AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

ENHANCING CONCEPTUAL UNDERSTANDING OF GENETICS THROUGH JIGSAW AND THINK-PAIR-SHARE METHODS: A QUASI-EXPERIMENTAL STUDY IN SENIOR HIGH SCHOOLS

AMOS MAMBO BULLU

2025

AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

ENHANCING CONCEPTUAL UNDERSTANDING OF GENETICS THROUGH JIGSAW AND THINK-PAIR-SHARE METHODS: A QUASI-EXPERIMENTAL STUDY IN SENIOR HIGH SCHOOLS

BY

AMOS MAMBO BULLU

(8221920008)

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

OCTOBER, 2025

DECLARATION

Candidate's Declaration

I hereby declare that this thesis, except where specific references are made to the work of others, is the result of my own original research. To the best of my knowledge, no part of this thesis has been submitted in support of an application for another degree or qualification at this university or any other institution.

Amos Mambo Bullu

Signature ………………………………….   Date: ………………………………

Supervisors' Declaration

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

Dr. Charles Amoah Agyei (Principal Supervisor).

Signature ………………………………….   Date: ………………………………

Dr. Eric Appiah-Twumasi (Co-Supervisor).

Signature: ………………………………….   Date: ……………………………….

ACKNOWLEDGEMENTS

The successful completion of this thesis, Enhancing Conceptual Understanding of Genetics through Jigsaw and Think-Pair-Share Method: A Quasi-Experimental Study in the Sekyere South Municipal of Ashanti, has been made possible through the tireless support of many individuals, to whom I am deeply indebted. I am especially grateful to my supervisor, Dr. Charles Amoah Agyei of the Department of Science Education and my co-supervisor, Dr. Eric Twumasi-Appiah, for their invaluable guidance, constructive feedback and encouragement throughout this research. My sincere appreciation also goes to Prof. Kofi Sarpong, whose advice and motivation were instrumental in shaping this work.

DEDICATION

I dedicate this work, first and foremost, to Jehovah, whose boundless grace, wisdom and guidance have carried me through this academic journey. I also lovingly dedicate it to my wife, Agnes Bullu, whose patience, love and encouragement have been my constant anchor and to my children, Enoch Mambo Bullu and Keziah Mambo Bullu, whose prayers and inspiration strengthened me throughout this pursuit. Finally, I extend this dedication to my extended family and all who, through their sacrifices and support, contributed to the realization of this dream.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

CPA	**-**	Conventional Pedagogical Approach
CLS	-	Cooperative Learning Strategy
SHS	**-**	Senior High School
STEM	-	Science, Technology, Engineering, and Mathematics
TPS	**-**	Think-pair-share
JS	**-**	Jigsaw

ABSTRACT

The study investigates enhancing conceptual understanding of genetics through jigsaw and think-pair-share methods: a quasi-experimental study in Agona SDA SHS, Adu Gyamfi SHS and Agona SHTS within the Sekyere South Municipal, Ashanti Region. Using a quasi-experimental design, specifically control group pre-test post-test model, the study involved 95 students— 50 males and 45 females and two schools were randomly chosen out of four schools in the Municipal. To assess students' performance, the Genetic Achievement Test (GAT), created and approved by experts in biology teaching, was used. Using jigsaw (JS) and think-pair-share (TPS), the experimental group learned genetics—which includes variation, inheritance, genetic crosses, and blood groupings—over the course of four weeks, whereas the control group was instructed using the traditional pedagogical technique (CPA).Mann Whitney U test was used for the analysis and semi structured questions were used to determined students' perception about the use of JS and TPS. Comparing the experimental group to the control group, the results showed a considerable improvement in their grasp of genetics. This implies that jigsaw (JS) and think-pair-share (TPS) improve conceptual learning and comprehension of intricate biological concept like genetics. Gender performance differences were further reduced by the fact that think pair share (TPS) and jigsaw (JS) shown similar accomplishments between male and female students. Based on the findings, students who engaged in think-pair-share (TPS) and jigsaw (JS) exercises showed improved attitudes about genetic concepts and increased confidence in their comprehension of them. These findings suggest that TPS and JS can improve biology instruction, especially in genetics classes, enhance student performance, and foster critical thinking.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter consists of the background of the study, the statement of the problem, the main objective, the specific objectives, the research questions, the significance, the justification, the delimitations and the limitations.

1.1 Background to the Study

The social life of civilizations and the economic development of nations are significantly impacted by scientific advancements in general, particularly in Biology. It is easy to observe how biology impacts various industries, including medicine, agriculture, economics, and the defense sector (Tatar, 2006). Genetics is the one that has the most significant impact. Understanding key concepts like sustainable development, scientific literacy, biological literacy and environmental literacy requires a strong background in biology or genetics (Nowgen, 2012). A biology education enables people to develop the abilities to gather information, establish cause-and-effect relationships, make observations and conduct research before concluding, which not only helps people make decisions about social and ethical issues in their daily lives by thinking more healthily (Dervişoğlu, Yaman & Soran, 2004). Genetics has now become an integral part of our everyday lives, impacting areas such as healthcare, agriculture and technology. However, it has also given rise to a multitude of ethical concerns. Consequently, students must not view genetic information as an enigmatic entity but grasp the fundamental principles of genetics in order to make well- informed decisions in their personal lives (Nowgen, 2012).

In the SHS biology syllabus, genetics is studied in year three under section '2' Genetics and Evolution (pgs. 65-70). The examination of genetics can provide students with a relatively straightforward and enhanced comprehension of more sophisticated principles in healthcare, agriculture and technology provided that they possess a sound understanding and awareness of the ramifications of genetic disorders (MOE, 2010). According to a report from the chief examiners of the West African Examination Council students' performance in recent years concerning genetic concepts has been less than satisfactory. The report indicated that students' performance in genetic crosses, inheritance patterns and genetic disorders is unsatisfactory (WAEC, 2017, 2018, 2019 & 2020). Applying appropriate methods and strategies in learning is crucial in biology education, which is regarded as a cultural requirement across the board (Aktaş, 2012).

These teaching strategies encourage students' participation and allow them to connect previously learned material to more recent learning. As a result, learning should be conducted using activities that facilitate effective learning, allow for advanced cognitive abilities and motivate students to collaborate, share and take part in discussions. The poor academic performance of Biology students in genetics concepts can be attributed to a primary reason, which is the intricate and abstract nature of the subject matter. As a result, students often face difficulties comprehending genetics-related concepts in biology. Consequently, their knowledge is limited to basic concepts, leading to a lack of understanding in this area. Other significant contributing factors include ineffective teaching strategies, inadequate teaching and learning resources, insufficient instructional design and a negative attitude towards the process of learning biology (Gidena & Gebeyehu, 2017; Ngussa, 2014). Teaching can be classified into two paradigms: teacher-centered and learner-centered (Cole-Onaifo, 2022). Because students do not practice language with peers, traditional teaching techniques make the classrooms teacher-centered, which hinders students' ability to better themselves (Yassin & Razak, 2018). It can also lead to anxiety in the students (Razak, Yasin & Maasum, 2018).

Lak et al. (2017), elucidate that a superior pedagogical methodology, known as the "learner-centered teaching approach," involves positioning the learner as the focal point of the learning process. This contrasts with the conventional "teacher-centered teaching approach," wherein the learner is situated at the core of the learning process while the teacher solely assumes a prominent role. An active learning environment is generated by implementing student-centered teaching, where teachers are regarded as facilitators and students are considered active learners (Bekenova & Nygatayeva, 2017). In the teaching and learning environment where the teacher takes center stage, students assume a passive role as mere beneficiaries of the teacher's expertise (Lak et al., 2017). One manifestation of the teacher-centric pedagogical approach is the utilization of rote memorization, which entails students acquiring knowledge through repetitive recitation to commit each word to memory verbatim (Bekenova et al., 2017). The teacher-centric approach to instruction is commonly known as the "traditional" or "conventional" teaching methodology, which was extensively employed by educators worldwide prior to the advent of the contemporary, student-centered approach (Lak et al., 2017). Conversely, in a learner-centric classroom, students actively participate in both the teaching and learning processes, affording them more excellent agency over what they learn, how and when. In this setting, the teacher formulates lesson plans that align with the learners' specific needs, promoting active engagement in the learning process and fostering a sense of ownership over their educational journey. The focal point of an instructional strategy that centers on the learner is centered on how the students acquire knowledge, as opposed to how the teachers deliver it (Lak et al., 2017). It has been demonstrated that some learner-centered strategies, such as the discussion method, think pair share, jig saw problem-solving, critical thinking, and cooperative learning, are effective for all types of students, including academically gifted and mainstream (disabled) students because they encourage learning and foster respect and friendship among diverse groups of students.

International educational guidelines like United Nations Educational, Scientific and Cultural Organization and United Nations, have prioritized creating more inclusive schools. Cooperative learning like jig saw and think-pare-share have been identified as best strategies to achieve this goal (Fabes et al., 2018; Farmer et al., 2020). A technique for planning classroom activities that forces students to rely on one another for success is called the Jigsaw Teaching Strategy (JTS). It divides the class into groups and divides the assignments into parts, which the group then puts together to form the whole. Jigsaw is a cooperative learning method that relies on social interactions and group dynamics. It is among the most straightforward methods of cooperative learning (Sahin, 2010). The Jigsaw strategy is sometimes called broken images, where each learner in the group takes a portion of the content, studies it and discusses it within the group, after which the many content components are arranged and arranged to create a single complete image.‖ Specifically, each expert from each learning group meets together in a single group to study a particular subject and then returns to their groups to teach their members what they have learned, according to (Al-Zuhairi, 2013). One cooperative learning technique called Think- Pair- Share (TPS) enables students to take part in group discussions, think critically about the provided problem and be able to present (Facione, 2000). The think-pair-share framework, which is arguably the most well-known cooperative learning activity, gives students the chance to consider the given issue and then practice offering and receiving possible answers. Because of its simplicity, instructors may easily introduce cooperative learning to their students and it can be easily modified to fit a variety of course structures. Students' critical thinking is stimulated by TPS activities because they examine the assigned topic in a group project rather of just looking at a grade or score.

It enables pupils to participate in groups, seeing their friends as essential educational resources. According to Casey and Goodyear (2015), cooperative pedagogies provide an intriguing viewpoint on enhancing socializing and learning. However, by dividing the students into smaller groups, cooperative learning transformed the learning process into one that is focused on the needs of the students (Machado et al., 2015). Cooperative learning involves each group managing its own and every member's learning in the sense that students can impart information to one another and explain what they have learned to the other students. As a result, to finish a work, resolve a dilemma or meet a particular objective set by the instructor, students in each group have conversations with one another. Cooperative learning practices that work improve individual accountability, constructive interdependence and collaborative skills. According to Johnson et al. (2007), cooperative learning occurs when students collaborate to complete particular task. Most kids say participation in truly cooperative learning groups' results in improved acceptance, friendships, self-confidence and even school attendance (Solomon et al., 2011). According to Bayrakçeken et al. (2015), a cooperative learning approach fosters critical thinking in students, helps them become more adept at problem-solving and plays a significant part in helping them take ownership of their own learning. In order to promote gender sensitivity, given the lack of consensus on academic accomplishments concerning gender, Kaur et al. (2020) suggest that educators should initially establish that all students in the classroom are equally valuable and capable of achieving success. Establishing a learning atmosphere that is democratic and inclusive, allowing individuals to express their viewpoints and engage in questioning and answering freely, enables the realization of this objective.

This outcome can be accomplished through the utilization of instructional methods that are sensitive to gender concerns, such as the implementation of the cooperative learning strategy (Basu, 2018). Indicators utilized in Ghana to assess students' academic performance in biology encompasses various components such as school-based assessment, including laboratory work, projects or fieldwork, mid-term tests, group exercises and end-of-term examinations. Additionally, in the final year of their academic journey, students are subjected to a standardized examination administered by the West

African Examination Council (WAEC). Both assessments employ a comprehensive grading system stipulated by the (MOE, 2010). It is noteworthy to mention that students' academic accomplishments are profoundly influenced by their disposition towards learning. It is imperative to recognize that attitude plays a pivotal role in the perception and retention of information (Guido, 2018).

1.2 Statement of the Problem

Science serves as the foundation for contemporary technology. Every country is making fervent efforts to advance its scientific and technological endeavors. Genetics represents an influential foundational discipline within biology, serving as a crucial component to numerous other subjects. Additionally, it experiences rapid advancement driven by the emergence of novel insights and cutting-edge technologies. Specifically, the field of molecular genetics exhibits even greater celerity in its development. Nevertheless, many students are overwhelmed by the prospect of engaging with this subject due to its specialized nature, which is replete with intricate and abstract concepts (Nowgen, 2012). Suppose students comprehensively comprehend the genetic foundations that underlie various phenomena, such as genetic disorders. In that case, they will be better equipped to comprehend more complex concepts in medicine, health care, agriculture and technology (MOE, 2010). However, based on the reports from the chief examiners of the West African Examination Council, students' performances in genetics concepts have not been satisfactory. The poor academic performance among biology students can be attributed to the challenging nature of the subject's abstract concepts. Consequently, students are left with a limited understanding of genetics in biology. Other significant factors encompass unsuitable pedagogical approaches, inadequate instructional materials, subpar instructional design and a pessimistic disposition towards acquiring biological knowledge (Gidena & Gebeyehu, 2017; Ngussa, 2014). Considering this, scholars posited plausible resolutions involving the implementation of learner-centered methodologies aimed at rectifying students' misconceptions, fostering an enriching learning milieu and cultivating a positive inclination towards biology (MOE, 2010; Felder & Brent, 2017). Despite the presentation of these recommendations, the academic outcomes of students in the field of biology persist in their decline (WAEC, 2021).

Consequently, it is plausible to suggest that educators in Ghana may have failed to select an optimal student-oriented pedagogical approach throughout the teaching and learning procedure, thereby accounting for the continued deterioration of students' performance in biology. The Senior High School biology syllabus encourages the use of a student-centered approach in the teaching of biology. Numerous science instructors aspire to enhance scientific accomplishments by employing more efficacious instructional methodologies, fostering the active participation of learners and emphasizing the supportive role of the teacher. Consequently, proficient educators employ various techniques and methodologies to aid their students in acquiring knowledge (Altamimi et al., 2014). The content of the SHS syllabus has been designed in such a way as to provide students with basic knowledge in biology so they can understand themselves and other organisms, which enables them to make very informed choices as they interact with nature. The scope of the content of the syllabus also enables the learner to pursue specialized careers relating to biology. It fully prepares the students who wish to continue the study of biology at the tertiary level. The syllabus indicated that biology teaching should be student-centered and activity-oriented (Ministry of Education, 2010). One of the student-centered methods is cooperative learning-jigsaw and think-pair-share. Altamimi et al. (2014), asserts that the use of cooperative learning techniques, such as jigsaw, improves student performance. This research endeavor aims to enhance the conceptual understanding of genetics through the jigsaw and think-pair-share methods: a quasi-experimental study in senior high schools in the Sekyere South Municipal Assembly.

1.3 Main Objective of the Study

The primary aim of this investigation is to enhance students' conceptual understanding of genetics through the Jigsaw and Think-Pair-Share methods: a quasi-experimental study conducted in senior high schools in the Sekyere South Municipal Assembly.

1.4 Specific Objectives

The specific objectives of the research are as follows.

1. To determine the difference in conceptual understanding of genetics between Senior High School biology students taught using the jigsaw and think-pair-share strategies and those taught using the conventional pedagogical approach.
2. To determine the difference in conceptual understanding between male and female Senior High School biology students taught genetics through the jigsaw and think-pair-share strategies.

3. To find out the perceptions of Senior High School biology students regarding the use of the jigsaw and think-pair-share strategies.

1.5 Research Questions

The following research questions guided the study.

1. What is the difference in conceptual understanding between students taught genetics in Senior High School through the jigsaw and think pair share strategies and those taught using the conventional pedagogical approach?
2. What is the difference in conceptual understanding between male and female Senior High School Biology students instructed using the jigsaw and think pair share strategies in genetics?
3. What are the perceptions of senior high school biology students on the use of jigsaw and think pair share strategies in the teaching and learning of genetics?

1.6 Significance of the Study

Firstly, this study aims to provide the Ministry of Education, curriculum developers and biology educators with valuable insights into the necessity of implementing pedagogical strategies that effectively enhance students' academic achievement, particularly in the Sekyere South Municipal Assembly. Secondly, it seeks to equip teacher training institutions in the municipality with essential knowledge regarding the significance of prioritizing learner-centered methodologies, which have been proven to foster students' academic progress. Furthermore, it seeks to assist the Sekyere South Municipal Education Directorate in organizing workshops for teachers to promote the use of jigsaw and think-pair-share strategies and emphasize their importance for improving students' academic performance. Overall, the implementation of these strategies in the Sekyere South Municipal has the potential to significantly improve teaching quality, learner participation, inclusivity and overall academic achievement, while also supporting Ghana's competency-based curriculum.

1.6 Justification of the Study

Think-Pair-Share (TPS) enables students to participate in group discussions, think critically about the problem presented and share their responses (Facione, 2000). The Think-Pair-Share framework, which is arguably the most well-known cooperative learning activity, gives students the opportunity to reflect on a given issue and then practice offering and receiving possible solutions. Jigsaw (JS) is a cooperative learning method that relies on social interaction and group dynamics and it is considered one of the most straightforward cooperative learning strategies (Sahin, 2010). Positive perceptions often correlate with improved understanding and retention, increased confidence and participation, enhanced social communication skills and more positive attitudes toward genetics. Cooperative learning has also been shown to foster a liking for school, reduce absenteeism, promote discipline and self-esteem and improve understanding of the curriculum (Pillay, 2000). Furthermore, it promotes cooperation, interpersonal skills, racial integration and effective communication skills (Pillay, 2008; Sharan, 2010; Bafile, 2008).

1.7 Delimitation of the Study

In this study, the researcher focused on the Think-Pair-Share and Jigsaw strategies as cooperative learning methods, although other strategies exist. The research was limited to senior high schools in the Sekyere South Municipal, with both male and female students participating. The sample size was restricted to only form three students. The curriculum content was confined to a single biological concept: genetics.

1.8 Limitations of the Study

The following are the limitations of the study.

1. **Use of Non-Parametric Tests**

   The study relied on non-parametric tests for data analysis due to the data's failure to meet the assumptions of parametric tests. While appropriate in this context, non-parametric tests primarily examine differences in distribution rather than precise numerical differences. As a result, the findings may be less powerful, since only medians and ranks are typically emphasized instead of means.

2. **Subject Area Restriction**
3. The study focused exclusively on the topics like variation, inheritance, genetics crosses and blood group. Consequently, the results may not be generalizable to other subject areas or broader aspects of science education.

1.9 Organization of the Study

This study was presented in symmetrical arrangements by the AAMSUTED Master of Philosophy thesis rules and guidelines. The thesis was presented in five main chapters (The Introduction, Literature Review, Research Methodology, Data Analysis and Discussion of Results, and Conclusions and Recommendations of the study). Nonetheless, several sub-headings were included under each major chapter per the ideas included in each chapter. Chapter one of this study led the reader to the background of the study, the problem statement, the aim and objective, the research questions, the delimitations and the research limitations. Chapter Two involved the literature review. This chapter looked in detail at the conceptual review, theoretical review, empirical review and the development of a conceptual framework for the study. Chapter Three discussed the methodology used in achieving the research objectives. It detailed the research philosophy, population and ideal sample size, sampling technique, primary research strategy and design, data source, data gathering methods, administration of data, and statistical tool for analysis. Chapter Four (Data Analysis and Discussion of Results) covered the analysis and discussion of the primary data collected using the appropriate statistical method. This chapter presented the results of the data collected with the survey instrument and extensively discussed the findings arising out of the study by situating it in the context of current and authoritative related studies. Chapter Five stated the conclusions and recommendations based on the findings. A summary of the findings was presented in this chapter of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

One critical phase in the research process is the review of relevant literature. The opinions of professionals, researchers, and theorists, either directly or indirectly, support the entire study. This chapter presents the theoretical review, conceptual review, conceptual framework, and empirical review.

2.1 Theoretical Framework

2.2 Constructivist learning theory

The active role that students play in creating their own knowledge and understanding of the world through experiences and reflection on those experiences is emphasized by constructivist learning theory. Constructivism is an educational philosophy and learning theory which posits that learners actively construct knowledge through meaningful interactions and lived experiences. Rather than viewing knowledge as something transmitted directly from teacher to student, constructivism emphasizes the learner's active role in making sense of new information by connecting it to prior understanding (Guy-Evans, 2023). This perspective aligns with the objectives of the study, as it underscores the importance of engaging students in collaborative strategies such as jigsaw and think–pair–share, where interaction, dialogue and reflection are central to learning. This approach holds that education should emphasize critical thinking and problem-solving skills, enabling students to make connections between new and existing knowledge. It places a strong emphasis on student-centered learning, in which instructors mentor rather than instruct, encouraging in-depth comprehension and practical application (Guy-Evans, 2023). Jigsaw and Think-Pair-Share are cooperative learning strategies that embody constructivist principles. They promote active engagement, peer teaching and deeper processing of content (Ramsook, 2018). Constructivism argues that knowledge is best built through interaction and problem-solving, not rote memorization (Linsenmeyer, 2021). Students in the experimental group engage in peer-led discussions, knowledge synthesis and collaborative inquiry, which fosters deeper conceptual understanding of genetics.

Constructivism recognizes that individual learners bring diverse experiences and perspectives to the learning process (McLeod, 2025). Gender-based differences may emerge due to socialization patterns, communication styles and engagement preferences, all of which are accommodated in constructivist classrooms. Jigsaw and Think-Pair-Share allow both male and female students to express ideas, receive feedback and collaborate, potentially revealing differences in how each group constructs understanding. Constructivism values learner voice and agency. Understanding students' perceptions helps evaluate how well the strategies support meaningful learning (Ramsook, 2018). Positive perceptions often correlate with engagement, motivation and deeper learning. Gathering student feedback aligns with Dewey's view that education should be democratic and responsive to learners' needs (Linsenmeyer, 2021).

2.3 Collaborative learning

Collaborative learning is a pedagogical theory in which students work together in small groups to achieve shared learning goals. It emphasizes social interaction, mutual responsibility and the co-construction of knowledge (Yang, 2023). Collaborative learning is grounded in social constructivist principles, particularly Vygotsky in the year 1978 view that knowledge is co-constructed through social interaction within the learner's Zone of Proximal Development. Building on this foundation, Johnson and Johnson (1989) advanced social interdependence theory, emphasizing positive interdependence and promotive interaction as essential conditions for effective group learning. Similarly, Slavin (1995) contributed extensively to the design and evaluation of cooperative learning approaches such as the jigsaw technique, highlighting their potential to enhance student achievement and motivation. Over time, scholars have distinguished collaborative learning from cooperative learning: while cooperative learning often involves more structured, teacher-directed group tasks, collaborative learning emphasizes shared meaning-making, negotiation and learner autonomy (Han & Ellis, 2022). Recent scholarship has further clarified this distinction, demonstrating that both approaches share common roots but differ in how they structure student interaction and knowledge-building (Yang, 2023).

In relation to the present study, collaborative learning theory provides a strong foundation for examining the stated research objectives. First, the theory predicts that structured peer interaction fosters deeper conceptual understanding compared to traditional teacher-centered instruction, thereby supporting the investigation of differences between students taught genetics through jigsaw and think-pair-share strategies and those taught with conventional approaches (Feng et al., 2023). Second, because collaborative learning highlights active participation and mutual responsibility, it provides a useful lens for exploring potential gender differences in how male and female students engage in and benefit from these strategies. Recent studies confirm that gender composition and interaction styles influence collaboration patterns and learning outcomes in science classrooms (Feng et al., 2023; Han & Ellis, 2022). Third, collaborative learning theory underscores the importance of students' experiences, motivation and attitudes toward group activities, aligning with the objective of exploring Senior High School students' perceptions of the use of jigsaw and think-pair-share strategies in genetics instruction. Taken together, this theoretical lens positions collaborative learning as a comprehensive framework for understanding both the cognitive and affective outcomes of cooperative strategies in biology education (Han & Ellis, 2022).

2.4 Conceptual Review

Think-Pair-Share (TPS) and Jigsaw (JS) are two cooperative learning strategies that have drawn more attention in educational research during the past forty years. These methods were first presented by Lyman in the1981 for TPS and Aronson and colleagues in year 1978 for Jigsaw. Their goal is to change the classroom paradigm from teacher-centered transmission models to learner-centered, participatory techniques. Both approaches emphasize active participation, peer interaction and knowledge co-construction, all of which are tenets of constructivist learning theory. This review synthesizes the latest evidence aligned with the objectives of this study: (1) differences in conceptual understanding, (2) gender-based outcomes, and (3) students' perceptions.

2.5 Concept of Jigsaw Strategy

In the 1970s, Aronson created the Jigsaw method, a type of cooperative learning where students become "experts" on various aspects of a subject and then instruct their peers. It operationalizes the social interdependence theory, which holds that group success determines individual success, and learners depend on one another to ensure accountability and cooperation (Kaur et al., 2020).

Recent reviews (e.g., Learning With Jigsaw: A Systematic Review, 2024; BMC Medical Education, 2024) affirm that the Jigsaw strategy improves academic performance, motivation, and peer communication, particularly when properly scaffolded. However, outcomes vary with discipline, learner characteristics and teacher facilitation (SAGE Review, 2024). Contemporary studies emphasize that Jigsaw's benefits are amplified when paired with complementary tools such as concept maps, digital collaboration tools, or reflective summaries.

2.5.1 Steps in Implementing the Jigsaw Strategy

The Jigsaw technique follows six structured phases designed to maximize student participation and understanding (Yassin et al., 2018).

1. **Topic Division** – The teacher divides the main topic (e.g., "Genetics") into subtopics (e.g., Mendelian inheritance, genetic crosses, mutations, genetic disorders and molecular genetics).
2. **Home Group Formation** – Students are organized into *home groups* of 4–6 members. Each member is assigned one subtopic to master.
3. **Expert Group Discussion** – Students who share the same subtopic meet in *expert groups* to discuss, analyze materials and clarify concepts using teacher-provided resources.
4. **Preparation for Teaching** – Each expert prepares to teach their subtopic to their home group peers, ensuring understanding through examples and visual aids.
5. **Home Group Teaching and Integration** – Experts return to their home groups to teach their sections. Each group collaboratively integrates the various subtopics into a full conceptual picture.
6. **Evaluation and Reflection** – The teacher administers individual and group assessments to ensure accountability, followed by reflective discussions on learning experiences

2.6 Concept of Think-Pair-Share (TPS) Strategy

Lyman (1981) created the Think-Pair-Share (TPS) strategy, a cooperative discussion method that encourages all students to participate verbally and cognitively in a particular question or issue. Constructivism and social learning theory are the foundations of TPS, which emphasizes the active creation of knowledge via discussion and introspection (Yassin et al., 2018).

Recent research have demonstrated that TPS fosters equal participation, improves thinking, and advances conceptual knowledge across disciplines (PMC, 2023; Science Direct, 2021; Research Gate, 2024; Journal of Learning Analytics, 2025). It offers learners with sufficient “wait time” to reflect independently before engaging in collaborative and public conversation

2.6.1 Steps in Implementing the Think-Pair-Share Strategy

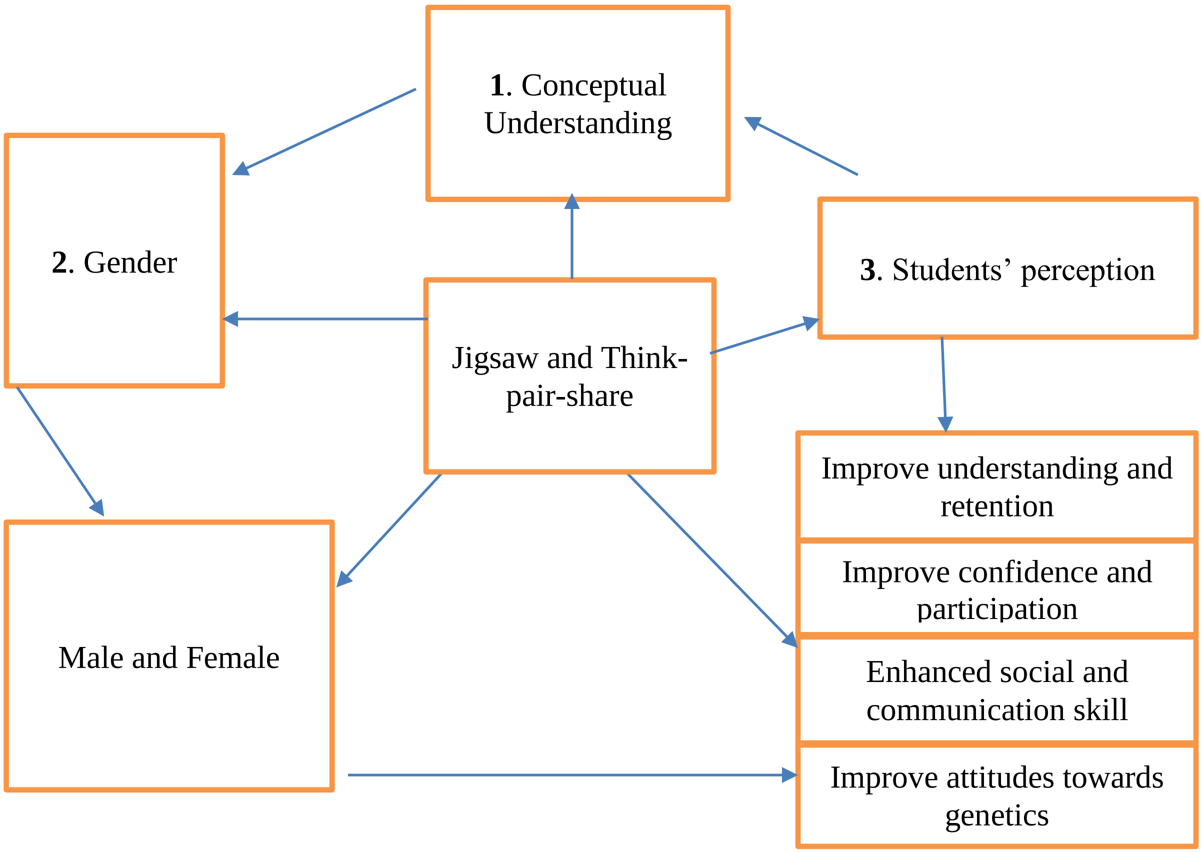
The TPS technique typically follows three sequential phases:

1. **Think** – The teacher poses an open-ended or conceptual question (e.g., “Why do offspring sometimes show traits not found in their parents?”). Students silently reflect and jot down their ideas for one to two minutes.
2. **Pair** – Students pair with a nearby partner to discuss their responses, compare ideas, and refine their understanding. This step allows peer correction and deepens reasoning.
3. **Share** – Pairs share their conclusions with the whole class. The teacher facilitates, synthesizes key points, and corrects misconceptions (Yassin et al., 2018).

2.7 Comparative Conceptual Review and Synthesis

Aspect	Jigsaw Strategy (JS)	Think-Pair-Share (TPS)
Theoretical Base	Social Interdependence Theory; Constructivism	Constructivism; Social Learning Theory
Structure	Multi-phase (expert and home groups)	Three-phase (think, pair, share)
Focus	Peer teaching, collaboration, and accountability	Reflection, dialogue, and communication
Cognitive Emphasis	Deep conceptual understanding through teaching others	Clarification and reasoning through dialogue
Affective Outcomes	Builds confidence, responsibility, teamwork	Enhances participation, communication, equity
Challenges	Complex implementation; dominance issues	Limited depth if poorly structured; anxiety during sharing
Enhancements	Combine with concept mapping or digital tools	Use digital or AI-assisted sharing tools; scaffolded questioning

2.8 Conceptual Frame Work



1. Conceptual Understanding

It emphasizes that students learn best when they actively construct knowledge through social interaction and collaboration. Jigsaw is a cooperative learning strategy in which students become "experts" on subtopics and teach their peers, promoting accountability and deep engagement. Think-Pair-Share is a cooperative learning strategy that promotes active engagement by encouraging peer discussion, individual reflection and whole-class sharing (Alam et al., 2024). Because they are actively participating in the learning process, students' comprehension of the subtopic under discussion is improved when they participate in group discussions. These are the independent factors whose influence on students' conceptual knowledge is being evaluated, as evidenced by the fact that they are seen branching from the "Instructional Strategy" node. Constructivist theory, particularly Vygotsky's notion of social interaction-based learning, serves as the foundation for these tactics. Students in the experimental group engage in peer-led discussions, knowledge synthesis and collaborative inquiry, which fosters deeper conceptual understanding of genetics.

2. Gender Differences in Conceptual Understanding

The diagram shows both *Male* and *Female* categories, which are analyzed to determine if gender influences conceptual understanding under different instructional methods. Constructivism recognizes that individual learners bring diverse experiences and perspectives to the learning process. Gender-based differences may emerge due to socialization patterns, communication styles and engagement preferences, all of which are accommodated in constructivist classrooms. Jigsaw and Think-Pair-Share allow both male and female students to express ideas, receive feedback and collaborate, potentially revealing differences in how each group constructs understanding (Alam et al., 2024).

3. Students Perceptions of Jigsaw and Think-Pair-Share

Another element affecting conceptual understanding is demonstrated to be student perceptions. This is in line with the third study question, which aims to ascertain how students perceive the application of Jigsaw and Think-Pair-Share in genetics education. Constructivism respects the agency and voice of learners. Assessing how well the tactics promote meaningful learning is made easier by knowing how students perceive the material (Knigh & Brame, 2023). Positive views are frequently linked to better comprehension and memory, more self-assurance and involvement, improved social communication abilities and an improved attitude toward genetics. Gathering student feedback aligns with Dewey's view that education should be democratic and responsive to learners' needs.

2.9 Concept of Cooperative Learning (CL)

Yassin, Razak, and Massum (2018), cite Brown (1994) as stating that cooperative learning is a method wherein a variety of students work together using resources that the facilitator provides to accomplish a particular goal. Cooperative learning is described by Johnson et al. (2000), as instructional strategies used in small groups where students collaborate to maximize their own and their friends' learning. The aforementioned definitions center on group work and give everyone two tasks: the first is to comprehend the contents and the second is to ensure that the other group members also understand them. Because of the instructional strategies outlined in the definitions' content, cooperative learning helps students develop critical thinking, reasoning and problem-solving skills, allowing them to construct various perspectives (Borich, 2017; Gillies et al., 2021). Once more, it is clear from the definitions that the most important aspect of cooperative learning is that students cooperate in small groups to achieve a shared objective by supporting one another's learning. In this way, group work in cluster studies conducted in conventional classrooms is comparable to cooperative learning; nevertheless, cooperative learning is distinct from cluster studies. The cooperative learning, positive commitment, individual accountability, group formation and spirit, teacher role, application of social skills, in-person interaction and rewards that set this model apart from conventional cluster studies have earned it a place in the literature. For example, in positive commitment, seen as a cooperative learning trait, students understand that their own success will impact their groupmates' success (Öztürk, 2017).

Furthermore, group goals were designed to compel students to cope with their and other students' competencies (Doymuş & Doğan, 2015). There is no dependence and group members in traditional cluster studies can operate independently of one another. Cooperative learning groups differ from typical cluster groups in terms of positive commitment and all other aspects of cooperative learning. Traditional cluster studies allow group members to operate independently of one another without any dependence. Cooperative learning groups differ from traditional cluster groups regarding positive commitment and all other aspects of cooperative learning. Cooperative learning is a process-based paradigm that enhances students' cognitive abilities and may be implemented through various strategies and tactics (Açıkgöz, 2014). These approaches vary depending on the learning objective, classroom size, social and physical structure, and subject matter to be taught (Aziz & Hossain, 2010; Okumuş & Doymuş, 2018; Öztürk & Doymuş, 2018; Thurston et al., 2010).

These methods and techniques are employed while considering students' readiness, interests and abilities. Student teams-achievement sections, learning together, team-game-tournament, literacy-writing-practice, combined cooperative reading and composition, group research, collaboration-cooperation, academic conflict, team-assisted individualization, jigsaw methods, let us ask together, learn together and mutual questioning are some of the approaches and techniques related to the application of the principles and features of the cooperative learning model (Öztürk, 2017).The goals and features of these cooperative learning approaches and strategies are similar even though they vary significantly because of variations in application and assessment. Examining pertinent literature highlights the cooperative learning model's significant advantages to educators, learners and educational institutions. The benefits of cooperative learning in academia, society, psychology, assessment and evaluation and the economy have led to its acceptance as a significant component of educational practices in recent years (Öztürk, 2017). Students absorb the information and recognize the advantages of working together academically because cooperative learning is a model that empowers them to take ownership of their work, demands that they participate actively in the learning process, and supports this (Açıkgöz, 2014).

When students work together to complete their gaps, reinforce their learning and structure their learning, they can discover a way to respond to their differences in the classroom, they consequently learn as they instruct (Ekinci, 2011). Numerous research studies have demonstrated the substantial and favorable impacts that cooperative learning has on students' academic achievement. These benefits include supporting scientific process skills, offering permanent and conceptual learning and placing the onus of learning on the student (Acar & Tarhan, 2008; Gradel & Edson, 2010; Karacop & Doymuş, 2012; Okumuş & Doymuş, 2021; Öztürk & Doymuş, 2018). Similarly, students' communication skills improve and their ability to express themselves improves in cooperative learning because of the constant interaction (Serrano & Pons, 2014). Additionally, their sense of responsibility and trust for one another grows (Demirel, 2015; Eshietedoho, 2010); skills like observing events from a different angle, empathizing and working together to overcome difficulties are supported (Ozturk, 2017). It is simpler to reach all students when distinct and alternative strategies are used in cooperative learning and it also enables each student to be evaluated based on their unique learning style. Since students collaborate in cooperative learning, cooperative learning is considered a more cost-effective and efficient model of instruction than other approaches (Öztürk, 2017). This is especially true in schools with limited resources. Additional definitions shed light on the shared goal that cooperative learning participants should consider and utilize to achieve it. With various instructional activities, small groups of students with varying skill levels can improve their understanding of a subject through cooperative learning (Dyson & Casey, 2012). Additionally, Smith et al. (2007), pointed out that when students work together to finish a task, learning can be cooperative. Johnson and Johnson's (2002), perspective also highlighted social skills as one of the cornerstones of cooperative learning. They claimed that for the cooperative learning groups to be truly cooperative, it is critical that the students feel that each individual matters to the group. They went on to say that the students in each group should use the appropriate social skills needed for cooperative learning. Some definitions emphasize how students engage with one another and the function of cooperative learning to make learning more student-centered than teacher-centered. According to Arendale (2005) and El-Deghaidy (2008), cooperative learning is a method of instruction that relies on activities that improve student-student interaction. Any type of pair work is crucial to cooperative learning because it allows students to practice the language verbally via productive discussion and motivating one another to maximize the benefits. Furthermore, in their definition of cooperative learning, (McCafferty et al, 2004), emphasized the significance of equitable opportunities for improving the efficacy of the cooperative learning process.

According to McCafferty et al. (2004), cooperative learning strategies assist students in collaborating productively. Science and education have identified cooperative learning as one of the most effective learning strategies. Unlike group work, where some students may finish assignments without sharing them with the rest of the group, cooperative learning necessitates equal opportunities for students to participate and communicate in order to produce the final product. Certain group projects cannot be classified as cooperative learning; hence, cooperative learning has its guidelines. Instead of placing emphasis on the teacher, cooperative learning seeks to place the focus on the learner. One of the tenets of cooperative learning is positive interdependence, which states that each group member oversees their own and the other members' learning. In addition, cooperative learning ought to be goal-oriented, with students cooperating to complete a particular assignment. Equal involvement opportunities for all students are a crucial component of the cooperative learning process.

2.10 Types of Cooperative Learning

According to Yassin and Razak (2018), distinguished three types of cooperative learning groups on page 645. They are.

i. Formal Cooperative Learning

ii. Informal Cooperative learning

iii. Base Group Cooperative learning

2.10.1 Formal Cooperative Learning

In order to accomplish shared objectives and finish a particular job or project, formal cooperative learning takes place over the course of one to several weeks. This can be used to teach any subject or course and guarantee the success of the cooperative learning approach after the instructor has established the goals of the students and explained the basics of cooperative learning (Yassin, Razak & Massum, 2018, p.645). Groups of three to five students are formed for formal cooperative learning and these groups should be varied. According to the cooperative learning strategy that the teacher has assigned them, the students can start studying. The teacher will be present to supervise them (Almuslimi, 2016, as cited in Yassin, Razak & Massum, 2018, p. 645).

2.10.2 Cooperative Learning without Form

A class as a whole participates in this type of cooperative learning for a few minutes. Teachers utilize it to enhance in-person instruction in summarizing, presenting and discussing material. The instructor may ask the class to debate a subject she poses or to list the key ideas from the course. Thus, it is transient and does not endure long (Almuslimi, 2016).

2.10.3 Base Group Cooperative Learning

Cooperative learning sessions like this one might last a year or more. The participants ought to demonstrate dedication and help and inspire the other students. This kind also benefits learners who wish to finish and master a course successfully. According to Almuslimi (2016), learners who are socially isolated and carefully selected before being separated into groups benefit from having a base group. Almuslimi (2016), states that the major goal of this kind of cooperative learning is to help students become more socially adept.

2.11 Requirements for Cooperative Learning

Effectively using student groups in the classroom, cooperative learning is a way to promote learning through cooperation rather than competition. It is the outcome of multiple components coming together to focus learning on achieving a common objective. Individualistic and competitive endeavors, however, are not necessarily more fruitful than teamwork. To choose the learning activities pertaining to social interaction and interdependence, these components need to be arranged and structured. The cooperative language learning principle is another name for cooperative learning elements. According to Richards and Rodgers (2016, p. 196), suggest the following essential components of cooperative learning.

2.11.1 Positive Interdependence

According to Gomez (2007), for students to understand the connection between their own and their group's achievement, they need to be aware of how they relate to one another.

Students must understand that cooperation and clear communication of the group's intentions are crucial to achieving the suggested goals. For students to understand the importance of each workgroup member in supporting the others, teachers must tangibly assign shared duties with a clear group goal. The goals established will not be achievable without the assistance of every organization member. Each group member contributes in a way that benefits every other member. The result of needing other people's labor is known as positive interdependence. The aim of the group project will be accomplished if every member meets their objectives; however, if one person falls short of the mark, the project's goal will be more challenging to reach. Everyone feels reliant on one another and necessary to the success of the team effort in this way.

2.11.2 Interpersonal and Group Skills

Johnson and Johnson (2003), state that students in cooperative learning groups must be taught academic content and social and group skills. These abilities are essential to the efficient operation of teamwork. This aspect of cooperative labor makes it inherently more complex than individualistic or competitive learning. It is not guaranteed that individuals who lack collaboration skills can carry out their tasks to the best of their abilities just because they are asked to participate in cooperative work. Teaching interpersonal skills like leadership, decision-making, communication, trust-building and conflict resolution must be done with the same consideration and care as academic skills.

There are numerous effective procedures and techniques for imparting social skills to students. The social components of cooperative learning are critical to students' professional development and it is imperative that teachers set out time to supervise and validate these components of cooperative learning. According to Morales (2007), just being a part of a team teaches people how to work cooperatively, even concerning the drawbacks of collaboration, such as not offering ideas or acting passively, aloof and uninterested in what goes on in the group. However, according to the author, practicing teamwork is a professional competency that cannot be learnt; thus, evaluation is necessary while teaching and learning are being developed. If learning and teamwork are recognized and assessed, they will succeed. The assessment procedure provides actual insight into the workings of the student group. It identifies the attributes that must be modified for the team to enhance its work products.

2.11.3 Individual Responsibility

The individual participant is responsible for fulfilling the objectives assigned to him. As a result, the ultimate grade for the group belongs to each student. This standard fosters a beneficial dependency. The norm fosters beneficial interdependence. Motivation and individual and team performance can be enhanced by realizing that your work depends on you and that others have faith in your capacity to complete the task. Prieto (2007), states that each worker contributes to the group's learning and success. This is known as individual responsibility. However, each student must be capable of working cooperatively at this time.

2.11.4 Face-to-face Interaction

Chen (2013), argues that non-verbal substitutes (instructions or materials) cannot replicate the effects of social interaction and verbal exchange among peers; instead, bright individuals who can work in teams and conduct research are needed, as well as people who can analyze the subject matter in a thorough and comprehensive manner and apply their experiences and knowledge to inform group decisions. From Santamaría's theory, we may conclude that in relation to the materials and activities, students must interact with each other (physically face-to-face) to engage in various cognitive processes and interpersonal dynamics, making face-to-face interaction crucial.

2.11.5 Group Processing or Evaluation

To accomplish the collective goal, team members must organize the tasks to be completed and regularly assess the goals' progress. They must also assess their talents and identify any necessary adjustments to improve their work and performance. All students must engage in discussion and participation in order to make the best decisions for the team. They must also assess how well they planned their activities, achieved their objectives and maintained positive interpersonal relationships throughout the cooperative learning process. We must remember that each student has goals, issues, resources and conflicts that come up as they mature (Prieto, 2007).

2.12 Methods of Cooperative Learning Activities

Cooperative learning is a methodical, deliberate, and well-organized set of student actions rather than an accident. Pupils go through numerous steps. The following methods have been mentioned by Johnson and Johnson (Chen, 2013).

2.12.1 Mutual Understanding

One step in the cooperative learning process is mutual understanding, in which students demonstrate empathy. Perceived performance is influenced by the development and maintenance of mutually shared cognition in a cooperative learning environment (Prieto, 2007). To comprehend how mutually shared cognition develops and results in better perceived team performance, interpersonal and socio-cognitive processes must be considered. Cooperative learning participants aren't hesitant to express their opinions.

2.12.2 Group Formation

Group formation is another effective cooperative learning technique where students develop affiliations with their classmates to collaborate and concentrate on reaching a common goal. Since each group member has an independent task, the performance of the entire group is impacted by the actions of any one member. Creating cooperative learning activities that work is likewise a difficult and significant step. Establishing conditions supporting meaningful interactions and intellectual progress is feasible by appropriately selecting persons into a group. A well-formed group can elicit strong emotions from pupils and impede the process of learning. As a result, one of the crucial phases in collaborative learning is group formation (Chen, 2013).

2.12.3 Task Division

Task division is another strategy for encouraging cooperative learning, where students split up a task into smaller groups and complete it alone. Additionally, they divide a task into smaller parts that combine to produce the whole. Depending on their individual needs, students are assigned varying assignments. Additionally, the instructor can provide assignments requiring students to share and include their arguments in specific activities. The teacher assigns the tasks based on the makeup of the group. Without a teacher, students can choose various assignments and engage in debates (Johnson & Johnson, 2003).

2.12.4 Time Management

Another method for successful cooperative learning in Biology classes is time management. It is the practice of allocating and scheduling the amount of time students spend on certain tasks. Since students are expected to complete assignments on time and there is never enough time for instruction and learning, time management is an essential part of cooperative learning (Johnson & Johnson, 2003). Students receive the topic or problem in collaborative learning and then present their arguments accordingly. The teacher has allotted time- based on the type of issue.

2.12.5 Sharing

Using a resource or space together is called sharing. It also relates to the distribution and division of labor. Students exchange various things during cooperative learning, including ideas, feelings, messages and thoughts. In groups, students discuss and add to the problem with their peers (Chen, 2013). This is known as the 16-issue. Students get the opportunity to become familiar with the socio-cultural features of other learners through cooperative learning.

2.12.6 Student-student Interaction

Student-student interaction is a vital part of any course experience. This interaction happens naturally in cooperative learning, as students listen to each other's comments, ask questions and build rapport through frequent contact. In cooperative learning, everyone can put their views or thoughts on issues or problems. Interaction helps them discover things that will endure a lifetime. Groups of students engage with one another and boost one another's confidence in a certain subject or issue (Chen, 2013).

2.12.7 Critical Thinking

Critical thinking, the intellectually rigorous process of actively and skillfully conceiving, implementing, analyzing, synthesizing and or assessing the task by monitoring the circumstance, is another cooperative learning approach (Chen., 2013). Since cooperative teams are believed to think more deeply and retain material longer than students who work quietly alone, the active interchange of ideas in small groups is said to boost participant interest and develop critical thinking, according to a number of cooperative learning studies. Shared learning allows students to participate in discussions, take ownership of their learning and develop critical thinking skills.

2.13 Teachers' Roles in a Cooperative Classroom (TPS and JS)

The teacher's responsibilities in a cooperative biology class differ significantly from those in a conventional classroom learning environment. The instructor's function instructors function shifts from providing information to facilitating discovery. For classroom instruction, the teacher must establish highly controlled and orderly environments. According to Altamimi & Attamimi (2014, pg. 30), asserts that when educators employ the CL approach, their role as knowledge transmitters shifts to that of learning mediators. This role calls for facilitation, coaching and modeling.

2.13.1 Facilitating

The function of the facilitator includes providing students with opportunities for collaborative work and problem-solving, rich surroundings and activities that connect new material to existing knowledge and a range of authentic learning tasks. Teachers may start by paying attention to the physical environment, moving desks so all students can see each other and creating an environment that encourages discussion. Moving their desks from the front of the room to a less noticeable spot can also be something they want to do. Finally, by creating learning activities that promote diversity while upholding high performance standards for each student, teachers enhance cooperative learning. Students must engage in sophisticated cognitive processes like problem-solving and decision-making, which are best completed in groups. Through these assignments, students can draw on various views and experiences while drawing connections between real-life items, events and situations in their local world and a larger one. In addition to building pupils' confidence, learning assignments are suitably challenging (Benjarano, 1987, pg. 485, as cited in Bayat 2004).

2.13.2 Modelling

Thinking while illuminating or clarifying a point. However, many local and state guidelines have stressed the importance of modelling in sharing collaborative classrooms with students. Students benefit by modeling not only one's opinions about the subject matter being studied but also the communication and cooperative learning process itself. Providing detailed instructions and thinking aloud are two instances of modeling. When it comes to content, educators could explain the thought processes behind their predictions about scientific experiments, their summaries of passages, their interpretations of unfamiliar words, how they express and resolve problems and how they arrange complex data (Chen, 2013).

2.13.3 Coaching

Giving pupils' indications or suggestions, offering feedback, refocusing their efforts and assisting them in using a method are all part of coaching. One of the main tenets of coaching is to provide students with just enough assistance when they require it, without going overboard or under, to allow them to take as much ownership of their own education as possible (Bayat, 2004).

2.14 Students' Roles in a Cooperative Classroom (JS and TPS)

In cooperative learning, a student's primary responsibility is collaborating with other group members to ensure the entire group has grasped the material. The student is the leading player in cooperative language learning. Each group member in a CL work has a specific role to play, according to Richard and Rodgers (2006, as cited in Soraya 2010, pg.45). These roles include the noise monitor, who regularly checks and tests the information, the turn-taker monitor, who offers a forum for discussing opposing views, the recorder, who is responsible for documenting group discussions and responses and the summarizer, who offers a succinct synopsis of the essential concepts. Almuslimi (2016, as referenced in Yassin, Razak & Massum 2018, pg. 648), describes the learners' role in cooperative learning as follows:

a) The facilitator is in charge of maintaining the pupils' focus.

b) The student who documents the group's decision and responses is known as the recorder.

c) Summarizer: this student is in charge of condensing the responses of the other students.

c) Reporter: the student who shares the group's thoughts with the other groups.

e) Timekeeper: this student is in charge of adhering to the task deadlines.

c) The student who poses inquiries is known as the questioner.

g) Praiseer: this student is in charge of motivating the other students by utilizing words of praise.

According to Richards and Rodgers (2001, as cited in Pacheco, Rozo, & Suarez, 2011), learning is a process that requires students' direct and active integration of group work and participation in activities. On the other hand, the most common cooperative learning model is pair grouping, which ensures that both students spend as much time as possible on learning activities. For instance, in a pair activity, students take turns playing the roles of instructors, recorders and information exchanges. As a result, when working in groups, students' responsibilities include talking with their peers about the content to be taught, supporting one another in learning the subject matter and motivating their partner to put in much effort to achieve a shared objective. Additionally, because the lectures are coming from their peers, students feel more at ease as directors and tutors of others through cooperative learning activities.

2.15 Strategies for Cooperative Learning

Cooperative learning (TPS and JS) is active learning strategies that can be used to enhance or replace the traditional learning system (Zaitwan, 2013). This teaching approach is based on recent research, with a focus on the impacts of side effects on behavior and learning (Nasrallah, 2016). Notably, cooperative learning encompasses a range of pedagogical approaches that incorporate student-to-student cooperation on a particular subject as an essential component of the educational process. By implementing these techniques, students will be able to study in a meaningful way and improve their reading comprehension abilities. Two of the cooperative strategies are used in this research.

2.15.1 Jigsaw (JS)

One CL tactic that Aronson first developed is the Jigsaw. The home groups were made up of mixed teams consisting of four or five students each. By comparing their area of expertise with other groups' related subtopics, each student becomes an expert on one of the subheadings (Karacop & Doymus, 2013). Afterwards, the students return to their home groups and help the other team members learn more about their subject through discussion. They learn the relevant topic material from their members and impart their acquired knowledge to their team. After that, each student receives an independent evaluation (Bergom et al., 2011). Students can actively engage in the learning process by using the jigsaw approach. After being exposed to this approach multiple times, students ought to feel more at ease performing their obligations (Artut & Tarim, 2007).

By adding up everyone's accountability for the group's presentation, an assessment of the supportive group could increase its efficacy (Thompson & Chapman, 2004; Maden, 2011). When used appropriately for learning tasks, Jigsaw can be used for reading, listening, communicating, and awareness exercises.

The Jigsaw technique's characteristics make it suitable for enhancing two crucial and related instructional goals that result in reading comprehension (Jenkins et al., 2003). The goals are to improve the learning environment and increase students' knowledge capacity. The jigsaw method gives each group member a crucial role in the instructional exercise, promoting participation, empathy and listening. Group members should collaborate as a team to accomplish a shared goal. Without teamwork from all members, no group member can ever prosper (Aronson, 2014). In addition, CL helps students acquire the content while instructing others in small groups, fostering their metacognitive consciousness (Meng, 2010; Frame, 2014). By holding each student accountable for providing the group with an explanation of a certain amount of the content, the jigsaw technique helps enhance cooperative learning. Students in this method are divided into two groups: the "home group" and the "jigsaw group" (Doymus, 2008). Every team member gain mastery over a distinct portion of the curriculum. Each teammate departs and collaborates with individuals from other teams who share their interests in the same field. The jigsaw strategy features four steps.

Students belong to a Jigsaw group; these groups consist of three to eight students each and show both within-group heterogeneity (i.e., sex, students' cognitive, social, and motor levels) and between-group uniformity.

Students join temporary "expert" groups consisting of students who have been assigned the same subset of material **(**Roseth et al., 2019), By taking this step, less proficient students can learn from more proficient classmates how to comprehend and instruct their content (Roseth et al., 2019).

Students rejoin their original Jigsaw groups and are tasked with imparting the abilities they have learned to their group members to make them as adept as they are.

Students in home groups collaborate to create a final collaborative piece through integration and assessment.

2.15.2 The Benefits of Jigsaw (JS)

According to certain theories, Jigsaw can enhance students' learning for the following reasons:

a. Many students find it less intimidating.
b. It boosts the amount of participation from students in the classroom.
c. It lessens the requirement for being competitive.

This reduces reliance on teachers as the subject matter experts in the classroom (Qiao & Jin, 2010). Less intimidation is the first advantage of Jigsaw that has been emphasized. In a classroom where teachers dominate the learning process, they move on with quick learners, intimidating slower learners to raise questions. Nonetheless, Jigsaw offers a conversation platform that allows students to feel comfortable asking questions. As soon as intimidation is reduced, engagement levels rise. A higher degree of participation increases student learning and lessens competition because every student meets their objectives. One of the main benefits of the Jigsaw method and most other CL techniques is that they increase student cooperation and decrease rivalry in the learning environment. The final advantage of Jigsaw that should be emphasized is that the teacher takes on the role of a facilitator, assisting pupils in solving problems, drawing their conclusions and cooperating to achieve their objectives. The teacher does not need to explain everything in a CL setting; instead, they provide help and ensure pupils stay on topic. As a result, students are more accountable to one another and the subject they must learn.

2.15.3 Think-Pair-Share (TPS)

The TPS strategy is active cooperative learning involving students' prior knowledge of the educational system or working through their reactions to problems (Nasr, 2003). The strategic steps of TPS involve asking the class questions regarding the material covered in the task, activity, or issue. Then, you ask them to consider the question for one minute on their own, refraining from talking or moving around the classroom while they are thinking. It is characterized by giving students the chance to reflect (both internally and externally with colleagues) and to think and revise before responding. The teacher then assigns students to work in pairs to discuss and think about the given question or activity for five minutes. Finally, the teacher requires the couples to participate by displaying what has been reached, including solutions and ideas about the question or activity

(Zaitun, 2007). It encourages active participation in the classroom by fostering strong peer relationships. It also enables students to participate more actively in the group and express their opinions. It also aids in the evaluation of pupils by teachers. Students take turns and have appropriate class discussions as the teacher goes around the room. The instructor poses a question to the class and then gives them time to consider it. Next, they collaborate in pairs to explore potential solutions. Ultimately, they put their ideas into practice to resolve the issue (Simon &Baum, 2017).

2.15.4 Procedure for Think Pair Share

The steps in the Think-Pair-Share strategy are as follows:

The initial stage is the thinking step

The TPS method was initiated when the instructor presented a thought-provoking issue or a problem about the lesson's subject so students could research potential solutions. Subsequently, the instructor instructed the pupils to work independently to find a solution to the problem at hand. They were also given a set amount of time to reflect, which was decided based on the student's prior knowledge, the type of question, and its complexity (Nasr, 2003).

The pairing step is the second step

The instructor asks the students to debate the subject in pairs. In an attempt to get the student seated next to him to agree, each student is asked to talk and share thoughts with him. In order to reach a consensus, they also share thoughts and opinions (Christine, 2001). The instructor asks the students to debate the subject in pairs. In an attempt to get the student seated next to him to agree, each student is asked to talk and share thoughts with him. In order to reach a consensus, they also share thoughts and opinions (Christine, 2001).

Step three: Sharing

To save time and effort, the instructor can assign each pair of students to collaborate with another pair to create a square of students who will brainstorm together. Instead, the teacher will talk about (10) groups while also discussing (20) pairs of pupils (Saleh & Ibrahim, 2015). The TPS method is a contemporary teaching technique that tries to improve students' energy, capacities and ability to deal with historical events rather than just giving them a sense of achievement. Additionally, it is appropriate for teachers new to cooperative learning and students of all ages (Saleh & Ibrahim, 2015).

2.15.5 Use of Think-Pair-Share and Jigsaw to Teach Genetics

Learning techniques like Jigsaw and Think-Pair-Share can significantly improve student understanding and involvement in genetics classes. Under the cooperative learning strategy known as "Think-Pair-Share," students first think about a problem or topic independently before having a pair discussion about it and then present their findings to the class. With the help of this approach, students can express their ideas clearly and critically before being influenced by the opinions of the larger group. To promote a deeper understanding of genetic variability and inheritance patterns, students in a genetics class could, for instance, individually analyses the consequences of a specific genetic mutation, discuss their results with a partner and then offer their aggregate thoughts to the class (Ahmed, 2006). Think-Pair-Share is enhanced by the Jigsaw method, which divides the class into "expert" groups that examine several facets of a complicated subject, such as genetics. All students are exposed to the entire range of subjects because each member of these expert groups subsequently 'teaches' their section to classmates in mixed groups. This method broadens the scope of the educational experience and gives students the confidence to take charge of their education and participate actively in the teaching process. In genetics, the Jigsaw method may entail each student becoming a mini-expert in their designated field—one group examining genetic problems, another investigating gene therapy and a third probing ethical issue (Saleh & Ibrahim, 2015).

Because they promote active engagement and help students develop their communication and problem-solving abilities, both approaches have been demonstrated to enhance student performance in science and health-related classes. When used in genetics, these teaching techniques can help clarify difficult ideas and foster a cooperative learning atmosphere where students are more likely to connect with the subject matter and use what they have learned in real-world situations. Teachers may create a dynamic learning environment that inspires students to engage in hands-on, interactive exploration of genetics by including Jigsaw and Think-Pair-Share in their lessons (Saleh & Ibrahim, 2015).

2.16 Advantages of Cooperative Learning

Students greatly benefit from cooperative learning techniques in language instruction when they are in the room. These benefits include raising their enthusiasm for learning, reducing their anxiety and enhancing their language proficiency. In addition, social skill development and benefit maximization are also greatly improved (Rabgay, 2018).

2.16.1 Reducing Anxiety

Using cooperative learning techniques in the classroom reduces students' anxiety levels, which is one of the numerous advantages that relate to the psychological aspects of learning. Asking a student to answer a question directly from the teacher's mouth is not the same as asking a question and then letting the class discuss the answer. Because they will be discussing the answer with other students they feel a connection to and because there are no hurdles to consider, pupils will not experience confusion or anxiety when working in groups. Students' skills will be refined by practicing with one another, which will increase their self-assurance and willingness to participate in responding to teacher inquiries. This will lessen their anxiety when communicating with one another (Rabgay, 2018).

2.16.2 Self-confidence

One such thing that causes anxiety in the classroom is the rivalry among students. Traditional classrooms encourage a competitive atmosphere among pupils, which raises anxiety levels and encourages communication anxiety. Cooperative learning fosters intergroup rivalry, which makes students feel more a part of their group and increases their confidence. This is why cooperative learning is seen as a treatment for anxiety.

Additionally, anxiety levels in typical classroom settings increase since each student's objective in interpersonal rivalry is to win, whereas in intergroup competition, the focus is on succeeding (Johnson & Johnson, 2000).

2.17 Implication of Literature Reviewed for the Present Study

The literature on earlier studies on students' difficulties understanding biological ideas has been studied for this study. The inability of the conventional teaching approach to improve student's learning and performance is very intriguing. Research using cooperative learning strategies like JS and TPS to support science concepts, especially biology, in learning and retention has been conducted. Nevertheless, there is still a problem with understanding biology topics. Regardless of grade level or subject area, the research reviewed indicates that cooperative learning strategies, among others, support students' academic progress; they also enhance relationships and aid in student retention. Nonetheless, most studies on applying cooperative learning strategies to help students were performed globally.

Research conducted by Zhang (2010), Rabgay (2018), Casey and Fernandez-Rio (2019), Johnson (2003), and Mirshekaran et al. (2018) has indicated that cooperative learning strategies such as jigsaw (JS) and think-pair-share (TPS) foster communication among students while simultaneously increasing productivity and academic success rates. Cooperative learning also improved student enthusiasm and attitudes in biology classes, resulting in higher academic achievement. Furthermore, other studies reported that students developed a strong sense of self-reliance in their own thoughts and ideas, learned to value other people's opinions and solutions, adapted peer group work to fit both their own needs and the needs of others in the classroom and began to view academic success and achievement more as contributions than as test scores. Therefore, this study aimed to examine the effectiveness of cooperative learning strategy on the performance of senior high school biology students in genetics.

2.18 Conceptual Understanding of Students in Genetics When Taught with JS, TPS and CPA

Studies comparing students' performance in genetics taught using the Cooperative Learning Strategy (CLS) versus the Conventional Pedagogical Approach (CPA) show that CLS generally enhances understanding and retention in scientific subjects. Cooperative learning, by nature, emphasizes student-centered instruction, where students engage actively with the material through group interactions, promoting a deeper understanding of complex topics like genetics (Johnson & Johnson, 2018). Research by Gillies (2021), demonstrated that students taught genetics through JS and TPS performed better in assessments and retained information longer than those taught through CPA. This finding aligns with previous studies indicating that the collaborative environment in CLS helps students articulate their understanding and clarify doubts through peer discussions, enhancing comprehension and retention (Slavin, 2020). In contrast, students exposed to CPA often experience more passive learning, which can be less effective for complex subjects requiring critical thinking and problem-solving skills, such as genetics. CPA methods are typically teacher-centered, focusing on lecture- based instruction that may limit student engagement and active participation (Kirschner et al., 2011). Research by Van- Ryzin et al. (2020), found that while CPA methods can successfully transmit factual information, they often fail to develop higher-order thinking skills crucial for understanding genetics, as students are more likely to memorize facts without grasping underlying concepts. This lack of engagement can lead to challenges in retaining complex information, as genetics often involves abstract ideas that benefit from collaborative exploration (Topping & Trickey, 2014).

JS and TPS has been shown to improve students' academic performance in genetics and positively impact their problem-solving and critical-thinking abilities. According to Johnson (2015), CLS fosters these skills by encouraging students to actively participate, articulate their ideas and engage in problem-solving exercises as a team. A study by Abrami et al. (2021), supports this by showing that JS and TPS significantly enhances students' critical thinking and ability to apply concepts to real-world scenarios, compared to CPA. When students work collaboratively, they are more likely to encounter diverse perspectives, challenge their thinking, and ultimately strengthen their understanding, which is particularly advantageous for mastering complex genetic concepts (Roseth et al., 2008). In addition to improved academic performance, JS and TPS contributes to positive social and psychological outcomes, essential for overall student success in genetics. Research highlights that CLS environments encourage students to take ownership of their learning and develop a sense of responsibility toward their and their peers' success (Gillies & Boyle, 2021). This collaborative responsibility is crucial in genetics, where students can learn from one another and benefit from different problem-solving approaches within the group. In contrast, CPA may limit these social benefits, as individual learning without peer support can hinder the development of interpersonal skills crucial for scientific collaboration (Slavin, 2020). In summary, the literature suggests that JS and TPS improves genetics performance by fostering more profound understanding and retention and enhances critical thinking, problem-solving, and social skills, indicating that it may be a more effective approach than CPA for teaching genetics.

2.19 The Conceptual Understanding of Gender When Taught Genetics Using JS and TPS

Research examining gender differences in conceptual understanding when taught genetics through JS and TPS has shown that this instructional method benefits both male and female students by promoting an inclusive learning environment that supports engagement and understanding. According to Sharan (2019), CLS minimizes gender-based performance disparities by creating a collaborative atmosphere where students support each other's learning, which helps equal opportunities for academic success. Studies by Webb et al. (2017), found that female students often experience increased confidence and participation in JS and TPS environments, as cooperative settings encourage open communication and reduce the competitiveness frequently seen in traditional classrooms, helping both genders reach their academic potential in genetics.

Evidence also suggests that CLS like JS and TPS positively influence female students' performance in genetics, where they have historically underperformed compared to their male counterparts in traditional instructional settings (Gillies & Boyle, 2010). The cooperative structure allows female students to engage with the material through peer discussions and collaborative problem-solving, which has been shown to enhance comprehension and critical thinking skills. According to Gillies and Boyle (2010), CLS provides an environment where female students can thrive, as it values their contributions and facilitates active involvement. In contrast, traditional lecture-based approaches may not offer the same level of encouragement for female students, potentially impacting their academic performance in subjects like genetics.

Male students also benefit from JS and TPS in genetics education, as the strategies promotes higher engagement and accountability within the learning group. Research by Roseth et al. (2008), demonstrated that male students in cooperative learning environments improved their understanding of genetics more than those in conventional classroom settings, as the interactive nature of JS and TPS channels their energies toward productive academic collaboration. Moreover, as Gillies and Boyle (2021), observed CLS like JS and TPS encourages male students to develop skills in active listening and teamwork, which may not be emphasized in teacher-centered learning. This interaction fosters a well-rounded learning experience, enhancing genetics comprehension and social and collaborative skills across genders. JS and TPS appears to be effectively bridge gender performance gaps in genetics by accommodating the unique learning needs of both male and female students, facilitating a more balanced academic outcome. According to Johnson and Johnson (2015), the supportive environment of CLS helps to create a sense of positive interdependence, where students understand that their success is connected to their peers' success, promoting mutual responsibility and engagement. This learning model proves especially effective in genetics, as students benefit from diverse perspectives and shared problem- solving approaches, improving comprehension and performance across genders. Thus, the literature indicates that JS and TPS may be a highly effective approach for reducing gender disparities in genetics education and fostering academic achievement and collaborative skills.

Perception of Students on the Use of JS and TPs in Teaching Genetics

Research on student perceptions of the JS and TPS in teaching genetics highlights a generally positive response, with many students reporting enhanced engagement and understanding of complex concepts. According to Sharan (2010), students often perceive CLS as a refreshing departure from traditional lecture-based methods, allowing for more active participation and collaborative interaction. In studies conducted by Chiu (2020), students reported feeling more involved in the learning process when taught through CLS like JS and TPS, as the strategies encourages them to work together, discuss ideas and clarify misunderstandings with peers. This approach helps students feel more confident in grasping difficult topics in genetics, suggesting that JS and TPS can improve both understanding and self-efficacy. Students appreciate the peer support inherent in JS and TPS, which helps them learn more effectively from their classmates and enhances their overall learning experience. Research by Johnson and Johnson (2015), found that students value engaging with actively building on each other's ideas, especially in challenging subjects like genetics. This collaborative environment fosters a sense of community and shared learning, making students more willing to ask questions and express uncertainties they might otherwise hesitate to share in a traditional classroom setting. According to Hsiung (2021), students believe that CLS like JS and TPS reduces the isolation they sometimes feel in independent study, providing a supportive network that enhances their overall learning experience.

Studies reveal that students perceive JS and TPS as beneficial for developing skills beyond academic knowledge, such as communication, teamwork and problem-solving. A survey by Gillies and Boyle (2021), found that students recognized the importance of these skills in scientific fields and appreciated that CLS provided a structured way to develop them in the classroom. In the context of learning genetics, where students often need to tackle complex and abstract concepts, the collaborative structure of JS and TPS helps students approach problems collectively, drawing on various perspectives within the group. Through these interactions, students report better grasping genetic principles and developing essential skills applicable inside and outside the classroom (Roseth et al., 2019). Students perceive CLS (JS and TPS) as a highly effective and enjoyable approach to learning genetics, appreciating both the academic and interpersonal benefits. According to Abrami et al. (2021), students express that CLS makes learning more engaging and challenging content more accessible by breaking down complex ideas through group discussion. This positive perception aligns with the goals of CLS, which aim to foster deeper understanding and collaborative learning. Given these findings, JS and TPS appears well-received by students as an instructional method for teaching genetics, offering a dynamic and supportive alternative to conventional pedagogical approaches that foster academic success and personal development.

2.20 Empirical Review

According to Zhang (2010), cooperative learning fosters student communication while increasing productivity and academic success rates. In contrast to the conventional lecture-based approach, cooperative learning improved students' enthusiasm and attitude in a biology class, resulting in higher academic accomplishment. Their degree of satisfaction, interest, evaluation and comprehension of the subjects taught via the cooperative learning approach demonstrated this. The study's conclusions also demonstrated the necessity of collaborative learning techniques training for teachers. The cooperative learning approach had to be implemented for learning to be effective. Some policy guidelines must be developed to effectively lead instructors and students through the method's step-by-step application (Rabgay, 2018). Al-Obeidi (2013), in contrast to the traditional method, aimed to ascertain the extent to which the Jigsaw method of cooperative learning influenced the past achievements of female fourth graders. The study sample in Diyala was split into two groups: the control group, which comprised 43 female students who were instructed using the traditional approach, and the pilot group, which comprised 42 female students who were instructed using the Jigsaw strategy. A history achievement test with 50 multiple-choice questions was created by the researcher, who also verified the test's validity, reliability and objectivity. After evaluating the data using the t-test of two independent samples, the researcher came to the conclusion that there was a statistically significant difference in favor of the experimental group. At the Fatima Zahra School for Girls of the Al-Anbar General Directorate of Education, Al-Qaisi (2015), aimed to ascertain the effects of the Jigsaw strategy versus the conventional technique on the achievement of physics and scientific processes for first- middle grade pupils. Sixty-two female students, thirty-two students from section A, and thirty-one students from section B were included in the study sample. Additionally, students who failed the course were statistically eliminated to assure equivalency due to their additional experiences. In terms of achievement and scientific operations, the experimental group outperformed the control group when physics was taught using the Jigsaw method, according to the study.

Cooperative learning is increasingly popular in many nations (Açıkgöz, 2014). The most important indications are the volume of research on cooperative learning, the intensity of the activities conducted on the topic, and the size of the participants in these activities. Similarly, students actively participate in today's view of education and the student-centered nature of the cooperative learning approach draws attention. Students can easily transition into this position because cooperative learning is a student-centered model that encourages active learning. The current educational curricula, therefore, aim to produce qualified, scientifically literate individuals who can comprehend and interpret science, come up with creative solutions to scientific problems, cooperate with others and potentially contribute to the nation's development. In order to support students in understanding fundamental scientific concepts and developing the capacity to assess scientific data when developing and testing ideas, some nations (such as the United States) have established general standards for science education (such as the Next Generation Science Standards, or NGSS). It is crucial to incorporate the fundamental scientific knowledge learned in various areas. Biology is one of the scientific fields in which research looks to accomplish these objectives (Nurse, 2016). Scientific advancements in biology, significantly impact national economies and social dynamics. Biology impacts various disciplines, including economics, agriculture, medicine and defense (Tatar, 2006).

2.21 Summary of Literature Review

The literature review in this study emphasizes the effectiveness of Cooperative Learning Strategies (CLS) over Conventional Pedagogical Approaches (CPA) in teaching genetics to senior high school students. JS and TPS fosters a more profound understanding and retention of complex topics like genetics by promoting student-centered, active engagement. Studies highlighted in the review indicate that students in JS and TPS settings tend to perform better in assessments and retain knowledge for longer periods than in CPA environments. This advantage is largely attributed to the collaborative atmosphere in JS and TPS, where students are encouraged to discuss and resolve their doubts with peers, thereby enhancing comprehension and fostering critical thinking skills. The literature also addresses the impact of JS and TPS on gender-based performance disparities, revealing that CLS benefits both male and female students by creating an inclusive learning environment. The collaborative nature of CLS helps reduce performance gaps, as it promotes equal participation, builds confidence and enhances engagement, particularly for female students who may thrive better in supportive, interactive settings than in traditional lecture-based approaches. Research demonstrates that CLS encourages both genders to participate actively, ultimately leading to improved academic outcomes and minimizing gender disparities in science education.

Student perceptions of JS and TPS are overwhelmingly positive, with many expressing that cooperative learning enhances their engagement and understanding of complex genetics concepts. Unlike the passive learning typically associated with CPA, CLS allows students to participate more fully, which many find refreshing and empowering. Studies show that students appreciate the peer support inherent in CLS, which helps build a collaborative learning community where they feel more comfortable expressing uncertainties and seeking help from their classmates. This peer interaction fosters a sense of responsibility and supports the development of academic and social skills. The literature highlights the additional benefits of CLS, including improved communication, teamwork and problem-solving skills, which are crucial in scientific education and beyond. These interpersonal and cognitive skills are developed more effectively in CLS settings due to the collaborative requirements of the learning process. As a result, CLS enhances students' academic performance in genetics and equips them with essential life skills, making it a valuable pedagogical approach in diverse educational contexts.

CHAPTER THREE

METHODOLOGY

3.1 Research Study Area

The investigation was carried out within the Sekyere South Municipal in the Ashanti region of Ghana. Agona is the principal town within this Municipal. Four (4) Senior High Schools, each providing instruction in science, are located within the Sekyere South District. Agona SHTS, SDA SHS, Adu Gyamfi SHS, and Okofo Anokye SHS are in the Sekyere South District.

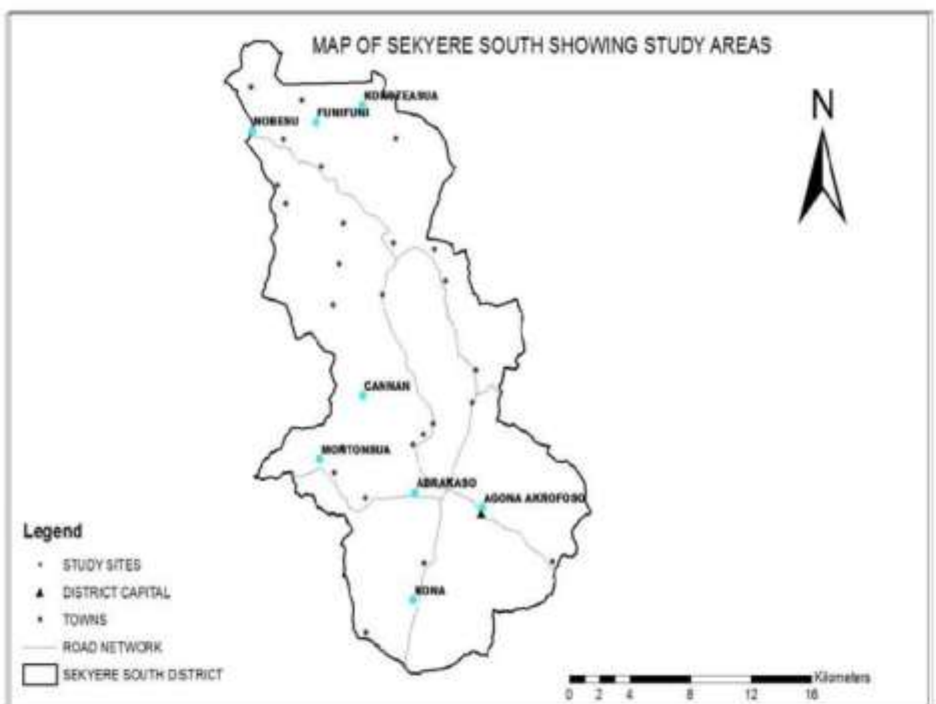


Figure 3.1: Map of Sekyere South Municipal

3.2. Research Design

The study employed a quasi-experimental pretest/post-test non-equivalent control group design. This particular design was selected because the study occurred in the natural environment of various schools with intact classes. Comparable to accurate experimental designs, quasi-experimental research designs provide some degree of control over the independent variable or variables but do not grant complete control. An empirical interventional study that uses randomized assignment to evaluate the causal impact of an intervention on a target population is called a quasi-experiment. Researcher control over treatment condition assignment is usually possible using quasi-experimental designs, provided that criteria other than random assignment are used (DiNardo, 2015). Quasi-experimental designs are generally more straightforward to set up than accurate experimental designs, which call for the random assignment of subjects because they are employed when randomization is impracticable. This includes two experimental and two control groups. Independent variables are manipulated to see their effects on the dependent variable. While the experimental groups were treated, the control group was exposed to the lecture method. Simple random sample was used to select two schools out of four schools in the district. Genetics Achievement Test and structured interview questions was used as research instrument .The Genetics Achievement Test was pre-tested in different school of the same level. The design of the study is illustrated in the **diagram 3.2.1**

A diagram of the research design

E → T1 → X1 → T2

C → T1 → XC → T2

C = Control Group

E = Experimental Group

XC------------- Treatment for Control Group

X1 ------------------ Treatment for Experimental Group

T1……………… Pretest

T2………………Post-test

JS and TPS tactics were used to treat the experimental group, whereas the traditional method was used to teach the control group. A post-test was also given to each group two weeks following the therapy to assess information retention.

3.3. Research Paradigm

Post-positivism is a framework well-suited to the nuanced study of educational interventions, such as comparing cooperative learning strategies (CLS) like JS and TPS with conventional pedagogical approaches (CPA) on student performance. Post-positivism moves beyond the traditional positivist belief in absolute truth, acknowledging that knowledge is conjectural and subject to revision, especially in the social sciences, where human behaviors and environmental factors add complexity (Phillips & Burbules, 2019). This paradigm is particularly useful in educational research as it allows for empirical, quantitative analysis while recognizing that factors such as class dynamics and individual learning preferences may impact outcomes (Lincoln et al., 2018).

Post-positivism's strength lies in its balance of objectivity and flexibility, particularly when examining instructional strategies where external variables often influence student outcomes. For instance, comparing CLS and CPA methods in high school genetics education requires controlling for diverse student characteristics, learning histories and classroom interactions. Post-positivism enables researchers to utilize quantitative methods like ANCOVA and t-tests to address these variables, thereby minimizing biases and increasing the reliability of findings (Bryman, 2016). This rigorous yet adaptable approach provides a realistic framework for analyzing complex educational interventions while acknowledging that results may not be universally generalizable.

Quantitative methods within a post-positivist framework allow researchers to measure and compare educational outcomes systematically. In such study, tools like ANCOVA help control for initial performance differences across groups, ensuring that pre-existing knowledge disparities do not skew the results (Tabachnick & Fidell, 2013). By comparing adjusted post-test scores, researchers can make data-driven inferences about the effectiveness of CLS versus CPA, making post-positivism a suitable paradigm for studies aiming to measure and evaluate instructional impact statistically robustly (Guba & Lincoln, 2018). The post-positivist approach also supports systematic control of potential biases, a key consideration when evaluating instructional strategies. For example, using intact classes from different schools helps to control for group interactions that might confound the findings. In educational research, student engagement, prior knowledge and sociocultural factors can all influence outcomes, making it critical to address these confounding variables (Denzin & Lincoln, 2020). Post-positivism encourages using statistical controls and carefully structured designs to mitigate such biases, ensuring that findings more accurately reflect the impact of the instructional method itself (Babbie, 2019). Another important aspect of post-positivism is its commitment to evidence-based knowledge that is continually refined in light of new findings. In contrast to positivism, which seeks unchanging truths, post-positivism accepts that knowledge is constantly evolving, especially in fields like education, where instructional methods and student demographics are in flux (Robson & McCartan, 2016). This openness to revisiting and refining conclusions ensures that post-positivist research remains relevant, promoting iterative improvements in teaching strategies based on empirical evidence and practical classroom experiences (Merriam & Grenier, 2019).This paradigm aligns well with current trends in education, emphasizing evidence-based practices, where findings are used to inform and refine instructional approaches. The adaptability of post-positivism allows educators and researchers to test, implement and continually improve strategies like cooperative learning, which has shown benefits for student engagement and comprehension in diverse classroom settings (Hattie, 2017). By grounding conclusions in empirical data, while remaining open to future adjustments, post-positivism supports sustainable, effective educational practices that respond to the needs of both students and educators.

Post-positivism is also well-suited to quasi-experimental designs, often employed in educational research where randomized control is not feasible. Using intact classes from different schools is an example of such a design, allowing researchers to observe naturalistic effects without artificial manipulation of the learning environment. This design enhances the authenticity of findings, as it respects the real-world dynamics of education, thus making post-positivism ideal for studies prioritizing statistical rigor and practical applicability (Yin, 2003). Post-positivism offers a rigorous yet flexible framework that accommodates the complexities of educational research. By employing quantitative methods while acknowledging the inherent variability in human-centered studies, this paradigm enables researchers to control for confounding factors and make statistically sound inferences regarding the effectiveness of instructional strategies like CLS (JS, TPS) and CPA. The study's goal of evaluating these strategies in a high school genetics course benefits from post-positivism's balanced approach, as it supports both empirical validation and continuous refinement of educational practices (Cohen et al., 2018).

3.4. Population

The study involved all Biology students in the third year of Senior High School (SHS 3) in the Sekyere South Municipal, located in the Ashanti Region of Ghana. However, the population accessible for this study was limited to the SHS 3 Biology students in the Sekyere South Municipal. The reason for explicitly selecting SHS 3 students is because the topic of Genetics is taught at this level, as stipulated in the Ministry of Education's syllabus.

3.5. Sample and Sampling Technique

Out of the four senior high schools in the Sekyere South Municipal where the study was conducted, two were selected through simple random sampling. From each selected school, one intact class was chosen to minimize potential group interactions. To control for potential interactions between groups, each intact class was selected from a different school, ensuring that students in the cooperative learning strategy (CLS)-JS, TPS and conventional pedagogical approach (CPA) groups were geographically and socially separate. This approach minimized the risk of cross-group influence, as students from distinct schools were unlikely to interact or share insights that could impact the study's outcomes. By keeping each instructional group within its own school setting, the study effectively isolated the effects of the instructional methods, maintaining a controlled environment that attributed performance changes solely to the teaching strategy employed rather than external group interactions. This method ensured more explicit, reliable comparisons between the CLS and CPA groups, strengthening the study's validity. Random Selection of class for the control group and experimental group

3.6. Research Instruments

Genetics Achievement Test (GAT) was used. The test is worth 30 marks and consists of eight essay-type questions. Students can answer six out of the eight questions for thirty marks. Five marks are awarded to each question for correct answers. Students were allowed to choose from the list of options to express themselves. Partial marks were allocated for partial answers. The choice of the essay type allows the investigator to know whether the students understood the lesson when they can construct sentences independently. Interview sections were also organized among some selected students. The investigator created this tool.

3.7 Pilot testing

The instrument was pre-tested in similar classroom setting to support construct validity, allowing for adjustments based on observed student responses and comprehension. The instruments were pilot tested in Agona Senior High Technical School. Form three science students took part in the pilot testing with intact class of 46 students with 28 boys and 18 girls. This process helped verify that the instrument assesses genetics knowledge effectively and minimizes potential biases, ensuring that it provides a reliable measure the instructional method's impact on student learning outcomes.

3.7. Validity of the Instrument

The instrument's validity in this study is critical to ensure that it accurately measures student performance in genetics and reflects the intended learning outcomes of both the jig saw and think pair share strategies and conventional pedagogical approach (CPA). Content validity was established by aligning the test items with the curriculum standards and learning objectives for high school genetics, ensuring that the instrument comprehensively covers essential concepts and skills required in the subject **(**Kalkbrenner**,** 2021). Subject- matter experts, such as experienced biology educators, reviewed the test items to confirm their relevance and appropriateness for the student's grade level, enhancing the instrument's face and content validity.

3.9 Reliability of the Instruments

To ascertain the dependability of the research instruments employed in this investigation a mini study was conducted in a different SHS exhibiting comparable traits those of the research participants. The Genetics Achievement Test (GAT) was subjected to a pilot study. The scores and responses from the pilot study were statistically evaluated using the inter-rater reliability statistic**,** the results of which are presented in **Table 3.1**.The scores are found in **appendix six (6).**

Table 3.1: Inter-Rater Reliability Results for GAT

Approximate		**Asymptotic Standard Approximate**		
		Value	**Error**	**T**^{b}
Significance				
Measure of Kapa	.690	0.68	38.453	.000
Agreement				
N of Valid Cases		46		

As observed from Table 3.1, in this study, the value of Kappa's measure of agreement, as seen from Table 3.3, was 0.690. Mchugh at al. (2021), provided a scale for interpreting measures of agreement where values ≤ 0 indicate no agreement, 0.01–0.20 indicate none to slight agreement, 0.21–0.40 indicate fair agreement, 0.41–0.60 indicate moderate agreement, 0.61–0.80 indicate substantial agreement, and 0.81–1.00 indicate almost perfect agreement. Therefore, per the scale, Mchugh at al. (2021), gave Kappa's measure of agreement, as presented in Table 3.3, was deemed substantial agreement. Therefore, the results from the pilot test of the GAT were deemed reliable for the instrument to be used in the main study.

3.10 Data Collection Procedure

3.10.1. Pre-Intervention Phase

Official authorization for the investigation was received from the headmasters/headmistresses of the chosen schools. The biology educators and diverse departmental leaders were also notified. A preliminary examination was carried out in a separate school with comparable traits to the primary research schools, which abstained from participating in the principal investigation. This aided in guaranteeing the efficiency of the research tools in relation to their validity and reliability**.** In order to secure the utmost collaboration of students and engage in ethically virtuous investigation, the researcher also explained to the students the purpose behind the research and the subsequent advantages it will contribute to their academic achievement. The subsequent phase was also followed by randomly allocating schools and classes into experimental and control groups, upon which the preliminary assessments of the Genetics Achievement Test (GAT) were administered.

3.10.2 Intervention Phase

After making the necessary preparations, the intervention commenced, where students actively participated in the instructional process. The diverse groups, namely the experimental and control groups, received instruction in genetics content for four weeks each. The researcher utilized distinct lesson plans for the experimental and control groups, ensuring that the content, assignments, and exercises remained consistent across both groups. Lesson plan in **appendix 2**

3.10.3 Post-Intervention Phase

During the final week, the post-intervention data collection took place. In this stage, the researcher recruited biology teachers from the assigned schools to help give the Genetics Achievement Test (GAT) to the experimental and control groups as part of the post-intervention evaluations. Subsequently, the researcher evaluated the students' written responses, which were prepared for subsequent data analysis.

3.11 Data Analysis Procedure

The data obtained from the research instruments were analyzed quantitatively and qualitatively. The scores and responses derived from the Genetics Achievement Test (GAT) were analyzed using SPSS for Windows. The following statistical tools were used to test the research questions. Research questions one and two were analyzed using non-parametric tests, specifically the Mann- Whitney U test because the collected data was not normally distributed. This was done to determine whether there is a statistically significant difference between the means in two unrelated groups and how they rank against each other. Research question three was tested using qualitative means, using thematic analyses. These analyses were done with an alpha of 0.05 threshold of probability ($p<0.05$), which served as the foundation for presenting findings on noteworthy differences between the scores of the control and experimental groups after exposure to the cooperative learning strategy.

3.11.1 Ethical Considerations

An official letter of authorization issued by the Department of Science Education was used to solicit appropriate authorization from the governing bodies of the educational institutions involved in the research. Furthermore, the individuals who participated in the study were provided with a comprehensive explanation of their rights and the anticipated advantages associated with their involvement. In addition, the participants were guaranteed their utmost level of anonymity and confidentiality.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter reports the findings of the study, provides answers to the research questions and offers a discussion of the results.

4.1 Distribution of Participants

This section provides the distribution of participants, which is presented in Table 4.1. The distribution was presented based on groups and gender.

Table 4.1: Distribution of Participants

Group	Frequency	Percentage Experimental
Male	22	27.3
Female	26	23.16
Total	48	50.53
	Control	
Male	22	27.3
Female	23	23.16
Total	**45**	**50.53**

Source: Field Data (2024)

Table 4.1 provides an overview of the distribution of participants in an experimental study examining the effects of jigsaw and think pair share strategies on senior high biology students' performance in genetics. Interestingly, the sample is split into two groups: a control group that uses conventional learning techniques and an experimental group that is exposed to JS and TPS. With 48 students in the experimental group (50.53%) and 47 in the control group (49.47%), this balanced distribution ensures comparable sample sizes for trustworthy statistical analysis, supporting the study's validity (Johnson & Johnson, 2007). Such parity minimizes selection bias and enhances the reliability of conclusions drawn from the study. Gender distribution within both groups reflects an attempt at gender inclusivity, with males slightly outnumbering females in the experimental and control groups. Specifically, the experimental group comprises 26 males (27.37%) and 22 females (23.16%), while the control group includes 24 males (25.26%) and 23 females (24.21%). This distribution mirrors findings from prior studies that emphasize the importance of gender representation when assessing educational interventions, as gender can influence group dynamics and learning styles (Slavin, 2020). Additionally, balanced gender representation enables a more comprehensive analysis of jig saw and think pair share impact across genders, which is critical for generalizing the findings.

The gender balance between both groups is crucial for evaluating how jigsaw and think-pair-share impacts male and female students differently. Previous research suggests that cooperative learning can foster improved academic engagement, particularly for female students, who often benefit from collaborative, discussion-oriented settings (Gillies, 2021). Conversely, male students have shown varied responses to JS and TPS, with some benefiting from the interactive nature, while others may perform better in competitive or individual-based tasks (Kagan, 2009). Therefore, the gender distribution in this study provides a valuable basis for comparing the performance outcomes of males and females in a cooperative learning environment, further enriching the findings. In the experimental group, the exposure to jigsaw and think pair share strategies can be particularly beneficial in a subject like genetics, which often involves complex processes and abstract concepts. Studies have shown that cooperative learning can help students grasp complex content by facilitating peer discussions and allowing students to articulate their understanding, reinforcing retention (Abrami et al., 2021). By assigning students to work collaboratively, the experimental group likely experiences increased engagement and motivation, particularly in topics that require conceptual understanding, such as genetics (Van -Ryzin et al., 2020). This supports research showing that student performance in scientific courses is improved by cooperative learning techniques, which encourage active learning and engagement with difficult content.

In contrast, the control group, which continues with traditional learning methods, may face challenges grasping complex genetic concepts due to the lack of peer interaction and collaboration. Traditional instruction, characterized by individual learning and teacher-centered approaches, is less effective in fostering more profound understanding, particularly in STEM subjects (Roseth et al., 2019). For instance, genetics often requires multi-layered cognitive processing, which students can better achieve through collaborative learning that allows peer support and knowledge-sharing. The absence of this interactive element in the control group may result in less retention and comprehension, potentially leading to lower academic performance than in the experimental group. The nearly equal distribution of participants across gender and group conditions strengthens the study's validity. It allows for a balanced analysis of cooperative learning's effectiveness in enhancing biology students' performance in genetics. This alignment of participant characteristics with the study design supports robust findings that may affect educational practices. By providing empirical evidence on the potential benefits of jigsaw and think-pair-share, this study can inform policies to improve science education outcomes, aligning with recent educational recommendations that advocate for active and collaborative learning strategies in complex subjects like genetics (Slavin, 2020; Abrami et al., 2021).

4.2 Data Suitability

Normality tests were done before assessing the study's results to ensure that the data was appropriate for a parametric test. The results are presented in the next section.

4.2.1 Normality Analyses of the Scores

The experimental and conventional groups' pretest and posttest findings were subjected to a normality test to ascertain whether parametric or non-parametric testing should be used. Numerical methods were used. Therefore, the Shapiro-Wilk and Kolmogorov-Smirnov tests were used quantitatively. Normality tests were performed under the null hypothesis that "the data sets are normally distributed (Das et al., 2022). The null hypothesis is rejected if the (p) values for the Kolmogorov-Smirnov and Shapiro-Wilk tests are less than the alpha level (0.05). Table 4.2 presents the results of the normality tests.

Table 4.2: Results on the Normality of the Test Scores

Groups		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Experimental	Pretest	.188	47	.000	.898	47	.001
	Post-test	.227	47	.000	.885	47	.000
Control	Pretest	.188	47	.000	.898	47	.001
	Post-test	.193	47	.000	.930	47	.008

a. Lilliefors Significance Correction

Table 4.2 presents the results of normality studies that checked whether the experimental and control groups' pretest and posttest scores were distributed normally using the Shapiro-Wilk and Kolmogorov-Smirnov tests. The p-values for every group and test result were below the 0.05 alpha threshold. This suggests that the data were not normally distributed, so non-parametric statistical techniques were required for further analysis. These results are consistent with the accepted rules for choosing statistical tests according to the distribution of the data (Das et al., 2022). Given the breach of normalcy assumptions, the choice to employ non-parametric tests, like the Mann-Whitney U test, guarantees the validity of the findings.

4.3 Results of the Study

This section presents the results of the various datasets taken from the respondents based on the research questions.

4.3.1 Results for Research Question 1

What is the difference in conceptual understanding between students taught genetics in Senior High School through the jig saw and think-pair-share strategy and those taught using the conventional pedagogical approach?

The difference in conceptual understanding between the two groups was determined by performing a Mann-Whitney U test on both students' pretest scores to justify differing interventions. The Mann-Whitney U test was performed since the data was not normally distributed. Table 4.3 shows the Mann-Whitney U test of the students' pretest results prior to the intervention.

Table 4.3: Mann-Whitney U test on the Pretest scores of both the Experimental and Control groups

Comparison	Mean Ranks	Mann-Whitney U	Z	N	*P*
Experimental Group	47.98	1127	-0.01	95	0.99
Control Group	48.02				

The pretest results of students in the experimental group, who were instructed using the jigsaw and think- pair- share technique and the control group, who were instructed using the traditional pedagogical approach, are compared in Table 4.3. According to the findings, the experimental groups mean rankings (47.98) and the control group's (48.02) were almost identical. There was no statistically significant difference between the groups' pretest results, as indicated by the Mann-Whitney U statistic of 1127 and the p-value of 0.99. These results show that prior to applying any instructional interventions, the initial performance of both groups was comparable. Since it verifies that any detected variations in post-test performance may be ascribed to the intervention rather than underlying inequities, this comparability is crucial for guaranteeing the validity of further studies.

Results on the difference in conceptual understanding between Experimental and Control Groups

Following the pretest results, the Mann-Whitney U test was repeated on both groups' post-test scores to examine the effects of each intervention on students' performance. Table 4.4 displays the Mann-Whitney U test of the students' post-test outcomes following the intervention.

Table 4.4: Mann-Whitney U test (Post-test) on the difference in performance between both groups

Comparison	Mean Ranks	Mann-Whitney U	Z	N	Effect size	*P*
Experimental Group	71.50	4560	-8.43	95	0.86	0.001
Control Group	24					

The post-test results of the experimental and control groups after the intervention are examined in Table 4.4. The experimental group achieved a much higher mean rank (71.50) than the control group (24.00), indicating a substantial difference between the groups, according to the data. The Z-value was -8.43, the p-value was 0.001, and the Mann-Whitney U statistic was 4560. These results show that the jig saw and think-pair-share technique had a statistically significant favorable effect on student's performance compared to the traditional educational method. Furthermore, a substantial influence was shown by the effect size (r), computed as 0.86. This outcome highlights the jigsaw and think-pair-share strategies potential as a pedagogical tool in educational contexts and demonstrates how well it works to improve genetic student performance.

4.3.2 Results for Research Question 2

What is the difference in conceptual understanding between male and female Senior High School Biology students who are instructed using the jigsaw and think- pair- share strategies in genetics?

Due to the failure of the dataset, to meet the assumption of the normality test, a Mann-Whitney U test was run on the pretest and post test results of both male and female students in the cooperative learning strategy to serve as a baseline for determining their differences in their performance.

Table 4.5: Mann-Whitney U test (Pretest) on the difference in performance between male and female students

Comparison	Mean Ranks	Mann-Whitney U	Z	N	Effect size	*P*
Female	22.27	237	-1.04	48	0.15	0.29
Male	26.38					

From Table 4.5 above; the findings indicate that the mean rank of male students was higher (26.38) than that of the female students (22.27). With a p-value of 0.29 and a Z-value of -1.04, the Mann-Whitney U statistic was 237. The p-value is greater than statistical significance at the 0.05 level, this depicts that there was no statistical difference between the performance of both male and female students prior to the introduction of the intervention (cooperative learning strategy) and any changes in their performance after the intervention might be attributed to the cooperative learning strategy. Though, the effect size (r) was 0.15, suggesting a small, these results imply that although male students outperformed female students, the difference was not statistically significant.

Table 4.6: Mann-Whitney U test (Post-test) on the difference in conceptual understanding between male and female students

Comparison	Mean Ranks	Mann-Whitney U	Z	N	Effect size	*P*
Female	28.59	196	-1.90	48	0.27	0.06
Male	21.04					

The post-test performance differences between male and female students in the experimental group, which employed the jigsaw and think- pair- share strategies, are assessed in Table 4.6. The findings show that the mean rank of female students was higher (28.59) than male students (21.04). With a p-value of 0.06 and a Z-value of -1.90, the Mann-Whitney U statistic was 196. The p-value fell short of statistical significance at the 0.05 level despite the effect size (r) being 0.27, suggesting a small to medium influence. These results imply that although female students outperformed male students by a small margin, the difference was insignificant. In order to investigate any gender variations in reaction to the JS and TPS technique, more study with a bigger sample size could be required.

4.3.3 Results for Research Question 3

What are the perceptions of SHS biology students on the use of jigsaw and think- pair- share strategies in the teaching and learning of genetics?

Theme 1: Improved understanding and retention

Students' perceived that cooperative learning improved their understanding and retention of complex genetic concepts since working in groups provided them with opportunities to discuss and clarify difficult topics. By explaining these concepts to peers and hearing different perspectives, students could reinforce their own understanding and remember information more effectively. For instance, in their own expression, **Kofi** stated that:

> ―*Discussing genetic concepts with my group helped me understand the details of DNA replication much better. I could remember the steps more clearly because*

we talked to each other.

Also, **Esi** said that:

> ―*I always struggled with Genetics crossing, but after explaining them to my peers and working through examples together, it finally clicked. Now I can do them on my own confidently*.

Again, **Keziah** articulated that:

> ―*By teaching my friends about genetic mutations, I realized how much I had actually learned. Explaining it made it stick in my mind*.

In another voice, **Kwabena** also, expressed that:

> ―*Working in a group helped me to see different ways of solving genetic problems, which helped me understand what we learned from different perspectives and remember what we learned for a longer period of time*.

Theme 2: Improved confidence and participation

Working in a supportive group environment can boost students' confidence. Students are more likely to ask questions and participate in discussions when they feel that they are not alone in their learning journey. This collaborative atmosphere encouraged students to take risks, share their ideas and learn from their mistakes without fear of judgment as students noted. For example, in the expression of **Ama**, it was said that:

> ―*I felt more confident asking questions in the small group settings. I wasn't afraid of looking dumb in front of the whole class. Meanwhile, at first, I always felt shy to ask or answer questions in class*.

To add to **Ama** voice, **Kojo** added that:

> ―*I used to be shy about speaking up, but my group was really supportive, which helped me become more comfortable to participate in the lesson*.

Also, **Akua** expressed that:

> ―*Sharing my ideas with my classmates and group members and getting positive response boosted my confidence. I'm now more active in class discussions*. *But I wasn't all that active since form one*.

Again, **Yaw** stated that:

> ―*Participating in group work made me realize that I understood more than I thought, which increased my confidence in my abilities*.

Theme 3: Enhanced social and communication skills

Cooperative learning inherently involves significant social interaction. Students reported improvements in their communication skills as they articulated their thoughts, listened to others, and negotiated different viewpoints. These skills were not only beneficial for learning genetics but are also valuable for their overall personal and academic development. For instance, according to **Manu**:

> ―*I learned how to explain difficult ideas clearly to my group members, which improved my communication skills*. *Now I can learn with people and stand in front of people to explain things and I like that*.

In addition to that, student J noticed how cooperative learning strategies helped him become a good listener. According to **Enok**,

—Group work helped me become a better listener because I had to understand others' points of view in order to contribute effectively. At first, I only wanted to speak because I felt I knew most of the things we were learning.

Also, **Sly** added that:

—Collaborating with different people in my group taught me how to work well with others and respect different opinions." I always argued and questioned what others knew. But in these group activities, because of the rules, i have learned to respect other people's opinions and ideas.

Theme 4: Improved attitudes towards genetics

Students tend to develop more positive attitudes towards learning when jigsaw and think-pair-share strategies are used. In this study, students enjoyed the collaborative nature of the lessons and were more likely to view learning as a fun and rewarding activity rather than a solitary and stressful task. Specifically, in **Foriwaa's** opinion, it was said that:

—I developed a positive attitude towards studying genetics because the jig saw was fun and interactive. I now like genetics too much. After the second test, I always find genetics question and solve almost every day.

Also, **Stevo** noted that:

—The group activities were supportive and made me look forward to genetics class instead of fearing it. Previously, when I was to prepare for genetics class, I felt worried, because I thought I was coming to receive scolding's and meet boring lessons. But now I feel free and like genetics more.

Again, **Esther** remarked that:

> ―The *group activities made me see learning genetics as enjoyable and not a forced work. The collective nature of group activities changed learning from not being interesting to interesting and enjoyable experience. Now I have a positive attitude towards studying genetics*.

4.4 Discussion of Findings

4.4.1 Difference in Conceptual Understanding of Genetics between Senior High School Biology Students Taught Using the Jigsaw and Think-Pair-Share Strategies and Those Taught Using the Conventional Pedagogical Approach

According to the Mann-Whitney U test results, the experimental and control groups' pretest scores were statistically identical, as shown in Table 4.3. In order to make sure that observed variations in post-test performance are due to the instructional interventions and not pre-existing inequities, comparability is essential. The lack of a significant difference supports the claim that both groups started the study with comparable levels of genetic knowledge ($p = 0.99$).

This is consistent with earlier studies that highlight the value of comparable baseline measurements in educational interventions (Hallberg et al., 2018). This kind of similarity strengthens the study's internal validity and makes it possible to evaluate the effects of the JS and TPS technique more clearly. Research question one aimed to determine the difference in performance between students taught genetics through the cooperative learning strategy and those taught using the conventional pedagogical approach. It was found that students using a cooperative learning strategy performed better in genetics than those taught using the conventional pedagogical approach. This finding is consistent with the findings of Attipoe (2015), Karacop (2017), Rabgay (2018), Muiawan (2020), Qamar and Saeed (2023) and Suuk et al. (2024). Notably, these studies found cooperative learning strategies more effective than the conventional teaching approach in different biology concepts. The study finds that jig saw and think pair share learning strategies enhance student performance in genetics compared to conventional pedagogical approaches, highlighting the significant impact of collaborative learning environments on educational outcomes. Cooperative learning like jig saw and think pair share, which involves students working in small groups to achieve common academic goals, fosters a more interactive and engaging learning experience (Gillies, 2016).

This approach promotes a deeper understanding of complex concepts Wyman and Watson (2020), develops essential skills such as communication, teamwork and problem-solving (Johnson & Johnson, 2018). These elements are crucial in genetics, a subject that often involves intricate and abstract concepts that can be challenging to grasp through traditional lectures. One reason for the improved performance under cooperative learning strategies is the active engagement it promotes. According to Johnson and Johnson (2018), in a cooperative learning setting, students are not passive recipients of information but actively participate in their learning process. This active engagement encourages them to think critically and ask questions, leading to a deeper understanding of genetic concepts (Awofala & Lawani, 2020). Peer discussions and group problem-solving sessions allow students to explain concepts to each other, reinforcing their understanding and uncovering misconceptions through collaborative efforts (Baloche & Brody, 2017). Moreover, the cooperative learning model aligns well with the constructivist theory of education Johnson and Johnson (2018), which posits that learners construct knowledge best through active engagement and social interaction. In the context of genetics education, students are more likely to understand and retain complex genetic principles when actively involved in discussions and problem-solving activities. This approach makes learning more engaging and helps students develop critical thinking and analytical skills, which are essential for mastering the intricacies of genetics. Furthermore, cooperative learning environments provide immediate feedback and support (Johnson & Johnson, 2018). Students who work in groups can quickly address any confusion by discussing it with their peers. According to Silva et al. (2021), this peer support system is particularly beneficial in genetics, where understanding one concept often depends on mastering previous ones. The immediate clarification and support reduce the likelihood of students falling behind, ensuring a more cohesive and continuous learning experience. Another critical aspect of cooperative learning is the development of social and communication skills (Silva et al., 2021). Cooperative learning helps build a sense of community and belonging among students. When students work together towards a common goal, they develop relationships and camaraderie that can enhance their overall educational experience (Bousalem et al., 2023). However, Genetics often involves complex terminology and processes that can be intimidating. However, cooperative learning encourages students to articulate their thoughts and reasoning, improving their ability to communicate complex ideas clearly and effectively. This practice not only aids their understanding of genetics but also prepares them for future scientific endeavors where collaboration and communication are key.

The positive outcomes associated with cooperative learning may also be attributed to increased motivation and engagement. According to Lei et al. (2023), when students work together, they often find the learning process more enjoyable and less isolating. The social aspect of cooperative learning can increase their motivation to participate and invest effort in their studies. This heightened motivation can lead to better attendance, increased participation, and a more positive attitude towards the subject matter, all of which contribute to improved academic performance in genetics.

4.4.2 Difference in conceptual understanding between male and female Senior High School biology students taught genetics through the jigsaw and think-pair-share strategies

Table 4.5 examines possible gender disparities in the cooperative learning strategy's efficacy. Although female students outperformed male students in terms of mean rank (28.59), the difference was not statistically significant (p=0.06). This implies that the cooperative learning approach was equally beneficial to male and female students, confirming its gender neutrality and inclusiveness. This result challenges long-standing stereotypes about gender differences in academic performance, particularly in STEM (Science, Technology, Engineering, and Mathematics) fields like genetics, but also highlights the potential of cooperative learning to create a more equitable educational environment. This finding supports the findings of Achor et al. (2013), as well as Akhigbe and Adeyemi (2020) and Ekineh and Adolphus (2019), who found the use of cooperative learning strategies to bridge the gender gap in biology.

Historically, male students have often been perceived to perform better in STEM subjects (Amedu, 2015; Azman, Nor, & Shah, 2018; Ekineh & Adolphus, 2019; Wrigley-Asante, Owusu, & Danquah, 2023), which can lead to biases in teaching and assessment practices (Achor, Orokpo, & Okoh, 2019). The study's results suggest that female students perform just as well as their male counterparts when given equal opportunities to engage in interactive and collaborative learning environments. This parity indicates that cooperative learning can help mitigate the effects of gender-based biases and provide an equal platform for all students to excel. Moreover, the equal performance of male and female students suggests that cooperative learning strategies may be particularly effective in addressing different learning needs and styles that are not adequately catered for in traditional teaching methods. In conventional classroom settings, the teaching style may inadvertently favor one gender over another due to differences in communication styles, engagement preferences, or responses to competitive versus cooperative tasks (Otukile-Mongwaketse, 2018). Cooperative learning, by its nature, involves diverse activities and collaborative problem- solving, which can engage a wider range of students effectively and inclusively (Achor et al., 2013). Again, according to Li (2016), students are frequently placed in competing groups in the conventional classroom, with grades and achievements serving as measures of individual success. This competitive atmosphere can exacerbate existing inequalities Wrigley- Asante et al. (2023), as it tends to favor those already confident and capable, while others may feel discouraged or marginalized. Gender stereotypes and societal expectations can further influence these dynamics, often placing additional pressure on female students to conform to specific roles and on male students to assert dominance (Agyepong & Diabah, 2021). According to Akhigbe and Adeyemi (2020), cooperative learning strategies mitigate these pressures by emphasizing collaboration over competition. Cooperative learning creates a sense of interdependence by organizing students into diverse groups where each member is responsible for contributing to the group's success (Johnson & Johnson, 2018). This interdependence encourages students to support one another, share knowledge, and develop mutual respect. As a result, the focus shifts from individual achievement to group accomplishments. This shift can be particularly empowering for students who may feel less confident in a competitive setting, providing them with a supportive network that values their contributions. For female students, this can mean more opportunities to participate actively and demonstrate their capabilities without fearing being overshadowed or judged.

4.4.3 Perceptions of Senior High School biology students regarding the use of the jigsaw and think-pair-share strategies

Research objective 3 sought to determine the views of SHS biology students on using jigsaw and think pair share strategies in the teaching and learning of genetics. Students' perceptions were solicited qualitatively to complement the quantitative findings. The interview results revealed four themes of students' responses: increased understanding and retention, improved confidence and participation, enhanced social and communication skills, and improved attitudes towards genetics. The qualitative results underscore that jig saw and think pair share improves students' understanding of genetic concepts, as revealed by the quantitative results. This can be attributed to the active involvement in JS and TPS, where students engage in discussions, explain concepts to peers, and tackle problems collaboratively. Such active engagement deepens comprehension and aids long- term memory retention, as students are more likely to internalize and recall information they have actively processed.

Additionally, this study revealed that jig saw and think pair share boosts students' confidence and participation. According to (Johnson & Johnson, 2018), when students work in groups, they are often more willing to express their ideas and ask questions compared to a traditional lecture setting. This collaborative environment provides a safety net where students feel supported by their peers, reducing the fear of making mistakes. As a result, students became more confident in their abilities to understand and discuss complex genetic concepts, which fostered a more inclusive and dynamic learning atmosphere. Moreover, enhancing social and communication skills is another significant outcome of JS and TPS noted in this study. Genetics, like many scientific disciplines, requires individual understanding and the ability to communicate findings and collaborate with others. Through group activities, students practice articulating their thoughts clearly, listening to diverse perspectives, and negotiating solutions. These skills are crucial for academic success and professional growth in scientific careers, where teamwork and communication are paramount. This study also highlights that students' attitudes towards genetics improved using cooperative learning strategies. Traditional teaching methods can sometimes make subjects like genetics seem daunting or uninteresting (Otukile-Mongwaketse, 2018).

However, involving students in JS and TPS tasks makes the subject matter more engaging and relatable. Students often found that discussing real-life applications and ethical implications of genetics within their groups made the subject more meaningful and relevant, thus fostering a positive attitude towards learning it. Furthermore, the qualitative findings indicated that JS and TPS strategies can bridge gaps in academic achievement. Students from diverse backgrounds and with varying levels of prior knowledge can support each other, leading to a more equitable learning environment. High-achieving students reinforce their knowledge by teaching peers, while struggling students receive personalized assistance. This peer-supported learning model ensures that all students have the opportunity to succeed, thereby reducing disparities such as gender in academic performance.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTION FOR FURTHER RESEARCH

5.0 Overview

This chapter captures the summaries of the study's findings. Based on the findings, conclusions, recommendations and suggestions were noted for further research work.

5.1 Summary of Findings

The following are the key findings of the study.

1. The Mann-Whitney U test on post-test scores demonstrated a statistically significant improvement in the performance of the experimental group compared to the control group ($p<0.001$), with a large effect size ($r = 0.86$). The experimental group achieved a much higher mean rank (71.50) than the control group (24.00), indicating that the jigsaw and think- pair- share strategy significantly enhanced students' understanding of genetics. This finding highlights the potential of JS and TPS learning as an effective pedagogical approach in science education.
2. Analysis of the post-test scores within the experimental group revealed no statistically significant difference in conceptual understanding between male and female students ($p = 0.06$). Female students had a slightly higher mean rank (28.59) than male students (21.04), with a small to medium effect size ($r = 0.27$). Although the results suggest a trend favoring female students, the lack of

statistical significance indicates that jig saw and think pair share strategies benefited both genders similarly.

3. The interview results revealed four themes of students' responses: increased understanding and retention, improved confidence and participation, enhanced social and communication skills, and improved attitudes towards genetics. The qualitative results underscore that jigsaw and think- pair- share improves students' understanding of genetic concepts, as revealed by the quantitative results. This can be attributed to the active involvement in JS and TPS, where students engage in discussions, explain concepts to peers and tackle problems collaboratively. Such active engagement deepens comprehension and aids long-term memory retention, as students are more likely to internalize and recall information they have actively processed.

5.2 Conclusions

Based on the findings of this study, the use of jigsaw and think- pair- share strategies in the Sekyere South Municipal was more effective in enhancing students' conceptual understanding in the study of genetics. This was because jigsaw and think- pair- share strategies placed students at the center of the teaching and learning process by employing diverse techniques like jigsaw and think-pair-share, which made content real to them. This study also extends existing studies by providing evidence to support the fact that using jigsaw and think- pair- share strategies can effectively bridge the gender gap in performance between male and female biology students in the Sekyere South Municipal. However, this quantitative evidence does not provide a holistic understanding of the effectiveness of jigsaw and think- pair- share strategies. As a result, to support the quantitative findings, qualitative findings revealed that SHS biology students in the Sekyere South Municipal demonstrated positive perceptions on using jigsaw and think-pair -share strategies in the study of genetics.

5.3 Recommendations

Based on the key findings, here are four recommendations for the study:

1. Jigsaw and think- pair- share strategies should be integrated more heavily into science curricula**,** particularly in complex subjects like genetics. Municipal Educational Directorate, Schools and educators in the Sekyere South Municipal should enforce and incorporate structured cooperative learning activities to promote deeper understanding and retention of challenging concepts, providing students with the interactive support needed for academic success in the Sekyere South Municipal.
2. Targeted efforts should be made to train teachers within the Sekyere South Municipal in jigsaw and think-pair-share strategies**,** equipping them with effective tools and techniques for facilitating group-based learning. Professional development programs focused on jigsaw and think-pair-share can enhance teachers' abilities to foster collaborative environments, benefiting students across diverse backgrounds and skill levels in the Sekyere South Municipal.
3. Promoting jigsaw and think-pair-share as a means to close gender-based performance gaps**,** particularly in STEM subjects, should be an emphasis by the

teachers and GES in the Sekyere South Municipal. By implementing jig-saw and think-pair-share strategies that support equal participation in schools in the Sekyere Municipal.

4. Sekyere South Municipal Education Directorate can help create inclusive classrooms that reduce initial academic disparities and encourage balanced performance outcomes for male and female students alike.

5. Further research on this study, using parametric tests to analyze the data and make conclusions, should also be conducted in a different district.

5.4 Suggestions for further research

1. In order to investigate any gender variations in reaction to the JS and TPS technique, more studies with a bigger sample size could be required.
2. Further research on this study, using parametric tests to analyze the data and draw conclusions, should also be conducted in a different district.
3. Research in different schools using SHS one students could be carried out in different district using JS and TPS.

REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, A., & Persson, T. (2021). *Effects of cooperative learning on students' academic* ance. *Journal of Educational Psychology*, *113*(3), 476–493. https://doi.org/10.1037/edu0000641

Acar, B., & Tarhan, L. (2008). *Effects of cooperative learning on students' understanding of chemical change*. *International Journal of Science Education*, 30(1), 39–59.

Achor, E. E., Ajaja, O. P., & Egbodo, B. O. (2013). *Effects of cooperative learning on gender differences in student achievement and self-efficacy in biology. Journal of Educational Research*, 15(3), 132–145.

Achuonye, I. C. et al. (2024). *Comparative Analysis of Jigsaw and TPS in Civic Education*.

Açıkgöz, K. Ü. (2014). *Cooperative learning in education*. *Educational Research and Reviews*, 9(4), 124–132.

Akhigbe, D., & Adeyemi, A. (2020). *Bridging the gender gap in biology: The role of cooperative learning strategies*. *Journal of Science Education*, 18(2), 56–64.

Aktaş, M. (2012). Importance of constructivist learning in biology education. *International Journal of Educational Development*, 32(2), 132–145.

Alam, S., Rauf, M. A., Khan, A., & Hussain, M. (2024). *Evaluation of the jigsaw method as a learning tool in undergraduate medical education.* BMC Medical Education, 24*(1),* 5831. https://doi.org/10.1186/s12909-024-05831-2

Almuslimi, F. K. A. (2016). *The Effect of Cooperative Learning Strategy on English Reading Skills of 9th Grade Yemeni Students and Their Attitude towards the Strategy*. *International Journal of Research in Humanities, Arts and Literature* 4(2): 41-58

Altamimi, N. O. M., & Attamimi, R. (2014). *Effectiveness of Cooperative Learning in Enhancing Speaking Skills and Attitudes towards Learning English: International Journal of Linguistics.Vol.6, No.4, ISSN 1948- 542*

Al-Zuhairi, Najla Abbas. (2013). *Jigsaw Strategy (images) according to the Awkward Situational and its effect on Learning the Skills of Facing Wall and Beating and Developing the Social Behavior in Volleyball, Journal of Studies and Research of Physical Education, (37), 316-345.*

Al-Obeidi, Wejdan Jasim Mohammed Saeed. (2013). *The Effectiveness of Jigsaw Strategy of Cooperative Learning on the Acquisition of the Fourth Graders in History, Unpublished MA Thesis, University of Diyala, Iraq.*

Al-Qaisi, Samira Adnan. (2015). *The effect of using (Jigsaw) Strategy on the Acquisition of Physics and Science Operations for Intermediate First Graders, Journal of the Faculty of Basic Education 21 (88), 145 to 176.*

Amedu, J. O. (2015). *Gender issues in science education: Implications for Nigerian science and technology*. *Educational Journal*, 4(2), 31–39.

Aronson, E. (n.d). *Overview of the Technique. Jigsaw Classroom. Retrieved on November 29, 2014 form http://www.jigsaw.org/overview.htm*

Arendale, D. R. (2005). *Postsecondary Peer Cooperative Learning Programs: Annotated Bibliography*. *Online Submission*.

Aronson, E. (n.d). *Overview of the Technique. Jigsaw Classroom. Retrieved on November 29, 2024 form http://www.jigsaw.org/overview.htm*

Artut, D. P., & Tarim, K (2007). *The effectiveness of Jigsaw II on prospective elementary school teachers. Asia-Pacific Journal of Teacher Education 35(2); 129–141.*

Aziz, Z., & Hossain, S. (2010). *The role of cooperative learning in the context of educational strategies. Educational Research International, 8(2), 117–132. https://doi.org/10.1155/eri.2010.45642*

Babbie, E. R. (2019). *The practice of social research* (15th Ed.). Cengage Learning.

Basu, R. (2018). *Instructional Design Models: Benefits and Challenges*. *UGC Approved Journal*, *Vol.-41 N* (June), 31–36.

Bayat. O, (2004). *The effects of cooperative Learning Activities on Student Attitudes towards English Reading Courses and Cooperative Learning. An unpublished Master's thesis Department of Teaching English as a Foreign Language. Bilkent University: Ankara*

Bayrakçeken, S., Doymuş, K., & Doğan, H. (2015). *Developing students' critical thinking skills through cooperative learning strategies. Science Education International, 25(4), 462–473.*

Bafile, C. (2008). *The ―Jigsaw‖ Approach Brings Lessons to Life. Retrieved April 13, 2024, from http://www.educationworld.com/a-curr/curr324.shtml*

Bergom, I., Wright, C. M., Brown, K. M., & Brooks, M. (2011). *Promoting college student development through collaborative learning: A case Study of hevruta. American College Personnel Association and Wiley Periodicals.*

Bekenova, A., & Nygatayeva, N. (2017). *Transition from a Teacher-Centered to a Learner- Centered approach in Kazkhstani Education*. *Bulletin of Science of Seifullin Kazakh Agro Technical University (Interdisciplinary), 1*(92), 106–111.

Borich, G. D. (2017). *Effective teaching methods: Research-based practice* (9th Ed.).

Bramlett, R. K. (1994). *Cooperative learning and the elementary school student. Journal of Educational Psychology, 86(2), 193–202.*

Bryman, A. (2016). *Social research methods* (5th ed). Oxford University Pres

BMC Medical Education. (2024). *Effects of the Jigsaw Method on Student Educational Achievement*.

Casey, A., and Goodyear, V. (2015). *Can cooperative learning achieve the four learning Outcomes of physical education?* A review of literature. *Quest* 67, 56–72. doi:10.1080/00336297.2014.984733this review, the duration

Casey, A., & Fernandez-Rio, J. (2019). *Cooperative learning and the affective domain. Journal of Physical Education, Recreation & Dance*, 90(3), 12-17.

Chiu, M. M. (2020). *Social dynamics and cooperative learning*. *Educational Psychology Review*, 32(1), 61–77. https://doi.org/10.1007/s10648-020-09525-2

Chen J, Wang Y (2013). *A study of cooperative learning in higher college English teaching. Theory and Practice in Language Studies* 3(7): 1258–1263.

Christine's. (2001). *using think-pair-share team up to learing from each other, the johns hopking university, Baltimore, Maryland.*

Cooper. L. James, Jean MacGregor, Karl. A. Smith, &Pamela Robinson (200). *New Direction for Teaching and learning.*

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th Ed.).

Cole-Onaifo, K. (2022). *Teachers' Transition from Teacher-Centered to Learner-Centered Classrooms Using the Next Generation Science Standards as a Tool* [Columbia University]. https://medium.com/@arifwicaksanaa/pengertian-use-case-a7e576e1b6bf

Cortright, R. N., Collins, H. L. & DiCarlo, S. E. (2005). *Peer instruction enhanced meaningful learning: Ability to solve novel problems. Advances in Physiology Education, 29(2), 107- 111*

Das, B. K., Jha, D. N., Sahu, S. K., Yadav, A. K., Raman, R. K., & Kartikeyan, M. (2022). *Basic Concept of Hypothesis Testing and Parametric Test. In Concept Building in Fisheries Data Analysis (pp. 59-80). Singapore: Springer Nature Singapore.*

Denzin, N. K., & Lincoln, Y. S. (2020). *The SAGE handbook of qualitative research* (*5th Ed.). SAGE Publications.*

Dervişoğlu, M., Yaman, S., & Soran, H. (2004). *Improving biology instruction through cooperative learning strategies*. *Journal of Biological Education*, 36(2), 76–81.

DiNardo CD, Ravandi F, Agresta S, Konopleva M, Takahashi K, Kadia T, (2015). *Characteristics, clinical outcome, and prognostic significance of IDH mutations in AML. Am J Hematol; 90: 732–6*

Doymuş, K., & Doğan, H. (2015). *Positive outcomes of cooperative learning in secondary education. Education Sciences*, 7(4), 134–142**.** https://doi.org/10.3390/educsci7010134

Doymus, K. (2008). *Teaching chemical equilibrium with the Jigsaw technique. Research in Science Education.*

Dyson, B., & Casey, A. (2012). Cooperative learning in physical education. *Journal of Physical Education and Sport Pedagogy*, 17(4), 345–362.

Durrington Research School. (2024). *How Effective is Think-Pair-Share?*

Ehsan, N., Vida, S., & Mehdi, N. (2019). *The impact of cooperative learning on developing speaking ability and motivation toward learning English*. *Journal of Language and Education*, 5(3 (19)).

Ekinci, E. (2011). *Cooperative learning and cognitive development*. *Journal of Science Education*, 12(3), 156–163.

El-Deghaidy, H, & Nouby, A (2008). *Effectiveness of a blended e-learning cooperative approach in an Egytian teacher Education programme.*

Eshietedoho, J. (2010). *Cooperative learning and student responsibility*. *International Journal of Education Development*, 22(5), 461–470.

Fabes, R. A., Martin, C.L., Hanish, L.D., & DeLay, D. (2018). *Gender integration in coeducational classrooms; Advancing educational research and practice. School psychology quarterly, 33(2), 182-190*

Facione, P. A. (200). *California critical thinking skills test: Form 200.Millbrae, CA: Insight Assessment*

Falk, H. (2012). *Effective cooperative learning in secondary classrooms*. Springer.

Farmer, T.W., Hamm, J.V., Lee, D., & Strerrett, B. (2020). *The Behavioral Academic and social Engagement (BASE) Model.*

Fathi, M., Barati, H., & Haghdoost, A. (2023). *Effects of the Jigsaw method on student Educational outcomes: A systematic review and meta-analysis.* Frontiers *in Psychology, 14*, 1216437. https://doi.org/10.3389/fpsyg.2023.1216437

Feng, Q., Luo, H., Li, W., Chen, T., & Song, N. (2023). *Effects of gender diversity on college students' collaborative learning: From individual gender to gender pairing*. Heliyo

Ferguson-Patrick, K. (2007). *Cooperative learning strategies in the classroom. Educational Review*, 13(5), 411–422.

Felder, R., & Brent, R. (2017). *Learner-Centered Teaching: How and Why *. 20*(May). Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE

Frame, L. D. (2014). *Wiki fever! Building a collaborative exam study guide to promote student success in the college classroom. Association for University Regional Campuses of Ohio 20:1-8.*

Fraser, B. J. (2001). *Learning environments research. In Classroom Environment* (Vol. 1, *pp. 89–109). Routledge.*

Gidena, A., & Gebeyehu, D. (2017). *The effectiveness of advance organizer model on students' academic achievement in learning work and energy*. *International Journal of Science Education, 39*(16), 2226–2242. https://doi.org/10.1080/09500693.2017.1369600

Gillies, R. M., & Boyle, M. (2021). *Cooperative learning and student academic achievement: A meta-analytic approach*. *Review of Educational Research*, 91(2), 291–320. https://doi.org/10.3102/0034654321996413

Gillies, R. M., & Boyle, M. (2010). *Teachers'''' reflections on cooperative learning: Issues of implementation*. *Teaching and Teacher Education* 26 (4) 933-940.

Gomez, J.G. (2007). *What do we know about creativity? Journal of Effective Teaching 7(1), 31-43*

Gradel, K., & Edson, A. J. (2010). *Cooperative learning in online and blended learning environments. The Journal of Educational Technology Development and Exchange*, 3(2), 23–41.

Guba, E. G., & Lincoln, Y. S. (2018). Epistemological frameworks for research. *Qualitative Inquiry*, 24(5), 379–389.

Guido, G. (2018). *The Origin of the Colour Charge into Quarks*. *Journal of High Energy Physics, Gravitation and Cosmology*, ***5***, *1–4.https://doi.org/10.4236/jhepgc.2019*

Guy-Evans, Olivia. (2023). *Constructivism as a Theory for Teaching and Learning. Simple Psychology.*

Han, F., Ellis, R. A. (2022). *Patterns of students' collaborations … in blended course designs*. *Journal of Computer Assisted Learning.*

Hallberg, K., Cook, T. D., Steiner, P. M., & Clark, M. H. (2018). *Pretest measures of the study. Outcome and the elimination of selection bias: Evidence from three within study comparisons. Prevention Science, 19, 274-283.*

Hattie, J. (2017). *Visible learning for teachers: Maximizing impact on learning*.

Heba, N., & Nouby, A. (2007). *Cooperative learning and student engagement*. *Journal of Educational Research*, 17(2), 56–62.

Hsiung, C. M. (2021). *The effectiveness of cooperative learning strategies on student engagement. Educational Research and Evaluation*, 27(1), 33–51. https://doi.org/10.1080/13803611.2021.1894551

Huang. J, Z.Wu, wu.Xue, D.Lin & Y. Chen (2024). *Non-Cooperative and Cooperative Driving Strategies at Unsignalized Intersectios*

Janssen, J., &Koller, I. (2021). *Experimental and quasi-experimental research in CSCL.*

Jenkins, J. R., Antil, L. R., Wayne, S. K., & Vadasy, P. F. (2003). *How cooperative learning works for special education and remedial students. Council for Exceptional Children, 6(3), 279-292.*

Johnson, D. W., Johnson, R. T., & Stanne, M. B. (2000). *Cooperative learning strategies in educational research. Educational Psychology, 12(5), 95–123.*

Johnson, D. W. (2003). *Social interdependence: interrelationships among theory, research, and practice. American Psychologist, 58(11), 934.*

Johnson, D. W., Johnson, R. T., & Stanne, M. B. (2000). *Cooperative learning methods: A meta-analysis. Minneapolis, MN: University of Minnesota.*

Johnson, D. W., Johnson, R. T., & Stanne, M. B. (2002). *Cooperative learning and social interdependence theory.*

Johnson, D.W., Johnson, R.T. & Smith, K. (2007). *The state of Cooperative learning in Postsecondary and Professional Settings. Education Psychology Rev 19, 15-29.*

Johnson, D. W., Johnson, R. T., & Stanne, M. B. (2010). Cooperative learning strategies in educational research. *Educational Psychology*, 12(5), 95–123.

Johnson, D. W., & Johnson, R. T. (2015). *Theoretical approaches to cooperative learning. In R. Gillies (Ed.), Collaborative learning: Developments in research and practice (pp. 17-46). New York: Nova*

Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and Research. Interaction Book Company.*

Journal of Learning Analytics. (2025). *AI-Enhanced Think-Pair-Share for Real-Time Engagement Tracking*.

Kalkbrenner, M. T**.** (2021). *A Practical Guide to Instrument Development and Score Research, and Evaluation, 26**(1).***

Kaur, T., Blair, D., Choudhary, R. K., Dua, Y. S., Foppoli, A., Treagust, D., & Zadnik, M. (2020). *Gender response to Einsteinian physics interventions in school*. *Physics Education*, *55*(3). https://doi.org/10.1088/1361-6552/ab764d

Karacop, A., & Doymus, K. (2013). *Effects of jigsaw cooperative learning and animation particulate nature of matter. Journal of Science Education and Technology 22:186*–203.

Kara, H., & Arslan, D. (2024). *Outcomes of jigsaw technique in nurse education: A systematic review and meta-analysis.* Nurse Education Today, 130, *105988.* https://doi.org/10.1016/j.nedt.2024.105988

Kagan, J. (2009). *The three cultures: Natural sciences, social sciences, and the humanities in the 21st century. Cambridge University Press.*

Knight, J. K., & Brame, C. J. (2023). *Reconsidering the "share" of a Think–Pair–Share: Emerging practices and alternatives.* CBE—Life Sciences Education, 22*(3), fe5*. https://doi.org/10.1187/cbe.22-06-0123

Kurt, F. (2001). *Enhancing student retention through cooperative learning*. *Science Education Review*, 25(1), 34–52.

Kirscher, P. A., Sweller, J., Kirschner, F., & Zambrano, J. (2018*). From Cognitive load theory to collaborative cognitive load theory*.

Kirschner, F., Paas, F., & Kirschner, P. A. (2011). *Task complexity as a driver for collaborative learning efficiency: The collective working-memory effect*. *Applied Cognitive Psychology*, **25**(4), 615–624. https://doi.org/10.1002/acp.1730

Lak, M., Soleimani, H., & Parvaneh, F. (2017). *The Effect of Teacher-Centeredness Method vs. Learner-Centeredness Method on Reading Comprehension among* Iranian EFL Learners. *Journal of Advances in English Language Teaching*, *5*(1), 1–10.

Lei, H., et al. (2023). *Motivation and cooperative learning in secondary education. Journal of Educational Research*, 76(2), 189–208.

Linsenmeyer, M. (2021). *Brief Activities: Questioning, Brainstorming, Think-Pair-Share, Jigsaw*... Springer chapter

Lincoln, Y. S., Guba, E. G., & Denzin, N. K. (2018). *Qualitative research frameworks. Handbook of Qualitative Research*, 3(1), 23–41.

Lujan, H., & DiCarlo, S. E. (2006). *Too much teaching, not enough learning: what is the solution? Advances in Physiology Education, 30(1), 17-22.*

Maden, S. (2011). *Effect of Jigsaw I technique on achievement in written expression skill. Educational Sciences: Theory & Practice - 11(2): 911-917*

Machado, I., & Coimbra, N. (2015). *Using cooperative learning in a Grammar workshop: a case study on students´ perceptions. Advances in Social Sciences Research Journal,* 2(3)

Mc Cafferty, & G. Jacobs, G.M., & Dasilvo Iddings, A.C. (2004). *Cooperative learning and second language teaching Cambridge University press*

McHugh, D.; Yanik, A.J.; & Mancini, M.R. (2021). *An innovative pharmacology curriculum for medical students: Promoting higher order cognition, learner-centered coaching, and constructive feedback through a social pedagogy framework. BMC Med. Educ., 21, 90.*

McLeod, S. (2025). *Constructivism as a Theory for Teaching and Learning*. Simply *Psychology*

Merriam, S. B., & Grenier, R. S. (2019). *Qualitative research in practice: Examples for discussion and analysis*. Jossey-Bass.

Meng, J. (2010). *Jigsaw cooperative learning in English reading. Journal of Language Teaching and Research, 1(4): 501-504.*

Mekonnen, T. (2025). *The effect of jigsaw cooperative learning on grade 9 students' academic achievement in biology in Ethiopian secondary schools.* SAGE Open, *15*(1), 21582440251318883. https://doi.org/10.1177/21582440251318883

Ministry of Education, Ghana (2010). *Teaching syllabus for elective biology*

Mikkila-Erdmann, M. (2001). *Active teaching strategies and retention in education. Journal of Science Education*, 13(4), 244–253.

Mirshekaran, R., Namaziandost, E., & Nazari, M. (2018). *The effects of topic interest and L2 proficiency on writing skill among Iranian EFL learners. Journal of Language Teaching and Research, 9(6), 1270-1276.*

Morales, J.F., Moya, Gaviria, E., & Cuadrado, I. (2007). *Psicologia social (3rd ed.). 918 pages*

Nasr, Mahmoud. (2003). *The impact of (think, pair, share) strategy with the help of computer architecture and environmental engineering materials in the teaching fourth grade primary on Achievement and retention of trend Mutual, the third scientific conference, the Egyptian Association for Mathematics Educations.*

Nowgen, D. (2012). *Biology education and scientific literacy*. *The Science Educator, 22(1), 114–128.*

Ngussa, B. M. (2014). *Application of ADDIE Model in instruction in teaching-learning transaction among teachers of Mara Conference Adventist secondary school, Tanzania. Journal of Education and Practice, 5(25), 99–105.*

Nguyen, T., VO, H., & Pham, L. (2023). *Enhancing student learning in science through Think–Pair–Share: A quasi-experimental study. International Journal of Science Education, 45*(12), 1598–1617. https://doi.org/10.1080/09500693.2023.2211587

Nurse, P. (2016). *The importance of biology education. Journal of Biological Education, 50(1), 7–9.*

Okumuş, S., & Doymuş, K. (2021). *Cooperative learning strategies in science education*. *Educational Studies,* 54(3), 91–110.

Öztürk, S. (2017). *Cooperative learning techniques and student interdependence*. *Journal of Cooperative Learning*, 15(2), 32–45.

Pelech, W. (2016). *Successful implementation of active teaching strategies*. *Education and Society*, 6(1), 112–134.

Pacheco Maldonado, I.M., Rozo Banoy, L.M., & Suarez Quinche, E. (2011). *Role of Cooperative learning Strategies in the development of 5th Graders 'Speaking Skill at George Washington School. Bogota.*

Pascal Adagwine**.** (2023). *The effect of Think-Pair-Share teaching strategy on the academic performance of students in selected topics in Integrated Science*.

Pillay, A. (2008). *Intermediate Phase Educators' Perceptionsof Co-operative Learning. Thesis submitted in partial fulfilment for the requirements of the degree of Master of Education. South Africa: University of Kwa-Zulu Natal*

Phillips, D. C., & Burbules, N. C. (2019). *Post-positivism and educational research. Rowman & Littlefield.*

Prieto Navarro, L. (2007). *Autoeficacia del profesorado Universitario; Eficacia percibida Y Practica docente. Madrid; Narcea*

Purwadhika (2021). *Comparative Study of TPS and Jigsaw in Reading Comprehension*.

Qiao, J. (2010). *On the Rural-Urban Disparity in Access to Higher Education opportunity in China (pp 22-31*

Qiao, M. & Jin, X. (2010). *Jigsaw strategy as a cooperative learning technique: Focusing on the language learners. Chinese Journal of Applied Linguistics (Bimonthly) 33(4): 113-125.*

Rabgay, T. (2018). *The effect of using cooperative learning method on tenth grade students' learning achievement and attitude towards biology. International Journal of Instruction, 11(2), 265-280.*

Ramsook, L. (2018). *Cooperative Learning as a Constructivist Strategy in Tertiary Education*. IJERN PDF

Robson, C., and K. McCartan. (2016). *Real World Research. 4th ed. Chichester, West Sussex, United Kingdom: John Wiley & Sons. (Open in a new window) Google Scholar*

Roseth, C. J., et al. (2019). *Examining the impact of cooperative learning on student* motivation. *Journal of Educational Research*, 113(2), 124–139. **https://doi.org/10.3102/0094654321978472**

Roseth, C. J., Johnson, D. W., & Johnson, R. T. (2008). *Promoting early adolescents' achievement and peer relationships: The effects of cooperative, competitive, and individualistic goal structures*. *Psychological Bulletin*, **134**(2), 223–246. https://doi.org/10.1037/0033-2909.134.2.223

Richard, J and Rodgers, T. (2016). *Approaches and method in language Teaching. Cambridge: CUP*

Saban, A. (2013). *Cooperative learning and student accountability*. *International Journal of Educational Strategies*, 9(1), 43–57.

ScienceDirect. (2021). *Comparative Effects of Think-Pair-Share Variants in Secondary Classrooms*.

SAGE Review. (2024). *Learning With Jigsaw: A Systematic Review*.

Serrano, J.M., &Pons, R.M. (2014). *Introduction to Cooperative learning*

Saleh, Hossam Yusuf and Ibrahim, Hadeel Sajid. (2015). *the Effect of (think, pair, share) strategy on the students of Biology achievement in Algas and their attitude toward it. Diyala Journal of Human Research, 66.1- 19.*

Sharan, Y. (2019). *Cooperative Learning for Academic and Social Gains: Valued pedagogy, problematic practice. European Journal of Education, 45(2), 300-313.*

Sharan, Y. (2010). *Cooperative learning for academic and social gains: Valued pedagogy, problematic practice. European Journal of Education,* ***45****(2), 300–*313. https://doi.org/10.1111/j.1465-3435.2010.01430.x

Slavin, R. E. (2020). *Cooperative learning as an instructional strategy. Educational Leadership*, 52(8), 22–27.

Slavin, R. E. (2008). *Cooperative learning, success for all and Evidence based Reform in Education.*

Slavin, R. E. (1995). *Cooperative learning: Theory, research, and practice* (2nd Ed.). Allyn & Bacon. *(Note: This is the typical citation of Slavin's work—if you used a different edition or chapter, adjust accordingly.)*

Sahin, A. (2010). *Effects of jigsaw technique on academic achievement and attitudes to written expression course. Educational Research and Reviews, 5 (12), 777-787.*

Soraya. (2010). *Enhancing Students' Oral Proficiency through Cooperative Group Work. An unpublished master's degree Thesis. Department of Foreign Language, Constantine University, Algeria.*

Solomon, S., J.S. Daniel. Nelly III, J, -P. Vernier, E.G. Dutton, & L.W. Thomason (2011). *The persistently variable background stratospheric aerosol layer and global climate change. Science, 333.*

Susan. (2001). *using think-pair-share in collage classroom, center for learning and teaching excellence, Arizona state university*.

Sijali, K. K. (2018). *Effectiveness of cooperative learning for improving learner's proficiency level of English language in secondary level education in Nepal.*

Simon, C., & Baum, W.M. (2017). *Allocation of speech in conversation. Journal of experimental Analysis of Behavior, 107.*

Smith, M. S. (2001). *Practice-based Professional Development for Teachers of Mathematics. Reston, VA: National Council of Teachers of Mathematics.*

Smith, P, & Bell, P. (2007). *Leading school in challenging circumstance; strategies for success-education management Administration and Leadership, 35(3), 339-343*

Tatar, M. (2006). *Okul ve öğretmenin öğrenci başarısı üzerindeki etkisi [Impact of School and Teacher on Student Success]. Publication Principles of the Journal of National Education, 171, 156–166.*

Tabachnick, B.G., & and Fidell L.S. (2013). *Using Multivariate Statistics (sixth Ed.).*

Thurston, A., Scardamalia, M., & Bereiter, C. (2010). *Cooperative learning in small groups*. *Learning and Instruction, 23*(3), 187–202. https://doi.org/10.1016/j.learninstruc.2010.04.003

Thompson, J. C., & Chapman, E. S. (2004). *The effect of cooperative learning on achievement of adult learners in introductory psychology classes. Social Behavior and Personality, 32(2), 139-146.*

Topping, K. (2023). *Cooperative learning through philosophy for children around the world.*

United Nations, (2012). *United Nation Secretary-Generals Global Education First Initiative. New York, United Nations*

Topping, K. J., & Trickey, S. (2014). *The role of dialog in philosophy for children. International Journal of Educational Research, 63, 69–78.* https://doi.org/10.1016/j.ijer.2013.01.002

United Nations Educational, Scientific and Cultural Organization. (2009). *Policy guidelines on Inclusion in education*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000177849

United Nations. (2012). *The future we want: Outcome document of the United Nations Conference on Sustainable Development*. United Nations. https://sustainabledevelopment.un.org/futurewewant.html

Van- Ryzin, M. J., et al. (2020). *Cooperative learning and student engagement*. *Journal of Science Education*, 27(1), 12–29.

West African Examinations Council, (2017). *Chief examiners report: Student performance in science*. West African Examinations Council.

West African Examinations Council, (2018). *Chief examiners report: Student performance in science*. West African Examinations Council.

West African Examinations Council, (2019). *Chief examiners report: Student performance in science*. West African Examinations Council.

West African Examinations Council, (2020). *Chief examiners report: Student performance in science*. West African Examinations Council.

West African Examinations Council, (2021). *Chief examiners report: Student performance in science*. West African Examinations Council.

Webb, N. M. (2009). *The teachers Role in promoting collaborative Dialogue in the classroom, British Journal of Education psychology 79-28*

Webb, M. E., Tracey, M., Harwin, W., Tokatli, O., Hwang, F., Johnson, R., Barrett, N., Jones, C. (2017). *The potential for haptic-enabled interaction to support collaborative learning in school biology*. *Paper presented at the Society for Information Technology & Teacher Education International Conference 2017*, Austin, TX, United States. https://www.learntechlib.org/p/177885.

Yang, X. (2023). *A historical review of collaborative learning and cooperative learning. Frontiers in Psychology, 14*, 1080422.

Yager, R. E. (2000). *Constructivist learning environments in science*. *School Science and Mathematics*, 100(1), 48–58.

Yassin, R., Razak, N. A., & Massum, A. K. (2018). *Cooperative learning strategies for diverse student populations. International Journal of Educational Research, 88(1), 102–112.*

Yin, R. K. (2003). *Case study research: Design and methods (3rd Ed.). Thousand Oaks, CA: Sage Publications.*

Yıldırım, A. (2024). *Evaluation of cooperative learning in science education: A mixed meta-method study. Journal of Science and Mathematics Education, 18*(2), 45–62. *https://doi.org/10.29333/scimath.14872*

Zhang, Y. (2010). *Cooperative language learning and foreign language learning and teaching. Journal of Language Teaching and Research, 1(1), 81-83.*

APPENDICES

APPENDIX ONE

LESSON PLAN FOR CONTROL GROUP

CONVENTIONAL METHOD

Lesson One

Class:	SHS three Biology
Time:	1hrs
No. of students	49
Sex:	Mixed
Topic:	Heredity, variation and Evolution
Subtopic:	Terms in Genetics

Instructional Objectives

At the end of the lesson, the students should be able to

1. Define
   a. genetics and heredity
   b. genotype and phenotype
   c. State with the aid of genetics cross the blood groups of the couple who had four children, two boys and two girls who have different blood groups.

Instructional Materials Chalk board illustration

Previous Knowledge

Students are aware of some characteristics they inherited from their parents.

Introduction

Teacher introduces the lesson by explaining some of the terms used in genetics

Activity I

Teacher defines the term heredity, genetics, phenotype and genotype to students

Activity II

Through chalkboard illustration teacher explains and draw a simple genetics diagram to students.

Conclusion

Teacher concludes by explaining some of the genetics terms to students

Assignment

1. Define

a. genetics and heredity

b. genotype and phenotype

2. State with the aid of genetics cross the blood groups of the couple who had four children, two boys and two girls who have different blood groups.

Lesson Two

Class: SHS three Biology

Time: 1 hrs

No. of students 49

Sex: Mixed

Topic: Heredity, variation and Evolution

Subtopic: Variation Instructional Objectives

At the end of the lesson, the students should be able to

1. Define variation
2. Explain Down syndrome.

Instructional Materials Chalk board illustration **previous knowledge**

Students are aware of some characteristics they inherited from their parents.

Introduction

Teacher begins the lesson by asking students to mention one characteristic which they inherited from their parents.

Activity I

Teacher explains the term variation to students

Activity II

Through chalkboard illustration teacher explain what a down syndrome is and what causes this disorder.

Conclusion

Teacher concludes the lesson by asking questions base on what the students have learnt.

Evaluation

1. define variation
2. Explain Down syndrome.

Lesson Three

Class:	SHS three Biology
Time:	1 hrs
No. of students	49
Sex:	Mixed
Topic:	Heredity, variation and Evolution
Sub topic:	**Causes of variation Instructional Objectives**

At the end of the lesson, the students should be able to

1. State five causes of variation in living things?
2. Explain briefly what will happen in a blood transfusion if the blood of the two individuals is not compatible

Instructional Materials Chalk board illustration **Introduction**

Teacher begins the lesson asking students to state one each of the differences that exist between themselves

Activity I

Teacher explains to students the causes of variation between themselves to the class. He therefore attributes it to the environment and other genetic factors such as gene mutation

Activity II

Teacher explains what will happen for receiving blood which is not compactible and it effect on the receiver.

Conclusion

Teacher summarizes the lesson by asking students questions based on what they have learnt.

Assignment

State five causes of variation in living things?

Explain briefly what will happen in a blood transfusion if the blood of the two individuals is not compatible

APPENDIX TWO

LESSON PLAN FOR EXPERINMENTAL GROUP

LESSON ONE THINK-PARE SHARE AND JIGSAW METHOD

Lesson One

Class:	SHS three Biology
Time:	2hrs
No. of students	49
Sex:	Mixed
Topic:	Heredity, variation and Evolution
Sub topic:	Terms in Genetics

Instructional Objectives

By the end of the lesson, the students will be able to,

1. Define

a.i genetics

ii heredity

b.i genotype

ii phenotype

2. State with the aid of genetics cross the blood groups of the couple who had four children, two boys and two girls who have different blood groups.

Previous knowledge

Students are aware of some characteristics they inherited from their parents.

Instructional Materials

1. Whiteboard or projector
2. Markers or chalk
3. Handouts with relevant information

Introduction (10 minutes)

a. Teacher reviews the concepts of heredity, genetics, phenotype, and genotype.
b. Teachers explain the purpose of the lesson: to explore how genotype translates into phenotype.

Jigsaw Activity (20 minutes)

a. Teacher divides students into small groups (3-4 students per group).
b. Teacher assigns each group one of the following topics:

i. Heredity
ii. Genetics
iii. Phenotype
iv. Genotype

c. In their groups, students research their assigned topic and prepare a short presentation.
d. Each group presents their findings to the class, sharing key points and examples.

Think-Pair-Share (15 minutes)

e. Pose questions related to the topics discussed:

i. ―What is the difference between genotype and phenotype?

ii. ―How do genes and alleles relate to genotypes in offspring?

iii. ―How can probability be used to predict possible genotypes?

f. Students think individually, pair up to discuss their answers, and then share with the class.

Model-Making Lab (30 minutes)

g. Teacher provides students with materials (e.g., paper, markers, scissors) to create models representing genetic traits.

h. Students simulate genetic inheritance by building and examining traits in a new population of offspring.

i. Emphasize the connection between genotype (genetic makeup) and phenotype (physical appearance).

i. Conclusion

ii. Teacher concludes the lesson by asking students questions based on what they learnt.

iii. Evaluation

1. Define

a. genetics and heredity

b. genotype and phenotype

2. State with the aid of genetics cross the blood groups of the couple who had four children, two boys and two girls who have different blood groups

LESSON TWO

THINK-PARE SHARE AND JIGSAW METHOD

Class:	SHS three Biology
Time:	1 hrs
No. of students	49
Sex:	Mixed
Topic:	Heredity, variation and Evolution
Subtopic:	variation

Instructional Objectives

At the end of the lesson, the students should be able to

1. explain down syndrome
2. define variation

Materials Needed:

1. Whiteboard or projector
2. Markers or chalk
3. Handouts with relevant information (optional)

Previous knowledge

Students are aware of some characteristics they inherited from their parents.

a. **Introduction (10 minutes)**

b. Teacher discusses the concept of **variation** in traits among individuals.

c. Teacher explains that genetic differences contribute to this variation.

Jigsaw Activity (20 minutes)

d. Teacher divides students into small groups (3-4 students per group).

e. Assign each group one of the following topics:

i. **Down Syndrome**: Causes, symptoms, and impact on individuals

ii. **Genetic Variation**: How genetic differences lead to variation

f. In their groups, students research their assigned topic and prepare a short presentation.

g. Each group presents their findings to the class, sharing key points and examples.

THINK-PAIR-SHARE (15 minutes)

h. Teacher Poses questions related to the topics discussed:

i. —What causes Down syndrome?‖

ii. —How does Down syndrome affect individuals?‖

iii. —Why is genetic variation important?‖

i. Students think individually, pair up to discuss their answers, and then share with the class.

Class Discussion (20 minutes)

j. Teacher facilitates a whole-class discussion based on the jigsaw presentations and think-pair-share responses.

k. Teacher encourages students to ask questions and engage in dialogue about variation and Down syndrome.

Interactive Activity (10 minutes)

l. Provide scenarios related to genetic variation (e.g., different hair colors, susceptibility to certain diseases).

m. Ask students to discuss how these variations might impact individuals' lives.

Wrap-Up (10 minutes)

n. Teacher summarizes the importance of understanding variation and genetic differences.

o. Discuss the need for empathy and inclusion when interacting with individuals with Down syndrome.

Assessment:

Evaluate student participation during jigsaw presentations, think-pair-share discussions, and the interactive activity.

LESSON THREE

JIGSAW AND THINK-PAIR-SHARE STRATEGY

Class: SHS three Biology

Time: 1 hrs

No. of students 49

Sex: Mixed

Topic: Heredity, variation and Evolution

Subtopic: causes of variation

Instructional Objectives

At the end of the lesson, the students should be able to

1. State five causes of variation in living things?
2. Explain briefly what will happen in a blood transfusion if the blood of the two individuals is not compatible

Materials Needed:

1. Whiteboard or projector
2. Markers or chalk
3. Colored water (blue, green, and yellow)
4. Plastic cups
5. Sharpie pen

Previous knowledge

- Students interact with sickle cell carrier in their class and familiar with some of the characteristics exhibited by them.

Introduction

1. Teacher begins by asking students what they know about blood types. Discuss the importance of blood compatibility during transfusions.

Use the think-pair-share strategy:

1. Teacher poses questions like:
1. —What are the four main blood types?‖
2. —Why is knowing your blood type important?‖
2. Students think individually, pair up to discuss their answers, and then share with the class.

Jigsaw Activity

1. Teacher divides students into small groups (3-4 students per group).
2. Assign each group one of the following topics:
   i. **ABO Blood Group System**: Explain the different blood types (A, B, AB, O) and their antigens.
   ii. **Rh factor**: Discuss the positive (+) or negative (-) Rh factor.
3. In their groups, students research their assigned topic and prepare a short presentation.
4. Each group presents their findings to the class, sharing key points and examples.

Explain - Blood Mixing Experiment

1. Using coloured water (representing different blood types), demonstrate what happens when incompatible blood is mixed.

2. Discuss the concept of **agglutination** (clumping of blood cells) and its dangers.
3. Emphasize that mixing incompatible blood during a transfusion can be life- threatening.

Elaborate - Consequences of ABO Incompatibility

1. Teacher discusses the symptoms of an **ABO incompatibility reaction**:
    1. Fever, chills
    2. Breathing difficulties
    3. Muscle aches
    4. Nausea
    5. Chest, abdominal, or back pain
    6. Blood in urine
    7. Jaundice

2. Evaluate

1. Teacher asks students to summarize the key points they've learned about blood variation and ABO incompatibility.
2. Teachers assess their understanding through class discussion or a short quiz.

APPENDIX THREE

INTERVIEW QUESTIONS

Individual

1. How do you feel about the method used by your teacher today?

2. How the method does used today by your teacher helps your understanding of the genetic concepts?

3. What changes have you noticed in terms of the relationship between you and your group mates since your teacher started using this method?

4. How will you describe the learning experience or activity that positively change your perception about genetics?

APPENDIX FOUR

GENETICS ACHIEVEMENT TEST QUESTIONS

AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

Student code:

Age:

Form:

Duration: 1hour **TOTAL MARKS: 30**

1. Before answering the question, please read the accompany instructions
2. Answer ***six*** questions only
3. Present your responses in accordance with each question's instruction
4. only make diagrams or flow charts if you are requested to
5. make your writing legible

Now you must respond to the following questions

1. Define

a.i genetics

ii heredity **2mrks**

b. i genotype and

ii phenotype **3mrks**

1 Define variation **5mrks**

2 A couple had four children, two boys and two girls. On investigation it was discovered that all the children had different blood groups. With the aid of a genetic diagram determine the blood groups of the parents. **5 mrks**

3 Explain Down syndrome. **5 mrks**

4 State five causes of variation in living things? **5 mrks**

5 Explain briefly what will happen in a blood transfusion if the blood of the two individuals is not compatible. **5mrks**

6 A woman who carries the allele for hemophilia is marries by a normal man. Illustrate the results with appropriate diagram. **5mrks**

7 Explain why females are considered the default sex in humans**.**

APPENDIX FIVE

MARKING SCHEME FOR THE GENETICS ACHIEVEMENT TEST

1. a. Genetics is the study of heredity and variation **1mrk**

2. Heredity is the acquisition of characteristics by offspring **1mr**k from parents through inherited genes **1mrk** **2mrks**

b. Genotype is the combination of all the genes **1mrk** possessed by an organism **1mrk** **2mrks**

Phenotype is the physical **1mrk** expression or observable characteristics **1mrk** of an individual genetic make-up.**1mrk** **3mrks**

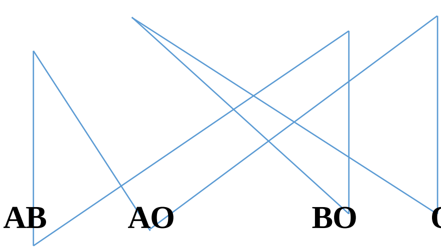
3. Variation is defined as the difference **1mrk** in characteristics **1mrk** among organisms **1mrk** of the same **1mrk** species.**1mrk** **5mrks**

4. 3 parents: Father Mother

Parent phenotype: Blood group A Blood group B

Parent genotype: **AO** × **BO** **1mrk**

Gametes: **A** **O** × **B** **O** **1mrk**



F_1 genotype: **AB** **AO** **BO** **OO** **1mrk**

F_1 phenotype **AB** **A** **B** **O** **1mrk**

from the above diagram, all the four children have different blood groups so the phenotypic expression of blood group of parents are **A** and **B** **1mrk** **5mrks**

4. Down syndrome is a genetic disorder **1mrk** caused by the presence of an extra **1mrk** copy of chromosome 21. **(1mrk)** its leaders to intellectual disability, distinctive facial features**1mrk** and various health issues.**1mrk** **5mrk**

Causes of variation

1. environmental factor **1mrk**
2. Cross over of genes between chromatids of homologous chromosomes during meiosis I segregation. **1mrk**
3. Random fusion of gametes during fertilization **1mrk**
4. Gene mutation **1mrk**
5. Chromosome mutation **1mrk**
6. Effect of wrong blood transfusion

Human red blood cells contain antigens **1mr**k with corresponding antibodies in serum.**1mrk**

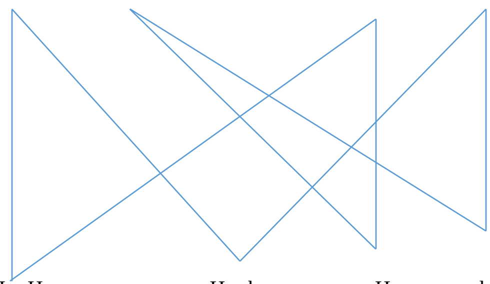
If a person is transfused with incompatible blood, **1mrk** the antibody reacts with the antigen causing agglutination. **1mrk**

This therefore leads to loss of oxygen, blockage of blood vessels and death.**1mrk** 5mrks

7 Parent phenotype normal carrier

Parent genotype X^HY X^HX^h **1mrk**

X^H Y X^H X^h **2mrks**



Genotype X^HX^H X^HX^h X^HY X^hY **1mrks**

phenotype normal normal carrier hemophiliac **1mrks**

female male female male

8 Females are considered the default sex in humans because only genes **(1mrk)** on the Y chromosome **(1mrk**) determine sex and trigger the development of the embryo **(1mrk**) into a male **(1mrk)** and without a Y chromosome, an embryo will develop as female **(1mrk**).

APPENDIX SIX

PILOT TEST RESULTS

ID	RATER 1	RATER 2
1	18	18
2	17	16
3	25	25
4	20	20
5	5	5
6	24	24
7	16	16
8	26	26
9	23	23
10	13	13
11	27	27
12	27	27
13	29	28
14	16	16
15	17	17
16	19	19
17	22	22
18	21	22
19	25	24
20	26	26

21	25	24
22	9	9
23	16	16
24	11	11
25	18	19
26	23	22
27	17	18
28	7	7
29	4	4
30	12	12
31	16	16
32	18	18
33	20	19
34	19	20
35	19	19
36	20	20
37	14	14
38	21	20
39	18	17
40	21	21
41	9	10
42	23	23
43	21	21

44	16	17
45	2	2
46	8	8

APPENDIX SEVEN

RESULT OF GENETICS ACHIEVEMENT TEST

RESULT OF PRE-TEST FOR EXPERIMENTAL GROUP

GROUP	GENDER	PRE-TEST SCORES
2	2	5
2	2	8
2	1	6
2	1	9
2	2	8
2	1	7
2	2	9
2	2	6
2	2	6
2	1	5
2	2	9
2	1	9
2	2	6
2	2	7
2	1	9
2	2	9
2	1	7
2	2	6
2	1	5

2	2	7
2	2	6
2	1	6
2	1	7
2	2	8
1	2	8
1	1	7
1	2	6
1	1	6
1	2	6
1	1	8
1	2	7
1	1	8
1	2	8
1	1	6
1	1	5
1	2	8
1	1	8
1	2	7
1	1	6
1	2	9
1	1	6
1	1	9

1	2	8
1	2	7
1	1	5
1	1	8
1	2	9
1	2	7

RESULT OF PRE-TEST FOR CONTROL GROUP

GROUP	GENDER	PRE-TEST SCORES
2	1	5
2	2	7
2	1	6
2	1	6
2	2	7
2	1	8
2	2	8
2	2	7
2	2	6
2	1	6
2	2	6
2	1	8
2	2	7

2	2	8
2	1	8
2	2	6
2	1	5
2	2	8
2	1	8
2	2	7
2	2	6
2	1	9
2	1	6
1	2	9
1	2	8
1	1	7
1	2	5
1	1	8
1	2	9
1	1	5
1	2	8
1	1	6
1	2	9
1	1	8
1	1	7
1	2	9

1	1	6
1	2	6
1	1	5
1	2	9
1	1	9
1	1	6
1	2	7
1	2	9
1	1	9
1	1	7
1	2	6

POST TEST RESULT FOR CONTROL GROUP

GROUP	GENDER	POST-TEST SCORES
1	**1**	14
1	**1**	11
1	**2**	14
1	**1**	19
1	**2**	19
1	**1**	17
1	**1**	17
1	**2**	19
1	**1**	19
1	**2**	18
1	**1**	16
1	**2**	16
1	**1**	17
1	**2**	17
1	**1**	15
1	**2**	17
1	**1**	18
1	**2**	17
1	**2**	15
1	**2**	17
1	**1**	18

1	**2**	17
1	**1**	14
2	**2**	18
2	**1**	18
2	**2**	19
2	**1**	15
2	**2**	15
2	**1**	13
2	**2**	18
2	**2**	18
2	**2**	18
2	**1**	17
2	**2**	17
2	**1**	16
2	**2**	16
2	**1**	16
2	**2**	11
2	**1**	17
2	**2**	14
2	**1**	13
2	**2**	14
2	**1**	14
2	**2**	13

2	**1**	13
2	**2**	14
2	**1**	12

POST TEST RESULT FOR EXPERIMENTAL GROUP

GROUP	GENDER	POST-TEST
2	2	21
2	2	25
2	2	21
2	2	23
2	1	21
2	2	21
2	1	20
2	2	21
2	1	21
2	2	21
2	1	20
2	2	20
2	1	21
2	2	21
2	1	21
2	2	24

2	**1**	24
2	**2**	24
2	**1**	25
2	**2**	22
2	**1**	23
2	**2**	23
2	**1**	23
2	**2**	26
1	**1**	26
1	**2**	25
1	**1**	21
1	**2**	20
1	**1**	20
1	**2**	24
1	**1**	21
1	**2**	23
1	**1**	23
1	**2**	22
1	**1**	24
1	**2**	21
1	**1**	20
1	**2**	20
1	**1**	20

1	**2**	22
1	**1**	22
1	**2**	23
1	**1**	20
1	**2**	20
1	**1**	26
1	**2**	22
1	**1**	20
1	**2**	24

APPENDIX EIGHT

INTRODCTORY LETTER

AKENTEN APPIAH-MENKA UNIVERSITY
of Skills Training and Entrepreneurial Development

FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF INTEGRATED SCIENCE EDUCATION
P.O. Box 40, Asante Mampong 0270001890, 0502972415

M/DISE/ADM/STU/01/51 **MARCH 11, 2024**

TO WHOM IT MAY CONCERN

Dear Sir/Madam

INTRODUCTORY LETTER FOR MR. AMOS MAMBO BULLU

We Write to introduce Mr. Amos Mambo Bullu, who is an M.Phil. (Science Education) student of this Department. Bullu is working on a project titled **"Enhancing Conceptual Understanding of Genetics Through Jigsaw and Think-Pair Share Method: A Quasi-Eperimental Study in Senior High Schools"** and would like to collect data from your institution for a period of six (6) months to enable him to complete his thesis, which is a requirement for graduation.

We would be grateful if you could offer him the needed assistance. We count on your usual cooperation.

Thank you.

Yours faithfully,

PROF. EBENEZER EKOW MENSAH
(AG. HEAD OF DEPARTMENT)

www.aamusted.edu.gh dise@aamusted.edu.gh