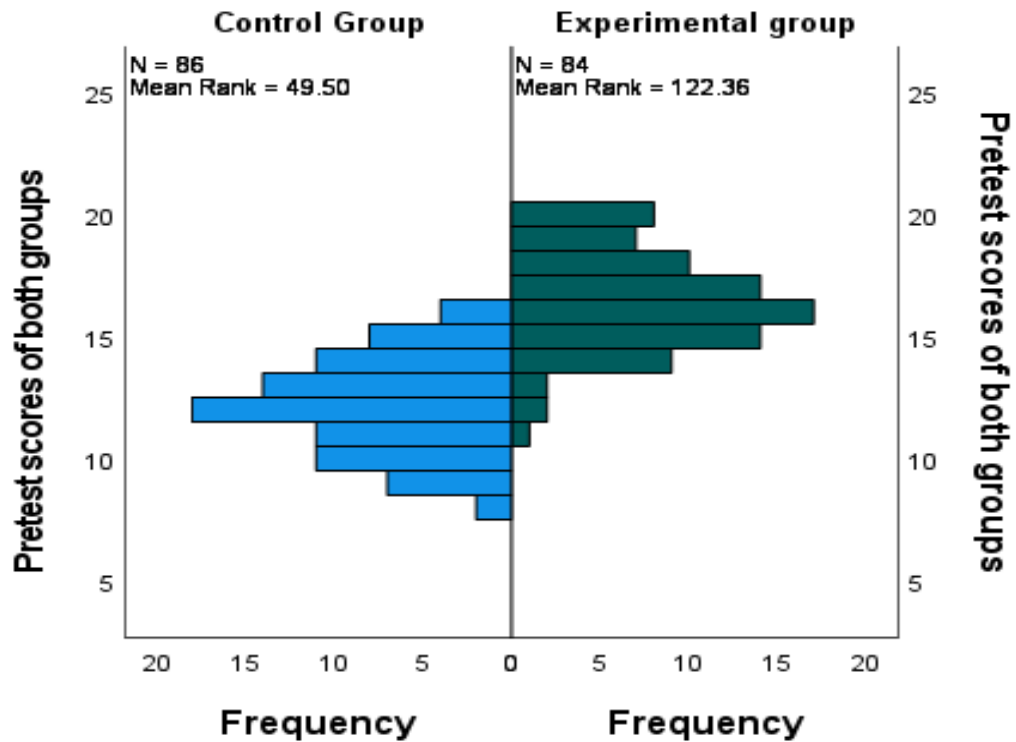


Research Question 2-Post-test (ISA vs Traditional)

Independent-Samples Mann-Whitney U Test Summary

Total N	170
Mann-Whitney U	516.000
Wilcoxon W	4257.000
Test Statistic	516.000
Standard Error	319.280
Standardized Test Statistic	-9.697
Asymptotic Sig.(2-sided test)	.000

**Independent-Samples Mann-Whitney U Test
Experimental and Control Groups**

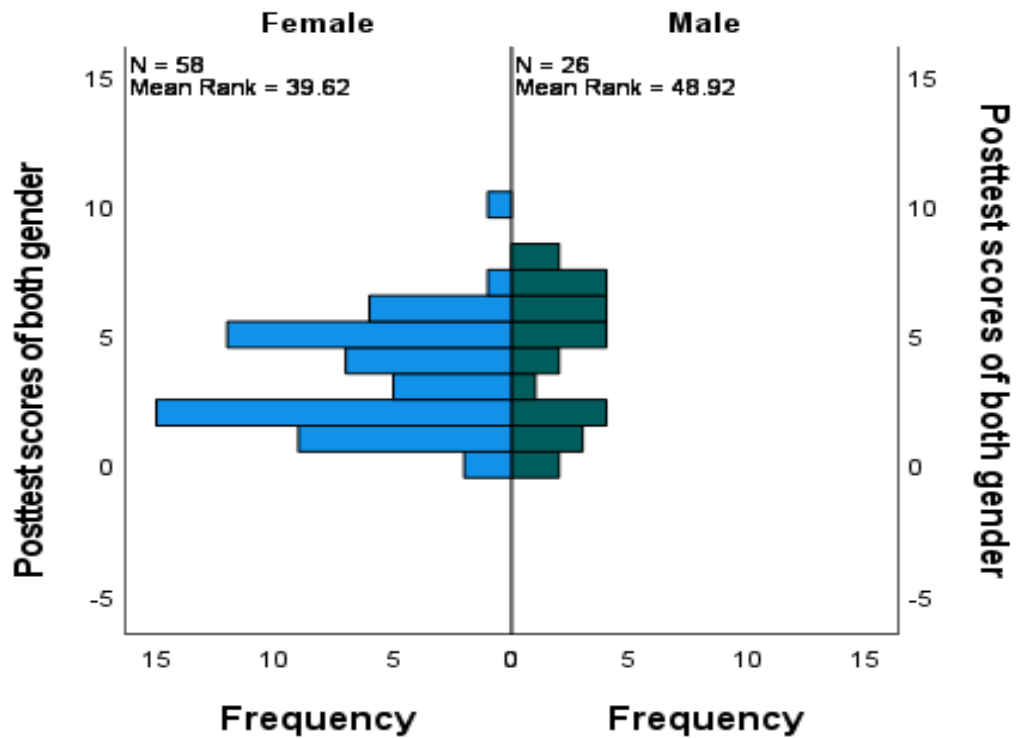


Research Question 3-Pre-test (Gender)

Independent-Samples Mann-Whitney U Test Summary

Total N	84
Mann-Whitney U	587.000
Wilcoxon W	2298.000
Test Statistic	587.000
Standard Error	102.059
Standardized Test Statistic	-1.636
Asymptotic Sig.(2-sided test)	.102

**Independent-Samples Mann-Whitney U Test
Male and Female**

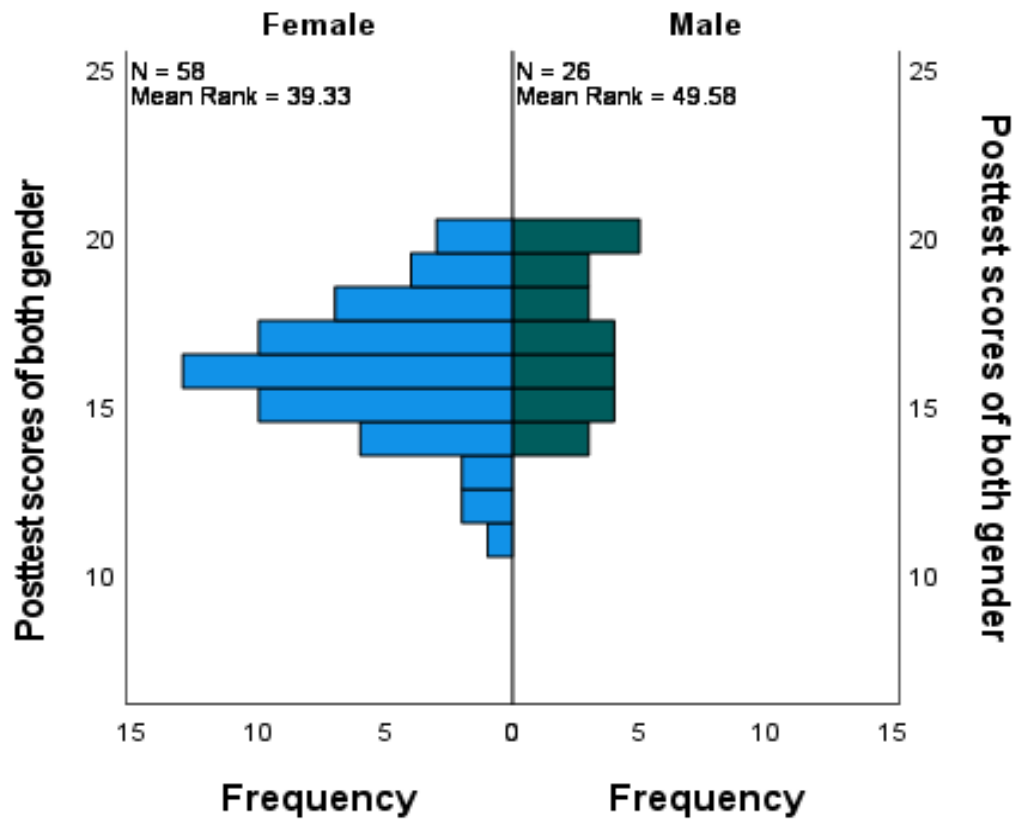


Research Question 3-Post-test (Gender)

Independent-Samples Mann-Whitney U Test Summary

Total N	84
Mann-Whitney U	570.000
Wilcoxon W	2281.000
Test Statistic	570.000
Standard Error	102.220
Standardized Test Statistic	-1.800
Asymptotic Sig.(2-sided test)	.072

**Independent-Samples Mann-Whitney U Test
Male and Female**



Research Question 4-Perception

Item Statistics

	Mean	Std. Deviation	N
1. I find genetics to be an interesting and engaging subject.	3.81	1.045	170
2. I believe genetics is relevant to my everyday life and future career.	4.25	.695	170
3. The concepts in genetics are easy to understand when taught effectively.	3.49	1.302	170
4. I feel confident in my ability to apply genetic principles to solve real-world problems.	4.08	1.077	170
5. Learning genetics is more difficult compared to other biology topics.	3.16	1.286	170
6. I believe genetics helps me understand the biological basis of inheritance and diversity.	4.24	.789	170
7. Studying genetics increases my curiosity about scientific discoveries and medical advancements.	3.94	.812	170
8. I feel that genetics is a subject that requires too much memorization rather than understanding.	3.30	.996	170
9. I think genetics should be integrated more with other subjects like chemistry and mathematics.	3.45	1.443	170
10. The knowledge of genetics helps me make informed decisions about my health.	4.20	.894	170

Research Question 4-Attitudes

Item Statistics

	Mean	Std. Deviation	N
11. I enjoy participating in genetics-related class activities, such as experiments and discussions.	4.06	1.025	170
12. I feel motivated to study genetics even when I face challenges in understanding the concepts.	3.76	1.047	170
13. I prefer interactive and hands-on learning approaches when studying genetics.	3.96	1.218	170
14. I am likely to pursue further studies or a career that involves genetics.	3.56	1.341	170
15. I believe genetics should be taught using real-life examples to improve understanding.	4.48	.655	170
16. I feel anxious when learning genetics because of the complexity of the concepts.	2.97	1.271	170
17. I am more engaged in genetics lessons when practical activities or case studies are used.	3.94	1.248	170
18. I believe everyone should have a basic understanding of genetics to make informed life choices.	4.23	.814	170
19. I enjoy learning about genetic disorders and how they affect individuals and families.	4.23	.917	170
20. If given the opportunity, I would like to participate in a genetics-related research projects.	4.28	.955	170

APPENDIX G

INTERVENTIONS

EXPERIMENTAL GROUP LESSON PLAN

Four-Weeks Lesson Plan on Heredity, Nucleic Acids, DNA structure, and

Replication

Duration: Four Weeks

One period = 60 minutes

Four periods per week

Lesson Plan for the ISA Instructional Model

The ISA **model** follows a structured instructional approach:

1. **Immersion**
2. **Structuring**
3. **Applying**

Week	Topic	Lesson Title	Objectives	Teaching/Learning Materials	Teacher Activities	Student Activities / Evaluation
Week 1	Heredity (60 min)	Lesson 1: Introduction to Heredity and Key Terms	Define the term heredity. Explain the its importance; Identify key terms (gene, allele, genotype,	Charts illustrating genetic traits. Videos on basic genetic principles. Flashcards for key terms.	Immersion: Real-life family traits; Structuring: Explain heredity and terms; Applying: Group	Immersion: Listen and brainstorm examples of family traits. Structuring: Take notes, ask questions, and discuss terms.

			phenotype, dominant, recessive)		activity matching terms	Applying: Work in groups to classify examples and present findings. Evaluation: Define 5 key genetic terms with examples.
Week 1	Heredity (60 min)	Lesson 2: Mendel's First Law (Segregation)	Explain Mendel's pea plant experiments; Describe Law of Segregation; Solve	Diagrams of pea plant traits, Punnett square charts	Immersion: Ask: "Why do some traits skip generations?" Structuring: Explain Mendel's	Immersion: Share ideas about trait variation. Structuring: Follow explanation

			monohybrid cross		pea experiments and Law of Segregation. Applying: Demonstrate monohybrid cross using Punnett squares.	and ask clarifying questions. Applying: Solve monohybrid cross problems in pairs. Evaluation: Solve and explain one monohybrid cross.
Week 1	Heredity (60 min)	Lesson 3: Mendel's Second Law (Independent Assortment)	Explain Law of Independent Assortment; Perform dihybrid crosses	Diagrams of traits, Punnett squares	Immersion: Ask students to predict inheritance of two traits at once.	Immersion: Brainstorm two-trait inheritance examples.

					<p>Structuring: Explain Law of Independent Assortment.</p> <p>Applying: Demonstrate dihybrid cross and ratio derivation.</p>	<p>Structuring: Take notes on independent segregation.</p> <p>Applying: Solve dihybrid cross problems in groups.</p> <p>Evaluation: Present solutions to dihybrid cross problems.</p>
Week 1	Heredity (60 min)	Lesson 4: Applications of Heredity	Relate heredity to real-life traits in	Charts, case studies	Immersion: Present a case study (e.g.,	Immersion: Discuss case study in groups.

			humans, plants, animals		sickle-cell inheritance). Structuring: Explain significance of heredity in everyday life. Applying: Guide discussion linking heredity to real examples.	Structuring: Ask questions and compare real cases. Applying: Present examples of heredity from real life. Evaluation: Present one real-life example of heredity.
Week 2	Nucleic Acids (60 min)	Lesson 1: Introduction to Nucleic Acids	Define nucleic acids; Explain role in	DNA/RNA diagrams, models	Immersion: Show DNA and RNA models; ask	Immersion: Observe models and suggest functions.

			heredity; Differentiate DNA and RNA		students what they represent. Structuring: Introduce DNA and RNA roles. Applying: Lead comparison activity (DNA vs RNA).	Structuring: Take notes on differences. Applying: Group activity comparing DNA and RNA. Evaluation: List 3 DNA–RNA differences.
Week 2	Nucleic Acids (60 min)	Lesson 2: Components of Nucleic Acids	Identify nucleotide components (sugar, phosphate,	Nucleotide diagrams, flashcards	Immersion: Show a nucleotide image and ask students to identify parts.	Immersion: Suggest functions of each component.

			base); Explain nucleotide structure		<p>Structuring: Explain sugar, phosphate, and base.</p> <p>Applying: Demonstrate assembly of nucleotide.</p>	<p>Structuring: Take notes, ask questions.</p> <p>Applying: Draw and label nucleotide.</p> <p>Evaluation: Draw and label nucleotide correctly.</p>
Week 2	Nucleic Acids (60 min)	Lesson 3: Base Pairing and Chargaff's Rule	Explain base pairing rules; Describe Chargaff's rule	Base pairing cards, nucleotide models	<p>Immersion: Ask: "Why don't A pair with C?"</p> <p>Structuring: Explain base-</p>	<p>Immersion: Predict base-pairing rules.</p> <p>Structuring: Take notes and ask questions.</p>

					<p>pairing rules and Chargaff's findings.</p> <p>Applying: Show how to construct complementary strand.</p>	<p>Applying: Write complementary strands from given DNA sequence.</p> <p>Evaluation: Produce complementary strand for a sequence.</p>
Week 2	Nucleic Acids (60 min)	Lesson 4: Applications of Nucleic Acids	Explain role in protein synthesis; Relate nucleic	Charts linking DNA to proteins	Immersion: Show diagram of DNA → RNA → Protein.	Immersion: Observe and interpret chart.

			acids to heredity		<p>Structuring: Explain transcription and translation.</p> <p>Applying: Guide discussion of how nucleic acids link to heredity.</p>	<p>Structuring: Take notes and ask clarifying questions.</p> <p>Applying: Explain in groups how DNA affects traits.</p> <p>Evaluation: Explain role of nucleic acids in heredity.</p>
Week 3	DNA Structure (60 min)	Lesson 1: Discovery of DNA	Describe contributions of Watson, Crick,	Photos, diagrams, models	Immersion: Show Rosalind Franklin's X-ray photo.	Immersion: Observe photo and predict what it shows.

			Franklin, and Wilkins		<p>Structuring: Explain contributions of each scientist.</p> <p>Applying: Guide discussion on scientific teamwork.</p>	<p>Structuring: Take notes on contributions.</p> <p>Applying: Discuss the importance of the collaboration of the scientists.</p> <p>Evaluation: Write contributions of 2 scientists.</p>
Week 3	DNA Structure (60 min)	Lesson 2: Double Helix Model	Describe DNA double helix;	3D DNA models, diagrams	Immersion: Show twisted ladder model.	Immersion: Observe model and suggest structure.

			Label major features		<p>Structuring: Explain backbone, bases, helix.</p> <p>Applying: Guide model labeling.</p>	<p>Structuring: Note features.</p> <p>Applying: Label model/diagram.</p> <p>Evaluation: Label DNA diagram correctly.</p>
Week 3	DNA Structure (60 min)	Lesson 3: Functions of DNA Structure	Link DNA structure to replication and protein synthesis	Charts showing replication and protein synthesis	Immersion: Ask: “Why does DNA need to replicate?”	<p>Immersion: Suggest answers to DNA’s purpose.</p> <p>Structuring: Note key points.</p>

					<p>Structuring:</p> <p>Explain significance of structure.</p> <p>Applying: Guide students to link structure with function.</p>	<p>Applying: Discuss how structure supports replication.</p> <p>Evaluation: Short essay on DNA function.</p>
Week 3	DNA Structure (60 min)	Lesson 4: Model Activity and Quiz	Demonstrate DNA structure using models; Review concepts	DNA model kits, quiz paper	<p>Immersion:</p> <p>Hand out model kits.</p> <p>Structuring:</p> <p>Demonstrate</p>	<p>Immersion: Handle models and explore structure.</p> <p>Structuring:</p> <p>Assemble models in groups.</p>

					assembly of DNA helix. Applying: Assign short quiz.	Applying: Take quiz on DNA structure.
Week 4	DNA Replication (60 min)	Lesson 1: Introduction to Replication	Explain semi-conservative replication; Introduce replication process	Charts, videos	Immersion: Show animation of replication. Structuring: Explain semi-conservative model. Applying: Discuss	Immersion: Watch video and predict outcome. Structuring: Take notes on steps. Applying: Share why replication matters.

					importance of accurate copying.	Evaluation: Define semi-conservative replication.
Week 4	DNA Replication (60 min)	Lesson 2: Steps of DNA Replication	Describe replication steps (initiation, elongation, termination)	Step-by-step diagrams, animations	Immersion: Show sequence cards out of order. Structuring: Explain steps in correct order. Applying: Have groups arrange steps.	Immersion: Try to arrange cards. Structuring: Take notes and ask questions. Applying: Sequence steps correctly.

						Evaluation: Arrange replication steps in order.
Week 4	DNA Replication (60 min)	Lesson 3: Enzymes in Replication	Identify enzymes (helicase, ligase, polymerase, primase)	Enzyme role cards, diagrams	Immersion: Ask: “What helps DNA unzip and copy itself?” Structuring: Explain roles of enzymes. Applying: Card-matching activity.	Immersion: Guess which molecules might help. Structuring: Take notes on enzymes. Applying: Match enzymes with functions.

						Evaluation: Describe role of one enzyme.
Week 4	DNA Replication (60 min)	Lesson 4: Accuracy and Mutations	Explain importance of replication accuracy; Describe mutations	Mutation diagrams, case studies	Immersion: Show example of genetic mutation. Structuring: Explain replication errors and consequences. Applying: Assign group	Immersion: Discuss impact of errors. Structuring: Take notes on mutations. Applying: Present case study findings. Evaluation: Present example of mutation effect.

					analysis of case study.	
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APPENDIX H

CONTROL GROUP INTERVENTION

Four-Weeks Lesson Plan on Heredity, Nucleic Acids, DNA structure, and Replication

Duration: Four Weeks

One period = 60 minutes

Four periods per week

Lesson Plan for the Control group

Week	Topic	Lesson Title	Objectives	Teaching/Learning Materials	Teacher Activities	Student Activities / Evaluation
Week 1	Heredity (60 min)	Lesson 1: Introduction to Heredity and Key Terms	Define the term heredity. Explain the its importance; Identify key	Marker board, textbook, charts.	Deliver lecture on heredity and key terms; Write definitions on the board;	Listen attentively; Copy notes; Repeat definitions after teacher.

			terms (gene, allele, genotype, phenotype, dominant, recessive)		Explain with simple examples.	Evaluation: Oral questioning of terms.
Week 1	Heredity (60 min)	Lesson 2: Mendel's First Law (Segregation)	Explain Mendel's pea plant experiments; Describe Law of Segregation; Solve monohybrid cross	Diagrams, Marker board.	Narrate Mendel's experiments; Demonstrate Punnett square on board.	Observe; Copy Punnett square; Answer teacher's questions. Evaluation: Respond orally to monohybrid cross question.

Week 1	Heredity (60 min)	Lesson 3: Mendel's Second Law (Independent Assortment)	Explain Law of Independent Assortment; Perform dihybrid crosses	Charts, Marker board.	Lecture on independent assortment; Demonstrate dihybrid cross step by step.	Copy worked examples; Repeat ratios after teacher. Evaluation: Teacher asks class to state expected dihybrid ratios.
Week 1	Heredity (60 min)	Lesson 4: Applications of Heredity	Relate heredity to real-life traits in humans, plants, animals	Textbook examples.	Read and explain textbook cases (e.g., blood group inheritance).	Take notes; Recite examples when called upon. Evaluation: Oral recitation of at

						least one heredity example.
Week 2	Nucleic Acids (60 min)	Lesson 1: Introduction to Nucleic Acids	Define nucleic acids; Explain role in heredity; Differentiate DNA and RNA	Diagrams in textbook, Marker board.	Explain differences between DNA and RNA; Dictate notes.	Listen, copy notes; Repeat definitions after teacher. Evaluation: Oral questions on the differences.
Week 2	Nucleic Acids (60 min)	Lesson 2: Components of Nucleic Acids	Identify nucleotide components (sugar, phosphate, base); Explain	Diagrams	Lecture on sugar, phosphate, and bases; Draw nucleotide on the Marker board.	Copy drawing; Label diagram from memory. Evaluation: Teacher asks students to draw

			nucleotide structure			and label in their exercise books.
Week 2	Nucleic Acids (60 min)	Lesson 3: Base Pairing and Chargaff's Rule	Explain base pairing rules; Describe Chargaff's rule	Marker Board	Explain base-pairing rules; Write examples on board.	Repeat pairing rules; Copy notes. Evaluation: Teacher gives sequence and asks students to state complementary bases.
Week 2	Nucleic Acids (60 min)	Lesson 4: Applications of Nucleic Acids	Explain role in protein synthesis; Relate nucleic	Diagrams, textbook.	Explain transcription and translation with chalkboard sketch.	Copy notes; Repeat key processes. Evaluation: Oral recitation on

			acids to heredity			DNA → protein process.
Week 3	DNA Structure (60 min)	Lesson 1: Discovery of DNA	Describe contributions of Watson, Crick, Franklin, and Wilkins	Notes, textbook.	Lecture on contributions of Watson, Crick, Franklin, Wilkins.	Copy notes; Repeat names and roles. Evaluation: Teacher questions students orally.
Week 3	DNA Structure (60 min)	Lesson 2: Double Helix Model	Describe DNA double helix; Label major features	Diagrams.	Explain features of double helix; Draw diagram on board.	Copy drawing; Repeat structure after teacher. Evaluation: Students label DNA diagram.

Week 3	DNA Structure (60 min)	Lesson 3: Functions of DNA Structure	Link DNA structure to replication and protein synthesis	Textbook diagrams.	Lecture on DNA functions.	Copy notes; Answer direct questions. Evaluation: Short oral Questions & Answers on DNA roles.
Week 3	DNA Structure (60 min)	Lesson 4: Model Activity and Quiz	Demonstrate DNA structure using models; Review concepts	Marker board, quiz questions.	Conduct question-and- answer drill.	Answer orally; Copy summary notes. Evaluation: Teacher checks students' answers.

Week 4	DNA Replication (60 min)	Lesson 1: Introduction to Replication	Explain semi- conservative replication; Introduce replication process	Diagrams, textbook.	Lecture on semi- conservative replication; Draw process.	Copy notes; Repeat definition. Evaluation: Teacher asks students to define replication.
Week 4	DNA Replication (60 min)	Lesson 2: Steps of DNA Replication	Describe replication steps (initiation, elongation, termination)	Diagrams.	List and explain steps on board.	Copy notes; Recite steps after teacher. Evaluation: Oral repetition of steps.
Week 4	DNA Replication (60 min)	Lesson 3: Enzymes in Replication	Identify enzymes (helicase, ligase,	Notes, textbook.	Lecture on helicase, ligase, polymerase, primase.	Take notes; Repeat enzyme roles.

			polymerase, primase)			Evaluation: Teacher asks the functions of the enzymes orally.
Week 4	DNA Replication (60 min)	Lesson 4: Accuracy and Mutations	Explain importance of replication accuracy; Describe mutations	Textbook examples.	Explain replication errors and examples of mutations.	Listen and copy notes. Evaluation: Oral question on mutation example.