AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

ASSESSING COGNITIVE CONFLICTS TEACHING STRATEGY INFLUENCE ON SENIOR HIGH SCHOOL BIOLOGY STUDENTS' GENETIC PERFORMANCE

CHARLES JACKSON GYIMAH

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BY

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DECLARATION

Candidate's Declaration

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

Charles Jackson Gyimah

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

Supervisors' Declaration

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

Dr. Charles Amoah Agyei (Principal Supervisor)

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Dr. Eric Appiah-Twumasi (Co-Supervisors)

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DEDICATION

This book is dedicated to my grandma, Christiana Anning, brother, Elliott David Johnston and the ever-amazing Constance Boadiwaa Appiah.

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ABSTRACT

This study investigated the effect of cognitive conflict teaching strategy on the academic performance of students' in Senior High school students in genetics. A Quasi experimental pretest posttest control group design was used for the study. Two groups of students were used in the study, that is, control group and experimental group. The experimental group was exposed to cognitive conflict teaching strategy while the control group were taught using the lecture method. One hundred and thirty-seven (137) students participated in the research from two Senior High Schools in the Ahanta West Municipality of the western region. The instrument used in the collection of data was Genetic content knowledge test, which was in the pretest and posttest. Three research questions guided the study and was analyzed using paired sample t-test and independent sample t-test. It was found out that; students' have difficulties in learning genetics. The use of cognitive conflict as a teaching strategy helped students overcome these difficulties, by exposing them to contradictory information which led students to find out scientific principles for themselves. It was therefore recommended that biology teachers should use teaching strategies that involves participation such the cognitive conflict teaching approach.

CHAPTER ONE

INTRODUCTION

1.1 Overview

The background to the study and problem statement are covered in this chapter. Furthermore, the study's aim, objectives, and research questions are explained. This chapter concludes with the study's importance, limitations and delimitation, and also emphasizes study's organization.

1.2 Background to the Study

The long-standing issue of students' performance in school has been invariably linked to teaching methodologies employed by teachers and instructors. Teaching methodologies has been used by teachers over the years to transmit knowledge to students. Teachers' choice of a teaching method comes down to several factors, such as availability of resources, time, class size and teachers' expertise (Murphy et al., 2020; Akdemir & Özçelik, 2019). The spine of education is teaching and its significance cannot be overlooked. The choice of teaching methodology employed by teachers has a substantial impact on the performance of students especially in cases where a complex topic is in the frame. The profession of teaching is intricate and multidimensional, requiring both a thorough comprehension of the subject matter and the capacity to clearly and succinctly convey complex ideas.

Teachers' methods and approaches to support the learning process are referred to as instructional strategies (Curtis et al., 2016). To put it another way, a teaching strategy is a collection of methods and techniques that are based on an approach and are employed to successfully complete the lesson's objectives (Ghaizi et al; 2022). The teaching methodology employed by teachers has its own impact on learner's achievement, thus forming the pillar upon which learning success is built. There are numerous teaching strategies that are used in diverse settings to achieve diverse goals (Morrison, Ross, Morrison, & Kalman, 2019). When the right teaching methodology is used, an impact is felt within learners' performance. Teaching instructions adapted by teachers carry along a perception of making the teaching and learning process easier, personal subjective preference and cultures. In this sense, teachers use various teaching methods depending on the process of learning setting, which eventually leads to differences in the progress of learners results both within and between classes (Illeris, 2018)

Darling-Hammond et al (2020) posit that, learners come to class with needs that are diverse, therefore, it is imperative for instructors to diversify their teaching methods to meet the needs of leaners. This ideology shows the significance of using different instructional methodologies that fosters deeper understanding and learning. According to Hill et al. (2022), effective instruction entails establishing a welcoming, encouraging, and demanding atmosphere of learning for every student. Teachers' ought to thoughtfully select their teaching strategies to align with the subject's content and instructional goals for the purpose of influencing students in ways that are desired. According to Kalantzis et al., (2022), the nature of the subject determines the teaching approach employed, as well as the level of the students. Students obtain better academic performance and show greater attention when teachers use a variety of teaching strategies and tactics (Wuryaningsih et al., 2019).

In the opinion of Omar et al. (2020), the primary goals of instruction is to help students gain, maintain, and apply knowledge; create practices and mindsets; and expand their knowledge of fundamental concepts and guidelines related to the subject matter. For this to occur, the teacher must enter the world of the learner and design teaching methodology that suits learners needs; thus, the learner should be taken into consideration when teaching methodologies are being designed to be used in the classroom (Wang et al., 2022). Instructions for teaching should be dynamic to cater for various learning styles as each learner answers questions in a unique way. Academic achievement rises when there is an alignment of the teaching methods to leaners needs leading to better engagement and motivation (Garcia et al., 2021).

Educators are expected to select teaching strategies that will sustain learners' interest, thereby increasing learning outcomes (Granjeiro, 2019). Teaching methods are grouped distinctly into two. Teacher centered methods and student-centered method (Lightweis, 2013). The significant difference between the two theories is their primary focus. The teacher centered method of teaching also known as the lecture method of teaching remains one of the oldest teaching methods, but its efficacy is widely regarded to be ineffective (Marmah, 2014). The idea of behavioral learning, which stresses the significance of giving appropriate challenges, results in the development of skills and desired behaviors through repeated practice and feedback (Schunk, 2020).. Learners in a teacher-centered classroom turn out to be passive information receivers, and there is little to no engagement by the leaners in the classroom ((Emaliana, 2017). The teacher-centered classroom is characterized with the use of textbooks for instruction (Hussain, 2017) as the teacher becomes the repository of all knowledge.

The traditional method of teaching has consistently been criticized for it one-way delivery of information. The instructor plays a crucial role in how students learn as the primary authoritative figure and repository of information (Woods & Copur-Gencturk, 2024; Murphy et al., 2021). Educators create and present lectures, organize the curriculum, and give learners guidance, illustrations, and tests. Conversely, students are treated as passive information consumers who do not develop the critical thinking, creativity, and problem-solving abilities necessary for accomplishment in modern scientific pursuits. Students main duty is to pay attention, make notes, and process the information that the instructor is presenting in a traditional class. Students and teachers rarely interact, and the circumstances of the classroom are marked by a single-way exchange of information.

In order to better prepare students for the difficulties and challenges of contemporary science and technology, many institutions are embracing more student-centered and active learning approaches as education develops (Klegeris, 2021; Dogani, 2023). The student-centered classroom sees the change in narrative as learners experience a shift in focus from teachers to the students (Pai & Mallya, 2016).. The student-centered model's capacity to take part learners from a variety of interdisciplinary experiences by tailoring course material to their individual viewpoints is one of its main advantages (Bremner et al., 2022; Shak, 2020). Student-led feedback systems serve as a potent catalyst for ongoing enhancements in both instruction and learning in a student-centered learning environment (Zhang et al., 2021).

The students centered teaching approach does not only put knowledge in the head of students but prepares them overall. A comprehensive educational approach that deviates from traditional methods teaches students to think critically, be creative, learn on their own, and have a professional mindset (Mladenovici et al., 2022). Learners who find themselves in a classroom that is students centered tend to be curious and are able to solve critical problems through the use of their critical thinking skills acquired in the classroom. It encourages open-mindedness and a willingness to take chances, acknowledging that different viewpoints and flexibility are essential for creativity (Gamage et al., 2021). In order to create an atmosphere where learners actively participate in their learning, student-centered teaching methods give priority to their needs, desires, and learning preferences (Dogani, 2023; Bremner, 2021; Darsih, 2018; Meng et al., 2019; Neumann, 2013; Starkey, 2019). Each of the three teaching philosophies—"for the student, of the student, and by the student"—offers a distinct viewpoint on student-centered learning. "Teaching for the student" places a high priority on bridging learning gaps, encouraging inclusion, and customizing instruction to each student's requirements and learning preferences (Garrett, 2008).

Additionally, it guarantees that every student finds a way to succeed, irrespective of their prior education or learning style. This strategy fosters a sense of equity and support in the classroom by having teachers modify their approaches to guarantee that every student may succeed. Recognizing the difference among students enables educators choose a teaching style that suits every learner. Students' investigative and critical thinking abilities are improved by the "for the student" concept (Goel, 2025). Students are inspired to investigate, challenge, and evaluate knowledge when inquiry-based learning is promoted, which fosters autonomous thought and problem-solving skills. This approach is essential for improving students' cognitive and metacognitive abilities, greatly benefiting their entire educational experiences (Tezer, 2024).

Customized learning experiences are made possible by teaching "of the students," which transfers the burden of learning from the instructor to the student. It gives students the freedom to follow their curiosity, which is crucial for their self-learning. Research shows that students' motivation and engagement levels rise dramatically when they participate in pedagogical decision-making (Geurts et al., 2023; Owuor et al., 2022). This self-directed learning also helps students develop important research skills and fits their educational experiences with their career aspirations, preparing them for futures that depict their values and interests (Adedokun et al., 2013; Arhin, 2018). By actively incorporating students in their own learning processes, the "by the student" method radically transforms the educational process (Bhardwaj et al., 2025). Rather than merely receiving information, students are encouraged to take charge of their learning journey and sharing their knowledge with peers.

A paradigm change from the traditional teaching and learning strategy to a more active and learner-centered approach that may meet students' 21st century skill needs is still occurring in the educational process in today's evolving environment (Schleicher, 2012). This change puts a great deal of pressure on teachers to have the innovative teaching skills necessary to allow them to actively engage in the learning process (Olelewe et al. 2020). Given the vast array of pedagogical options available, educators must prioritize choosing instructional strategies that will both interest students and improve acquiring and maintaining knowledge (Alvarez-Bell et al., 2017; Bidabadi et al., 2016; Granjeiro, 2019; Tews et al., 2015). Different instructional techniques and approaches that are meant to inspire students and enhance learning and academic performance should be used in classrooms to make sure that students realize their full potential in the classroom (Dunlosky et al., 2013; Friesen, 2011; Tanner, 2013).

A common source of biology learning challenges for students is genetic material (Ojo, 2024). Biology relies heavily on genetic material. According to Nusantari (2014), genetics is the study of genetic material. Seven key ideas are covered in general genetics: 1) the definition and application of genetics; 2) the structure of genetic material; 3) the reproduction of genetic material, including cell reproduction, semi-conservative DNA replication, and other processes; 4) the work of genetic material covering the scope of genetic material; 5) genetic material changes; 6) genetics in the population; and 7) genetic material engineering. This demonstrates how crucial genetic information is to biology, making it imperative that students grasp it. However, it is challenging for high school students to learn about genetic material due to its abstract nature. The learning process of these leaners will be hampered if their learning challenges are not recognized. Therefore, in order to properly accomplish educational objectives, it is imperative that students' learning challenges be identified and addressed as soon as possible. To help students achieve the best learning outcomes, steps must be taken to diagnose learning issues.

There are various factors that affect students' performance in genetics such as pedagogical approaches, learner's prior knowledge and their engagement with the learning material. Collaboration, problem- solving skills and there is a significant improvement understanding and retention of genetic concepts as learners engage in activities that are practical compared the traditional method of teaching (Singh et al., 2020). This finding is supported by Dewey et al., (2021) who argues that, with hands-on activities, students show a greater interest and improved performance in difficult subject areas like genetics. Students' perception towards genetics and its importance to learners motivates them to academic success. The importance of contextualizing genetics to real world situations enhances learners' performances and involvement (Meyer et al., 2020).

Studies abouts students in schools leads to the inescapable conclusion that, leaners consider genetics to be difficult. Genetics is a fundamental concept in biology, yet, it is identified as a challenging topic for students (Smith, 2020). Research by Dorji et al., (2017) posited that, high school students possess little and inadequate understanding of genetics. Students even attempt to avoid answering questions on genetics altogether (Adelana et al., 2021). Difficulties in genetics may stem from several factors, including but not limited to a lack of prior knowledge, abstract and complex concepts, mathematical and symbolic representations. The lack of existing knowledge poses a threat to the understanding of genetics. Students understanding of genetics is often built on the prior knowledge, which may not be sufficient or inadequate (AAAS, 2020). Again, the abstract and complex nature of genetics makes it difficult for learners to visualize and understand (National Research Council, 2020) hence, learners cannot relate to the concepts. Students often do not have the visualizations skills which is needed to understand complex genetic mechanisms (Wang et al., 2020).

Despite the significant advancement of science education, the field of science has long been criticized for gender biasness, a worrying trend that has persisted over the years. At the forefront of the biasness is the underrepresentation of women and other areas of science such as Technology, Mathematics and engineering. Research have indicated that, practices in the classroom widely favors the male counterparts, giving them the opportunity to explore and engage in scientific inquiry (Moss-Racusin et al., 2018). This practice has the tendency of discouraging female students from higher learning in science.

Girls have historically underperformed and been underrepresented in science at all educational levels, most notably in secondary schools around the globe (Lundberg, 2020: McDool & Morris, 2022; UNESCO, 2017). Underrepresentation of girls has also been observed in the lower tiers of the educational ladder in science related courses, favoring men more than females in further fields of occupations (Matete, 2022). According to

Alexakos and Antoine (2003), gender differences in interest, engagement, and accomplishment have persisted in elementary and secondary scientific classes, with physics and chemistry topics experiencing the greatest disparity. Women are still underrepresented in STEM fields (mathematics, science, technology, and engineering), especially in computer science, engineering, mathematics, and physics according to Allegrini (2015). Çakiroglu (1999) emphasizes that gender disparities occur in written science-related achievement assessments across all school levels and subject areas, typically favoring men.

Despite a conscious effort to increase the representation of females in science, studies show otherwise. Research by National Science Foundation (2021) indicates that, the number of women who obtained a bachelor's degree in 2020 in the field of engineering, computer science and physical science is 28%, 19% and 48% respectively, indicating a clear gap in these disciplines. A crucial factor affecting women in academia has been bias and stereotypes that has existed in academia over time. Overcoming bias and stereotypes in gender is a challenge that is seen as a benchmark for women in STEM (National Academy of Sciences, Engineering and Medicine, 2020).

The content in the curriculum and the teaching approaches used by educators also plays an important role in changing the gender perceptions of science. Gender diversity is often lacked in teaching materials, such as textbooks, which often underrepresent the contributions made by women in science. (Ceci et al., 2019). Teaching strategies such the traditional method of teaching, which breeds competition and individual achievement may indirectly disadvantage females who learn better through collaborative work (Stoet & Geary, 2018). The cognitive conflict teaching strategy is one of the more successful methods that educators can use to bridge the gap that is perceived to exist between males and females.

According to Mufit et al. (2018), cognitive conflict is a well-known crucial component of the conceptual change process and can be successfully used as a teaching-learning approach to support students' conceptual growth. When handled well, cognitive conflict may encourage a positive mindset and improve cognitive development in science education (Chi, 2018). Students' cognitive achievement in acquiring science-related concepts is positively impacted when there is cognitive conflict. Students that experience cognitive conflict are more likely to critically assess and change their preconceptions, which improves their cognitive accomplishment and fosters a better comprehension of concepts (Deng & Zhu, 2019) and improved problem-solving abilities and a capacity to apply scientific ideas to practical contexts (Koballa & Glynn, 2019). Utilizing cognitive conflict in science learning through student-centered methods fosters critical thinking abilities and improves cognitive accomplishments (Wang & Palius, 2021).

A phenomenon known as cognitive conflict occurs when students' cognitive structures clash (Akmam et al., 2018). Disparities in students' first perceptions of their educational experiences lead to conflict (Prayogi & Verawati, 2020). When events (also known as "anomaly data") that contradict what learners now comprehend throw off their mental equilibrium, cognitive conflict results (Prayogi et al., 2019). According to constructivism philosophy, cognitive conflict is characterized as a conceptual scheme that is built on the learner's optimism. The instructor uses it as a teaching tool in the classroom to replace false beliefs with alternative, accurate conceptions (Mady, 2011). As per the findings of Abdul Wareth and Said (2012) and González-Espada, Birriel, and Birriel (2010), the cognitive conflict technique of teaching involves the following stages:

Creating conflict: By showcasing an unexpected event student are drawn in. Students are inspired to inquire about these inconsistent displays from the teacher.

Looking for a solution: As a result of these inconsistent displays, students get keen to identify a remedy. The essential tasks to resolve this disagreement have been identified and students actively participate in experimentation, categorization, forecasting observation, and data registration. A significant portion of the proper lesson topic is also taught to them.

Resolving the issue: rather than listening to theoretical explanations, students may address the problem by themselves by doing exercises that help them come up with answers to several questions. They pick up various abilities like gathering information, paying attention, cooperating, and posing queries. By providing a resolution to cognitive conflict, learners are able to attain cognitive equilibrium; a false belief is swapped out for a solid scientific explanation.

Numerous researches have demonstrated how well students' beliefs about science may be changed by using the cognitive conflict technique; Al-Rubaiyi et al. (2015), Al-Mahdi (2017), Jawad, (2015), Al-Otaibi (2015), Kornell and Bjork (2020), Chiu and Kuo (2021), Amaguchi, Nakagawa, and Higuchi (2021), Gomez and O'Connor (2023), Aksu and

Yıldız (2024), Al-Rubaiyi et al., (2015), Al-Mahdi (2017), Jawad, (2015), Al-Otaibi, (2015), Kornell and Bjork (2020), Chiu and Kuo, (2021), Amaguchi, Nakagawa and Higuchi (2021), Gomez and O'Connor, (2023), Aksu and Yıldız, (2024).

Due to the success stories of the cognitive conflict strategy in other fields of study, it is imperative to learn the effect of cognitive conflict teaching instruction on the performance of students in genetics.

1.3 Statement of the Problem

Genetics came up as one of the topics perceived to be difficult during an interaction with SHS three Biology students and how the topic is taught in the Ahanta west Municipality. Ana responded that, "*she has never understood genetics because it is not physical and she can't relate to it.*" Another respondent, Enoch stated that, "*I don't get how genes and DNA fit together*." The response from Biology students reflects the chief's examiners report on Biology, starting how students perform poorly in biology especially on questions relating to genetics. (WAEC, 2019, WAEC, 2020, WAEC, 2021, WAEC, 2022, WAEC, 2023). Over the years, the Chief Examiner has noticed numerous student difficulties in genetics. In 2019, it was discovered that the majority of candidates fared reasonably well in terms of definitions but poorly on the genetic diagram. They were unable to accurately express the genotypes of the parents, which had an effect on the results Students struggled to perform genetic crosses, particularly dihybrid crosses, and to analyze pedigree charts. Many candidates failed to correctly identify genotypes and phenotypes. Again, Students found it challenging to apply genetic principles to solve problems. They often failed to recognize the relevance of genetic concepts to real-life situations.

In 2020 Report, the chief examiner reported that Students had difficulty understanding and applying genetic terminology, such as genotype, phenotype, dominant, and recessive. Many candidates confused these terms or used them incorrectly. Students struggled to differentiate between genotype (the genetic makeup of an organism) and phenotype (the physical characteristics of an organism). This led to errors in predicting offspring traits. 2021 reported Students faced challenges in understanding molecular genetics concepts, including DNA structure, replication, and gene expression. Many candidates lacked a clear understanding of the molecular basis of genetic inheritance. Students found it difficult to apply genetic principles to real-life situations, such as genetic counseling or predicting disease inheritance. They often failed to recognize the practical implications of genetic concepts.

2022 Reports Genetic Inheritance Patterns: Students struggled to understand genetic inheritance patterns, including monohybrid and dihybrid crosses. Many candidates failed to correctly predict offspring genotypes and phenotypes.

- Role of Genes and Chromosomes in Inheritance: Students had difficulty understanding the role of genes and chromosomes in inheritance. They often confused the functions of genes and chromosomes or failed to recognize their importance in determining traits.

- 2023 Reports of Genetic Variation and Mutation: Students faced challenges in understanding genetic variation and mutation. Many candidates failed to recognize the causes and effects of genetic mutations or to understand the role of genetic variation in evolution.
- Applying Genetic Concepts to Solve Problems: Students struggled to apply genetic concepts to solve problems. They often failed to recognize the relevance of genetic concepts to real-life situations or to use genetic principles to predict outcomes.

2024 WAEC examination reported that Students faced difficulties in understanding genetic engineering and biotechnology applications. Many candidates lacked a clear understanding of the techniques and implications of genetic engineering. Students struggled to understand the implications of genetic advancements on society. They often failed to recognize the potential benefits and risks of genetic technologies or to consider the ethical implications of genetic research.

Difficulties in genetics is not only peculiar to Ghanaian students but cuts across several countries. Several researches conducted revealed that, genetics, which is a component of Biology is difficult for students. Research by Tammu (2022) in Indonesia, Machová and Ehler (2023) in the Czech Republic, Osman et al. (2017) in Lebanon, and Kilic et al. (2016) in England and Turkey have reported genetics as a difficult topic to learn. Auwalu et al. (2014), Olorundare (2014), and Abimbola (2015 reported that, students misunderstood the concept of genetics.

Learners' achievement in genetics has been connected in number of researches to how courses in science are taught (Scherer, Siddiq, & Viveros, 2020; Al-Zoubi & Bani-Younes, 2015; Hattie & Donoghue, 2016; Young & McGowan, 2021; O'Neil & Fisher, 2020; Marzano & Simms, 2021; Gonzalez & Rojas, 2020; Bishop & Verleger, 2020; Bruscia, 2021), The majority of genetics teachers employ a teacher-centered methodology. These tactics, however, don't seem to enhance students' conceptual comprehension, which hinders their performance. Given the vast array of pedagogical options available, educators must prioritize choosing instructional strategies that will both interest students and improve learning and retention and take away misconceptions (Bidabadi et al., 2016; Granjeiro, 2019; Tews et al., 2015; Alvarez-Bell et al., 2017). Cognitive conflict strategy is one of the ways of teaching that arouses students' interest, improve learning and retention and takes away misconceptions' students have in science and genetics as a whole (Al-Mahdi, 2017).

Though research on the effectiveness of cognitive conflict has been done elsewhere (Al-Mahdi, 2017), it appears not much has been done in Ghana. This is regrettable because there is strong evidence that cognitive conflict improves students' conceptual grasp of genetics and performance as a whole. It wouldn't be out of line to educate Ghanaian students utilizing cognitive conflict methodology in order to assess the approach's durability in our system of learning, given how poorly they perform in genetics topics. This will determine whether or whether the cognitive conflict technique is effective in raising genetics proficiency among Ghanaian senior high school students. Therefore, the purpose of this study was to close a knowledge gap about the application of cognitive conflict strategy in Ghana's educational system.

1.4 Purpose of the Study

The study's purpose was to investigate how well students performed in genetics when taught using a cognitive conflict approach.

Objectives of the Study

Specifically, the study aimed to:

1. Determine how senior high school biology students' academic performance in genetics is affected by the cognitive conflict teaching technique.
2. Ascertain the effect of the cognitive conflict teaching strategy and traditional method of teaching on students' in senior high schools academic performance in genetics
3. Determine the impact of the cognitive conflict teaching approach on the academic performance of senior high school biology students studying genetics, both male and female.

1.5 Research Questions

To direct the investigation, the following research questions were developed:

1. What is the effect of cognitive conflict teaching approach on senior high school biology students' performance in genetics?
2. What is the difference between SHS students taught genetics using the cognitive conflict teaching strategy and those who are taught using the traditional method?

3. What is the effect of cognitive conflict teaching approach on the sex of senior high school biology students when taught genetics?

1.6 Significance of the Study

Results emanated from this study can be used by teachers and students aspiring to be teachers in the field of Biology in the Ahanta West district. Findings from this research may help the Biology teacher acquire the best teaching techniques to teach genetics. Students aspiring to be biology teachers might also be better placed to choose the right teaching method from the onset to enhance their teaching of genetic concept. Additionally, institutions that has been mandated to train biology teachers may use the findings from this research as a resource to add to the plethora of teaching strategies used to teach aspiring teachers

1.7 Delimitation of the Study

In the Ghanaian senior high schools, there are three-year groups, first year, second and third year. This study was conducted with the SHS 3 biology students since genetics is a third-year topic. There are so many teaching approaches to teaching biology in the senior high schools. The research was however restricted to cognitive conflict teaching approach.

1.8 Limitation of the Study

The limitation of this study is its restricted generalization, as this study was conducted in only one municipality and involved few schools.

1.9 Organisation of the Study

There were five (5) chapters for the entire study. Chapter one elaborated on the introduction of the study. This chapter considered the study background, problem statement, study purpose, research questions, study significance, delimitations, limitations, term definitions, and study organization. The review of relevant literature on the subject matter was the sole focus of Chapter 2. Research methodologies were covered in Chapter 3. The population, sampling strategy, data gathering tools, data collection process, data processing, and data analysis were all included in this. Results and a discussion were presented in Chapter 4. Chapter five also talked about summary, conclusions and recommendations about the research.

CHAPTER TWO

LITERATURE REVIEW

The chapter provides a summary of the pertinent literature that was reviewed for the study. The aim of the research was to find the effects of cognitive conflict teaching strategy on students' performance in genetics in the Ahanta West Municipality. The empirical work and the theoretical framework are both covered in this chapter, which was aided by experts in science education on students conceptual development, students' low performance in genetics, learners inability to understand genetics ideas, and the use of conceptual development in instruction. Theoretical framework begins the analysis of this chapter.

The literature was based on the topic in order to represent the current problems with students' conceptual understanding. Students' comprehension is currently dependent on constructivism and other related ideologies. Therefore, examining the literature in the context of conceptual change and cognitive conflict

2.1 Theoretical Framework

This study was conducted within the constructivist paradigm. Constructivism has various manifestations across disciplines, from mathematics and science to philosophy and education (Lerman, 2016), with each one of them suggesting various ways of teaching and learning with the view of how knowledge is constructed. One view theories of constructivism agree on is how should knowledge be built, that is, through a constructive process. Thus, the learner is in charge of his/her own learning. Students learn best when they are actively engaged in the learning process, constructing their own knowledge through experiences, interactions, and reflections (Hmelo-Silver, 2004; Jonassen, 2004; Lave, 2012; Brown, 2017). Constructivists think that new understanding arises from the interaction of prior knowledge and new information. Teachers play a crucial role in facilitating students' active learning by providing opportunities for them to explore, discover, and construct their own knowledge (Linn, 2018). Educators engaged in cognitive conflict are concerned with instructional approaches and stages of growth, which occur organically when learners move their mental models to a more scientific understanding.

Constructivism is a significant theory on the process of education that is founded on observation and empirical research. It expresses how individuals form their own opinions and comprehension of the world via experience and reflection (Woolfolk, 2016). When there is an encounter with a new knowledge, the individual solves the problem with a previous knowledge and experience, through modification of existing beliefs or throws away the new knowledge completely as it is seen as not important (Educational Broadcasting Corporation, 2004).

Educators who are aligned with constructivism encourage their students to come with meanings of the real world, which is influenced by their background and culture. In the learning process, the learner’s previous knowledge is cnsidered as well as the culture of the learner by constructivist. The learner's background, experiences, and context shape their construction of meaning and understanding of new information (Kearns, 2019). Leaners take charge of what they learn in order to succeed; they must take part actively in the educational process and take responsibility for their progress in the educational ladder (Kolb, 2017). Educators who believe in constructivism see the significance of previous knowledge in the process of learning as it provides them with an insight of students' abilities and inabilities.

Learners are constantly urged to re-evaluate how activities help them in the gain of new knowledge by educators who ascribe to constructivism as it helps learners gain more understanding. By questioning themselves and the strategies they use, learners become good at whatever is being learnt. This is evident in a classroom where Students acquire the ability to learn. (Woolfolk, 2016). When learners are given the autonomy to explore and investigate, they are more likely to develop a deeper understanding of complex concepts (Duke & Pearson, 2016).

The attention of a classroom that is constructivist based is shifted onto the learner instead of the teacher. Knowledge is constructed in the classroom instead of being a place where learners are filled with knowledge without questioning it. It is characterized by active learning which allows students to play an integral role in the learning process. The role of the teacher in a constructivist classroom shifts from being the sole source of knowledge to being a facilitator, thereby creating an environment that encourages students to learn and discover by themselves and take ownership of their learning (Weimer, 2013). Such experiences are intended to allow the learner to find a pathway to connect with real world experiences and problems, thereby increasing importance and students' engagement with materials.

The study's conceptual framework combines the cognitive conflict teaching strategy with the conceptual transformation approach. The approach of conceptual transformation was modified from Treagust and Duit (2018). Treagust and Duit (2018) saw conceptual change as a process that apacomplex but involves steps to identify and address leaners misconception, which can normally be linked or associated to learners existing knowledge and experiences. This ideology puts emphasis on leaners preconception and using it design learning strategies that can bring about conceptual change. According to constructivist, conceptual change seeks to aid students change or swap misunderstandings and impart fresh information that will benefit the student more. Conceptual transformation refers to learning areas in which learners' pre-instructional conceptual structures need to be radically reorganized to make way for comprehending the desired knowledge.

The conceptual change approach to teaching used in this study was adopted because it has meaning to the learning of science under the constructivist domain (Duit, 2018). It was ideal to use a conceptual change approach as a framework for the implementation of the developed intervention, so in addition to attempting to understand learners' conceptual comprehension of genetics, this study also focused on teaching strategies that aim to improve students' conceptual understanding of genetics. Appropriate instructional methodology was developed based on students' understandings, with the cognitive conflict teaching approach as the base of the teaching method.

The cognitive conflict teaching approach is based on the constructivist paradigm. Cognitive conflict, which arises when learners' existing knowledge and understanding are challenged by new information or experiences, is a key mechanism for promoting conceptual change and learning in the classroom (Hmelo-Silver, 2018). In this context, teaching "is not mainly oriented to scientific issues but students' connections as well" (Duit & Komorek, 1997, p. 341). The outcome is that, the teaching strategy takes three stages of the students conceptions into account; (a) determining the current level of knowledge held by the students; (b) exposing the students to contradicting material, which is typically done through texts (Guzzetti & Glass, 1993) and discussions, which either explicitly state the contradiction or merely serve to direct student or peer debate (in small groups or the entire classroom) (Dreyfus, Jungwirth, & Eliovitch, 1990; Weaver, 1998; Tillema & Knol, 1997), or by the teacher; and (c) assessing the extent to which students' previous ideas have changed.

2.2 Conceptual Framework

Creswell (2018) defines a conceptual framework as a diagram or chart that shows the relationships between concepts, variables, and hypotheses. It can be used to clarify research questions, highlight key concepts, show how various components relate to one another, and provide a visual representation of the study design. Babbie (2022) explains it as a theoretical framework that integrates ideas, theories, and assumptions to guide research, analysis, or decision-making. Cognitive conflict is a method of teaching which involves presenting learners with information that contradicts their existing beliefs, values and perspectives, causing learners to question their prior knowledge and reconcile discrepancies. Cognitive conflict is grounded in the theory of cognitive dissonance, which suggest that, individuals experience a state of discomfort when presented with information which does not align with their beliefs and challenges it (Haidt, 2020). The state of dissonance experienced by individuals pressures them into trying to reduce or stop the dissonance (Haidt, 2020).

The introduction of cognitive conflict by educators has the ideas, theories, and assumptions to guide research, analysis, or decision-making. Cognitive conflict is a method of teaching which involves presenting learners with information that contradicts their existing beliefs, values and perspectives, causing learners to question their prior knowledge and reconcile discrepancies. Cognitive conflict is grounded in the theory of cognitive dissonance, which suggest that, individuals experience a state of discomfort when presented with information which does not align with their beliefs and challenges it (Haidt, 2020). The state of dissonance experienced by individuals pressures them into trying to reduce or stop the dissonance, according to Haidt, (2020). The introduction of cognitive conflict by educators has the tendency to motivate learners in critical thinking, analysis and problem solving.

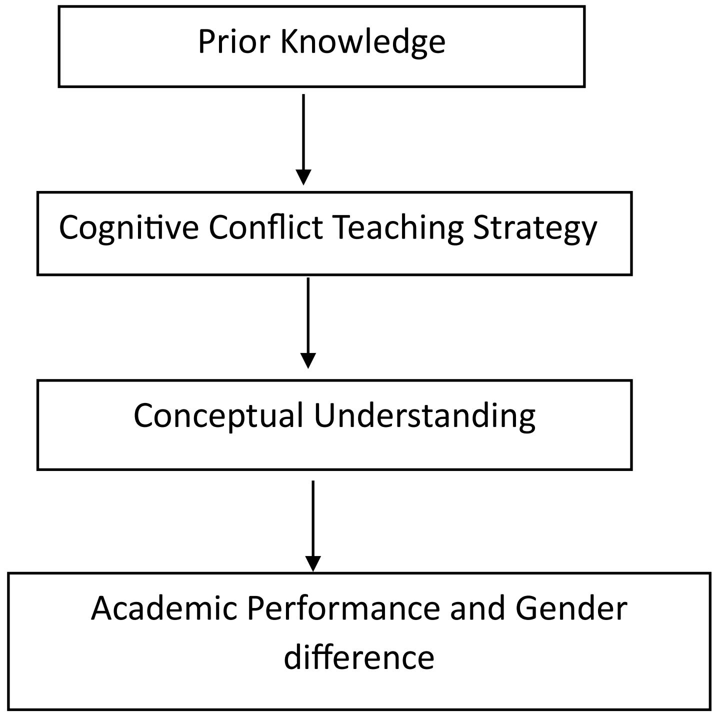

Figure 2.1: Conceptual framework of the study

The conceptual framework for the effect of cognitive conflict teaching strategy on students' performance in genetics outlines a systematic approach to understanding the relationships between teaching methodologies, cognitive processes, and educational outcomes. Detailed explanation of the conceptual framework given below:

Prior Knowledge

Prior knowledge refers to the background knowledge and misconceptions students hold before learning new content. When cognitive conflict is introduced, it becomes important for students to reflect on their existing knowledge. This helps them identify gaps in their understanding and encourages them to adjust their views.

Impact on Performance: A solid understanding of prior knowledge is critical, as it serves as a foundation for the assimilation of new concepts. Students who acknowledge and address their misconceptions are likely to perform better.

Cognitive Conflict Teaching Strategy

Cognitive Conflict Teaching Strategy as the independent variable. This method involves presenting learners with information or scenarios that contradict their existing knowledge, prompting them to actively engage with and question their understanding. This initial stimulus is crucial, as it sets the stage for the learning process.

Purpose: The strategy aims to foster deeper understanding by challenging students' pre-conceived notions. This cognitive dissonance encourages them to explore new concepts in genetics that they might find difficult or perplexing.

Cognitive Engagement

Cognitive engagement refers to the degree to which students are mentally involved in their learning. The cognitive conflict strategy prompts students to become more engaged as they seek resolution to the discrepancies between their prior understanding and the new information presented. This engagement can take the form of critical thinking, problem-solving, and active participation in discussions. Increased cognitive engagement is strongly associated with improved comprehension and retention of complex genetics concepts, leading to better performance.

Conceptual Change

The process by which students alter, improve, or replace preexisting conceptual models, misunderstandings, or intuitive notions in order to arrive at a more precise and widely recognized grasp of a subject is known as conceptual change. It is essential to effective learning, especially in scientific classes where students frequently have misunderstandings about difficult ideas.

Dependent Variable: Students' Performance in Genetics

The final component of the framework is Students' Performance in Genetics, which is the dependent variable. Performance can be measured through various indicators, including: Academic Achievement: Scores on tests, quizzes, and assignments. Practical Application: Ability to apply genetic concepts to solve problems or conduct experiments. Conceptual Understanding: Depth of understanding of key genetics principles.

Relationships and Interactions

The arrows between variables indicate the direction and relationships of influence. The cognitive conflict teaching strategy affects students' prior knowledge, cognitive engagement, and Student engagement, influence students' academic performance in genetics.

2.3 Cognitive Conflict Strategy and Misconceptions

The cognitive conflict teaching style is a teaching approach where students are presented with new knowledge that tests their prior knowledge and beliefs, thus, ignites critical thinking and deep learning. Cognitive conflict teaching strategy has been used in various areas of the academic to improve academic performance. According to Akkmam et al. (2018), cognitive conflict is a circumstance where a disagreement in students' cognitive structures occurs. Disparities in students' early beliefs of their learning experiences give rise to conflict (Prayogi & Verawati, 2020). When experiences also known as "anomaly data" disturb students' mental equilibrium and do not align with their present thinking, it can lead to cognitive conflict (Prayogi, et al., 2019).

Cognitive conflict can occur within the same person as concepts become confusing, although socio-cognitive conflicts can sometimes arise between individuals, the model typically attempts to incite conflict by presenting novel, contradicting information (Limon, 2001). A contradiction can occur in a learner's conception when an educator brings new knowledge to class that catches learners' attention but contradicts with his or her conception (Kang, Scharmann, & Noah 2004). Conceptions are shaped by individuals' experiences, social interactions, and prior learning, as well as influenced by external factors such as media, peer groups, and cultural background" (Tsai & Lee, 2020). On the other hand, misconceptions could happen and stem from errors in categorization. When students categorize concepts in ways that are not consistent with their scientific or mathematical definitions, it is referred to as a category mistake, which can be a common obstacle to conceptual understanding" (Santos & De Lima, 2020). By helping students develop in all areas (mental, social, and psychological) the cognitive conflict strategy helps them meet educational objectives. It equips learners to adjust to society and their surroundings. In order to arrive at a scientific interpretation of any contradictory events, students must seek clarifications, employ their skills, document information, and make observations. This allows them to pass paradoxical circumstances through good thinking and problem-solving skills.

Misconceptions are notions that do align with scientific facts. In the absence of evidence, people's intuitive theories are not necessarily accurate. They can be based on incomplete, incorrect, or outdated information, and they can be influenced by personal biases and prior experiences. Misconceptions are a common phenomenon in learning and can persist even when learners are presented with evidence to the contrary (Mestre, 2015). The dissonance can cause a person to take a second look at one's understanding, which will ultimately lead to further interaction with the fresh knowledge acquired. Category mistakes can occur when learners incorrectly place concepts into either ontological or lateral categories, resulting in misconceptions that can be persistent and resistant to change. Ontological category mistakes involve categorizing concepts that are fundamentally incompatible, while lateral category mistakes involve grouping concepts that are related but not equivalent (Venville, 2019). Category mistakes are responsible for a number of strong misconceptions, as Chi (2008) suggests that once a category mistake is registered into a learner's mental framework, it results in a mental model that is inaccurate or defective. To put it another way, students might consider some ideas from ontological categories that are distinct from those that scientists have ascribed. This implies that an ontological shift in the student's cognitive structure must accompany conceptualization transformation.

Misconceptions play a crucial role in understanding the dynamics of how students construct knowledge. Rather than viewing misconceptions merely as barriers to learning, Kornell et al., (2019) argue that, errors can be a source of motivation for learners, as it prompts them to re-examine their prior knowledge and misconceptions, which leads to deeper understanding and knowledge. They serve as a baseline from which students can advance their understanding. Identifying, clarifying, and addressing misconceptions becomes essential in promoting meaningful learning, as students must first grapple with their erroneous beliefs before, they can fully embrace new, scientifically accepted concepts. This approach recognizes the active role students play in their learning journey, as they must confront and reassess their current viewpoints to make way for new insights. Cognitive dissonance, as defined by Kurtz (2018) is a state of holding two cognitive beliefs, values or opinions. It challenges our present worldview in the face of new information as a natural human response. Kahan (2016) also explains cognitive conflict as a natural response to change and growth when our prior knowledge is challenged in the presence of new information, which becomes a source of discomfort and resistance. This dissonance can trigger a re-evaluation of one's understanding, leading to a deeper engagement with the new information. Educators can facilitate cognitive conflict by creating learning experiences that challenge students' existing notions, thus encouraging them to critically assess and revise their conceptual frameworks (Tanner & Allen, 2006). This engagement encourages students to actively participate in their learning, fostering a deeper understanding of scientific principles.

Reviews of the literature on cognitive conflict-based teaching initiatives have generally shown promising outcomes. Hwang and Wu (2021) argued that, the power of cognitive conflict as a teaching methodology enhances leaners performance in genetics. It was further corroborated by Hesse and Koller (2020) who maintained that, to forster a deeper understanding of concept, cognitive conflict can be used to bridge the gap between pre-existing knowledge and new information. Further research conducted by Kas and Cartwright 2020 and Hernandez et al., 2020 all stated leveraging cognitive conflict as a teaching strategy to improve on learners' performance. This suggests that cognitive conflict is a viable strategy for addressing misconception-related teaching challenges.

2.4 Cognitive Conflict and Academic Performance

Cognitive conflict teaching strategy is a method of teaching that preys on students' prior knowledge. This method of teaching puts learners' prior knowledge to test and challenges their knowledge and beliefs, thereby promoting critical thinking and deep learning. Research have shown that, cognitive conflict has the potential to increase students' academic performance through the change of scientific conceptions. Academic performance according to Busalim et al. (2019) is the total measurement of attainment by students in a test that student took after a period of instruction and assessment. The ability of a student to accomplish a given academic assignment and be assessed using an objective criterion is termed as academic performance (Olivier et al., 2019).

Several researchers have investigated into the efficacy of cognitive conflict teaching strategy on student's performance. Al-Mahdi (2017) found that the Tulkarem Education Directorate's tenth grade learners' misconceptions were corrected and their problem-solving abilities in chemistry were enhanced by the use of disparate events. In their research, they intentionally used teaching strategies that sought to bring about cognitive dissonance in students, by presenting them with contradictory findings. The outcome of the research showed that, students who were taught or exposed to cognitive conflict had a better comprehension of difficult principles in science and improved their performance. Again, research conducted by Tawfik et al., (2018) indicated that, learners who engage in reasoning to solve a problem get a deeper understanding of concepts, retains knowledge and are able to transfer knowledge into new areas of study. The outcome of the results indicated that, cognitive conflict can lead to improved academic results by helping in critical thinking and conceptual understanding. In a research conducted by Duit and Treagust, (2003), the findings of the research further supported the efficacy of cognitive conflict teaching strategy. Duit and Treagust (2003) discovered that, when students are faced with demonstrations that brings about misconception in their mental model, there is a likelihood for students to reshape their understanding of scientific concepts, leading to enhanced performance in academics.

Cognitive conflict strategies include: (a) assessing learners and their present knowledge; (b) exposing them to opposing knowledge; and (c) evaluating the degree of conceptual change between students' first ideas or beliefs using a posttest after a teaching intervention (Potvin, 2021). Because it explains the phases in which cognitive conflict arises and how to settle the subsequent conflict, the comprehension of the cognitive conflict process model is essential. When a learner (a) recognizes unusual circumstances, (b) shows an interest in the conflict, or in any other way, and (c) reevaluates the cognitive process scenario, cognitive conflict processes take place. Students get interested in or otherwise concerned with a scenario when they recognize that it does not align with their notion (Schmidts et al., 2020). As a result, according to Lee et al. (2003), the preparatory stage comes before cognitive conflict. According to this paradigm, a learner experiences cognitive conflict when they (a) identify an unusual scenario, (b) participate in cognitive reappraisal of the situation, and (c) express interest in or concern about addressing an intellectual conflict.

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It is worthy to note that these findings are important for educators looking to enhance students' academic performance. By intentionally developing scenarios that brings about cognitive dissonance, educators can guide students to confront their misconception, thereby fostering deeper cognitive engagement.

2.5 Cognitive Conflict and Gender

The formation new mental models and gaining of new knowledge is a complex cognitive activity acquired through the process of learning. Cognitive process, however, do not occur on their own; they require various stimuli and conditions to enhance their growth. one of such stimulating approach in the educational context is the use of cognitive conflict strategies. Akmam et al., (2018) posits that, when learners are faced with disturbances in the mental models, which leads to differences in their existing knowledge and new knowledge, a state of cognitive dissonance has occurred. This disbelief in their existing knowledge arises in the face of "anomaly data"- information that do not align with their prior knowledge, causing learners to take a second look at their comprehension (Prayogi et al., 2019).

The main objective in bringing in cognitive conflict in an educational setting is to create a state of confusion among students with regard to what they already know when they are faced with information that do not match their existing beliefs. Studies conducted by some researchers (Adnyani 2020; Akman et al., 2019; Chow & Treagust 2013; Haryono 2021; Li et al., 2020) showed that by using cognitive conflict as a teaching strategy, students' academic performance is greatly enhanced across various academic performance. As much as the teaching strategy has had an effect on students' performers, researchers are have begun exploring the differential responses to it based on gender. The American Psychological Association (2015) explains gender as socially assigned roles, characteristics, behaviours while the World Health Organizations (2019) explains that gender is deeply rooted in societal norms. This understanding has pushed many researchers into researching into gender differences particularly with regards to cognitive conflict approach.

Evidently, students perform better when they are taught using cognitive conflict teaching strategy, hence, the difference in performance between males and females is closed. It appears that previous research demonstrating gender differences in scientific accomplishment is contradicted by the lack of significant performance differential between male and female students taught utilizing the cognitive conflict teaching strategy and the standard approach (Pekman & Linn, 2020; Kardash & Forbes, 2020; Aydogan &

Ozer, 2020; Erdem & Aydin, 2020). Other researchers who have researched into the efficacy of cognitive conflict teaching strategy on gender parity have also reported contradictory findings, stating that, females outperform males in this regard (Baser, 2009). However, Ma-Naim, Bar and Zinn (2012) advocated that, cognitive conflict has no bearing on gender and favored both males and females. The findings also corroborate findings of Chakkrapan et al. (2014) who discovered that, males and females exposed to this teaching approach perform at similar level. Dahiru (2013) reiterates that sex has no discernible impact on scientific performance. The inclusiveness of the teaching strategy eliminates bias Bunkure (2012) forstering a deeper scientific reasoning

Additionally, Hidayatulla (2021) posited, the use of cognitive conflict as a teaching strategy improves the scientific reasoning of students in physics about waves in Mataram, Indonesia. Furthermore, there was an improvement of the reasoning reasons of learners that were exposed to cognitive conflict than those exposed to the traditional teaching method. According to research conducted in Embu, Kenya, there is a significant difference in the reasoning abilities of students instructed with the the traditional approach and those instructed using the cognitive conflict strategy (Ngicho et al., 2020). In another study, there was a comparable improvement between males and females in scientific reasoning when taught natural resource conservation through cognitive conflict technique in Biu Education Zone, Bono State. These findings corroborate Chakkrapan et el., (2014) and Nnorom (2013), who came out similar findings in Thailand and Anambra State, respectively.

2.6 Conceptual Development and Change

Some writers on conceptual development see it as being made up of exchanging leaners conceptions with scientific concept (Gilbert & Watt, 1993; Posner et al., 1982). Some authors have a different take on it. This is because conceptual change does not necessarily mean eradicating or modifying learners' conceptions totally. This is due to the fact that, learners' prior knowledge is valuable to what is done daily and are seen as valuable to future to specific events. Additionally, even professionals among the majority of adults have several major beliefs about fields in which they lack expertise. Research also has it that, it is virtually near impossible to completely eradicate old knowledge, and that they have the tendency to survive alongside scientific conceptions (Mutimuciou, 1998). The implication of this in teaching is that, teachers are expected to expand learners understanding of concepts and not only pay attention to erasing learners' prior knowledge. Evolutionary change was term Gilbert and Watts gave to enlargement of conceptual structures. In the expansion of the term evolutionary change, Gilberts and Watts explained the bountifulness and precision of meanings for leaners frameworks. In theory, evolutionary change had an implication in classroom teaching, as teachers are expected to start instructions from students known facts that are closer to science to a more scientific paradigm. This implies that, learners' conception before instructions should be consolidated with scientifically proven facts in the classroom. This ensures that, learners become aware of the flaws in their already existing knowledge and prepares learners to receive new facts and knowledge with an open mindset.

It is stated that a student's capacity to reason in situations requiring a thorough comprehension of concepts, definitions, relations, or representations of either is reflected in their conceptual knowledge of a notion. Balka and Miles, (2015) argues that, there is the need to urge leaners to establish a link between what they already know and what they are learning.

2.7 Genetic Concepts Students Have Difficulty Learning

Students’ difficulty in genetics have been a long-standing issue in Biology and several researchers have attempted explaining why genetics is difficult for students to learn. According to Etobro and Fabinu (2017), making a conscious effort to find out learners’ perceptions about learning provides an overview of the what learners already know and do not know and taking steps to make topics that are thought to be difficult easier. According to Buah and Akuffo (2017), science students find a number of biology topics challenging. Cell Division, Cell Metabolism and mitosis are said to be difficult to learn according to a study by Fauzi and Mitalistiani (2018). Students also find mitosis; DNA structure and genetic coding challenging in biology. Certain factors are enumerated to have contributed to students’ difficulty in genetics, such as teacher centered methods, low learning intensity, abstract nature of genetics, misconceptions (Etobro and Fabinu, 2017). Low learning intensity by students affects their academic performance which is influenced by lack of motivation. Motivation moves students to work hard to achieve their aims, complete objectives and sets out a positive learning behaviour. Students that lack self-motivation to learn results in underwhelming performance, leading to self-decline academically and lack of interest in learning (Kim et al., 2021). Students’ willingness to learn a concept adversely affects their performance (Karpicke & Paller, 2021) but unfortunately, underperforming students do not have the self-drive to appreciate the concepts of genetics. This leads to situations where students fail to get a better understanding of genetic concepts (Hativa et al., 2020). The lack of interest by students to learn genetic material which is perceived to be difficult and not learnt as a whole affects their performance, even though students acknowledge the importance of genetics (Alonemarera, 2020). According to Soe (2018), Students will better understand biology as a subject if they have a good attitude about learning the subject. Additionally, students find it challenging to relate to genetics because of its abstract character. Although they will be abstract in nature, students may already be familiar with the material before a formal introduction in the classroom. Students acquire knowledge of relevant topics after learning about genetics, yet they frequently misunderstand these concepts and related concerns. This is due to the fact that understanding the subject requires more than just information. Relationships must be understood and bridges between knowledge must be created in order to comprehend the subject.

The multi micro-level processes of genetics that cannot be seen makes genetics unrelatable. For instance, processes such as gene expression and molecular interactions occur at a different level, which is meant to be understood by students is not taken into consideration during traditional teaching (Sullivan et al., 2020). Students therefore do not see the relevance between abstract concepts and the real world (Sullivan et al., 2020). The abstract nature of the genetic content makes it hard for students to connect concept

(Cisterna et al., 2013) which leads to difficulty in connecting genetic concepts (Ezeaghasi, 2018).

Learners' misconception of genetics have made it difficult for students to learn genetics as documented by some researchers. Science Hub (2011) reported on students' alternative conception of gene, with students thinking that, genes and DNA are separate from each other. A lot of students had the idea that, DNA and genes were actually separate from each other, forgetting that, gene is a fraction of DNA. These learners convey the belief that a person's genes determine their identity and how they appear to be related to others. Science Hub 2011 further went on the report that, Students have the idea that, different cells contain different genes. Students believe that the DNA in the skin is not the same as the gene in the eye. But the fact is, gametes are the only cells in the body with unique DNA, all of the cells in the body have the same DNA. The idea of DNA is also fraught with many students' alternative conceptions, which makes it hard for them to learn and comprehend genetics (Koksal & Akkaya, 2017). According to their study, which aimed to determine eighth-grade students' acquaintance, knowledge levels, and Students' different ideas about inheritance include the following ideas about DNA: Every single one of the genes that make up an organism are contained in its DNA, which is a fundamental block of nucleic acids and a nitrogenous purine base in their structure.

Learners' difficulty in genetics can be attributed to misconceptions. Misconceptions stem from students' prior knowledge before formal education begins. The main premise here is that, in accordance with constructivism theory, students must have some prior information, faith, or idea before a new learning experience is introduced; they do not start with a blank slate when they attempt to learn in school. However, According to Smith et al. (2020), students' opinions and abilities in science can be significantly impacted by previous understanding of a scientific idea. Even in the face of contradictory findings, some misconceptions are deeply rooted and co-exist with the new information. When misconceptions are strongly supported by the student, it will be difficult for the students to learn new scientific concept (Mukhlisa, 2021).

2.8 Cognitive Conflict Teaching Strategy and Traditional Teaching Method

A teacher's approach to teaching in the classroom or outside can have an effect on students learning (Idika, 2017; Kuriawan et al., 2019). The emphasis tends to move from the teacher to learners in a Cognitive conflict classroom. Passive students no longer wait in the classroom like empty vessels to be filled with knowledge from the teacher, who is now viewed as an expert. Students are encouraged to actively participate in their own learning process under the constructivist concept. In order to guide, coordinate, prompt and assist learners in nurturing and evaluating their comprehension and, leading to their learning, the instructor primarily serves as a facilitator (Nelson, 2017). Additionally, both teachers and students in constructivist classrooms consider knowledge as a dynamic, ever-evolving perspective of the world we live in and the capacity to effectively stretch and explore that perspective rather than as static facts to be remembered. Classrooms that patronize cognitive conflict teaching strategy allows learners to test their hypothesis as they engage in hands-on-experience. Lessons are crafted around the learners, they are student centered, interactive and learners are powered by the facilitator. The goal in using cognitive conflict as a teaching method is to allow learners discover concepts autonomously.

The lecture method, or traditional teaching strategy, is widely used in education (EduCorpus, 2025). The traditional approach disregards the students and, as a result, their level of mental interest. It entails students covering the background information and memorizing facts by heart. Students were not encouraged to think creatively or participate in the creative aspects of the exercises. The typical classroom frequently appears to be a one-person operation with a student who is not really involved. Direct and unilateral instruction typically predominates in traditional classrooms. Adherents of the traditional approach make the assumption that students need to learn a set body of knowledge. It is expected of students to take the material at face value without challenging the teacher resulting in little interaction between the student and the teacher (Sarıhan et al., 2016). Students rarely ask questions on their own, think independently, or engage with one another since the teacher tries to impart ideas and meanings to the passive student (Gholami et al., 2016).

According to Osmani et al., (2018) and Habibzadeh et al., (2019), the lecture method of teaching affects a student's learning ability and critical thinking skills.Teaching methods considered to be teacher centered are connected to low academic performance (Hattie, 2020), as there is just one reservoir of knowledge (Di Base, 2019).

2.9 Summary of Literature Review

The chapter examined how well students performed in genetics when taught using a cognitive conflict approach, with emphasis on constructivism. It is predicated on the idea that students learn best if they are actively involved, and by allowing them to construct their own understanding of concepts through experience and interaction. It also argues that, one of the key drivers of conceptual change and deeper learning is challenging leaners existing schema with new information that can lead to cognitive conflict. The research further explores the concept of cognitive dissonance, a situation where learners are confronted with new information that challenges their existing knowledge and beliefs, causing them to take a second look at their understanding of concepts. Critical thinking, problem-solving and deeper engagement with material can be encouraged by teachers as they present learners with new information. The study further notes that, while cognitive conflict teaching strategy can be a powerful tool for conceptual change, its implementation requires careful planning. Activities must be carefully planned and designed to bring about meaningful outcome to reduce frustration among students whiles correcting misconceptions.

The chapter touched on gender related issues that are affected by cognitive conflict, citing research that suggested how males and females solve problems. Females tend to lean towards collaboration and empathy, while males often display competition and assertiveness. However, the study highlighted on the need to investigate into how these differences impact individual and group learning outcomes.

Overall, the study provided an overview on how cognitive conflict as a teaching methodology in a constructivism paradigm can be used to harness leaners potential. An understanding of cognitive dissonance and how knowledge is constructed can educators leverage on creating a conducive classroom that promotes critical thing, conceptual change and ultimately enhanced academic performance for all students.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter's goal was to investigate how well Ahanta West senior high school biology students understood genetics through the use of the cognitive conflict instructional approach. This chapter discussed the research methodology under the following headings: population of the study, sampling strategy, and research design, data collection instruments, pilot study, intervention used in the group, validity of the developed genetic knowledge content test materials, data collection procedure, data processing and analysis.

3.2 Study Area

The study area under which the research was done is the Ahanta West Municipality, with its capital being Agona Nkwanta. The Municipality is located 24km away from the regional capital, Takoradi of the western Region. Ahanta West Municipality has an estimated population of 153,140, with females dominating (50.9%) and males representing 49.1% according to the Ghana Statistical Service Census 2021. It is bordered by The Gulf of Guinea to the south, Mpohor district to the north, to the East is the Nzema East District and bordered by Sekondi Takoradi Metropolitan Assembly to the east. The landscape of the Municipality is generally flat, with few hills that are isolated, such as the Butre Hill. Its size is approximately 673 square Kilometers. The Ahanta west district falls within the High Rain Forest Vegetation Zone with rubber plantations covering several hectares of land.

Figure 3.1: Map of Ahanta West Municipality.

3.3 Research Paradigm

The research lends itself to the positivist paradigm. The general doctrine of positivism which held that all genuine knowledge is based on sense experience and can be advanced only by means of observation and experiment (Bryman, 2020). Positivism claims that science provides us with the clearest possible ideal of knowledge. Positivist paradigm lends itself to quantitative studies. Positivism focuses on the hypothetico-deductive technique to verify a priori assumptions, which are commonly articulated quantitatively. Functional correlations can be inferred between causal and explanatory elements (independent variables) and outcomes (dependent variables). According to Creswell and

Creswell (2018), positivism is well-suited for quantitative research it emphasizes objectivity, empirical evidence, and the scientific method. The positivist approach is also useful for quantitative research because it emphasizes the importance of objectivity. This approach strives to eliminate bias and ensure that their findings are based on empirical evidence (Bryman & Bell, 2015). This objectivity is achieved through the use of rigorous research designs and statistical methods.

3.4 Research Design

The research design for this study is quasi-experimental pretest-posttest control group non-equivalent design. In research contexts, the quasi-experimental pretest-posttest control group design contains multiple features that enable researchers to assess the effects of treatments on various groups and draw conclusions about causality. The ability of the quasi-experimental pretest-posttest control group design to show causal linkages involving an intervention and its effects constitutes a single of its main benefits. Researchers can determine the effect of the intervention on the dependent variable by contrasting the treatment group's pretest and posttest results with those of the control group (Shadish et al., 2014). According to Babbie (2011), a non-equivalent quasi-experimental design utilizes a pre-existing control group that is similar to the experimental group but is not formed by randomly allocating individuals to groups. Due to the difficulties of randomly allocating students to the control and experimental groups in a school environment, this research,h used a non-equivalent quasi-experimental design (Gall & Borg, 2007; Shadish, Cook & Campbell, 2002). The quasi-experimental pretest-posttest control group design is more practical for studies involving groups in the classroom (Cresswell, 2014), highlighting its significance and suitability for this study. The quasi-experimental pretest-posttest control group design allows researchers to examine changes over time and compare the interventions groups progress to the control groups' progress. (Kazdin, 2011).

An illustration of the research design is shown in figure below

$EG \longrightarrow O_1 \longrightarrow X_1 \longrightarrow O_2$

$CG \longrightarrow O_1 \longrightarrow X_0 \longrightarrow O_2$

Where: -

EG = Experimental group

CG = Control group

X_1 = Treatment

O_1 = Pre-Test

X_0 = No Treatment

O_2 = Posttest

By offering a point of reference, the control group aids in isolating the impact of the intervention, and the pretest enables researchers to evaluate the groups' initial equivalency.

It is difficult to control extraneous factors in a non-equivalent quasi-experimental design, and comparing non-equivalent groups is statistically complicated since participants are not randomly assigned to the control and experimental groups (Trochim, 2006). Due to these restrictions, a number of steps were implemented in an effort to reduce the impact of differences between the two groups. To begin, schools were chosen based on a set of criteria aimed at balancing the two groups (schools that have been teaching biology for at least five years, co-educational schools to ensure that participating boys and girls have similar learning environments, and schools with at least one functional science laboratory to minimize infrastructure and resource discrepancies). Second, before the intervention, both groups took pre-tests to evaluate their knowledge of the measured learning objectives, and the results showed that they were at par (Creswell, 2008).

3.5 Population of the Study

All third-year Biology Senior High School students in the Ahanta West municipality of Ghana's Western Region made up the study's population. Final year students of these Senior High schools were used in the study as genetics is a topic that is taught in the third year. Again, the final year science students were used as it is assumed they have been taken through the basic topics of genetics such as cell biology. All final-year science students in the Ahanta West municipality were the study's available population. There are three senior high school high schools in the Ahanta west Municipality, out of which one is a single sex school and the remaining two are mixed schools. There were an estimated 350 science students.

3.6 Sampling Procedure

The study was conducted in the Ahanta West Municipality, which is made up of 3 senior high schools. Simple random sampling was used to select 2 out of the 3 schools. Simple random sampling was again used to select one of the schools as control group and the other as experimental group. In the schools, form 3 classes were purposively selected. In a school where they had more than one science class, simple random sampling was used to select one intact class. These schools were selected due to the fact that, they offered general science program which included Biology. In all, 137 students took part in the research. Sixty-eight (68) students from one class formed the experimental group, while sixty-seven (67) students from the other class formed the control group.

3.7 Data Collection Technique

One of the factors considered for collecting data and analysing of data is how the data would be collected. How data is collected from various sources, documented and analysed for decision making is known as data collection (Creswell, 2018). The data was collected quantitively in two phases but separately. Pretest data was gathered first, then the intervention, and finally posttest data.

Structured genetics test (pretest) was given to 137 SHS 3 students to start the data collection process. Students were asked to use 1 hour in answering the test items (Genetics Content Knowledge Test). Scripts on the text items were collected and scored within a week. Testing of students was then followed by the intervention period (experimental group) which lasted 4 weeks whiles the control group were taught using the traditional method of teaching. The post-test was administered after six weeks of instruction to both groups. Studies have shown that, interventions that are related to behavior can display results within the shortest possible time (Hofmann et al., 2010). This study was corroborated by Hillman et al., (2016) who also suggested that, an intervention period of 6 weeks should produce observable changes.

3.8 Instrument

Genetics Content Knowledge Test (GCKT)

The researcher used the instrument known as the Genetics Content Knowledge Test. The instrument was used to evaluate students conceptual understanding of genetic content. The GCKT test had 25 items on it, which was made up of 20 objective tests. Students were expected to provide concise answers to questions. For the 5 subjective, each question was assigned 3 marks for a correct response. The 5 subjective test items were selected randomly to cover aspects of genetics in the biology curriculum and students find it difficult as well as the objective test.

Administering the Treatment

Cognitive conflict instructional strategy was used as a medium of instruction for the experimental group (Appendix B). Traditional method of instruction was used to teach the control group. The experimental group were taught using the intervention (Cognitive conflict teaching strategy) to trigger conceptual change among students. For a period of 1 hour, 30 minutes, two times in a week, students were exposed to the intervention. This was aimed at provoking students' prior knowledge of genetic concept to trigger an investigation into the concept.

Pre-Intervention Stage

The lesson began with a pre-intervention stage where students were presented with a scenario: "A person with a genetic disorder wants to have children. Should they consider genetic testing and counseling?" Students were asked to write down their initial thoughts and opinions on the topic. This stage aimed to identify students' existing knowledge, attitudes, and potential misconceptions about genetics and genetic testing.

Intervention Stage

Two groups were used in this study, namely, the Experimental group and the control groups. The Experimental groups were instructed using the cognitive conflict teaching strategy while the control groups were taught using the traditional method of teaching. During the intervention stage for the experimental group, the experimental group experience began with an introduction stage. Students completed a pre-test to assess their prior knowledge and attitudes. The teacher then introduced the topic, setting the stage for a thought-provoking activity. During the interaction stage, students participated in a cognitive dissonance-inducing activity, engaging in a scenario-based discussion that challenged their existing beliefs. They shared perspectives, debated, and reflected on their thoughts. As students grappled with the complexities, they began to experience cognitive dissonance, prompting a deeper exploration of the topic. In the conceptual stage, students further developed their understanding, making connections between the activity and key concepts. Through this process, they refined their thinking and attitudes. Finally, the assessment stage involved a post-test, which evaluated students' knowledge and attitudes after the activity. This allowed the teacher to assess the effectiveness of the cognitive dissonance approach after the Intervention.

Intervention for the Experimental Group

Stages	Teacher/Students Activities
Stage 1 **Preparation Stage**	Introduction to the topic Pre-test Statement of the objectives of the lesson Students made to share ideas on the topic
Stage 2 **Teacher student's activity**	Cognitive dissonance-inducing activity, including: Scenario-based discussion Reflection and revision of initial opinions.
Stage 3 **Conceptual Stage**	The teacher clarifies and interact with students after the class to ensure leaners have comprehended the lesson and assess if the learning objectives has been achieved
Stage 4 **Assessment**	Teacher stresses on the key concepts of the lesson Post-test survey to assess changes in students' knowledge and attitudes
Stage 5 **Evaluation**	Comparison of pre-test and post-test scores to evaluate the effectiveness of the cognitive dissonance activity.

Students in the second group (control group) were exposed to the lecture method of teaching (Table 3.1). The lesson began with a pretest to assess their knowledge. Teacher introduces the lesson and writes notes on the board and asks students to write it into their note books. Teacher explains the notes given, explaining all concepts as students listen attentively. As the lesson progressed, learners are allowed to ask questions for clarification. The lesson ended with a posttest to assess the effectiveness of the standard method of teaching.

Interventions stage for the control group

Stage	Teacher students Activity
Stage 1 **Preparation Stage**	Introduction to the topic
Stage 2 **Teacher student's activity**	Pre-test Statement of the objectives of the lesson Standard instruction, lecture-style instruction
Stage 3 **Conceptual Stage**	Teacher responds to leaners questions and highlight key concepts
Stage 4 **evaluation**	Teacher evaluates learners using class exercise (posttest)

Post-Intervention Stage

In the post-intervention stage, students were asked to reflect on their initial opinions and how they had changed (or not) after the discussion. They wrote down their revised thoughts and opinions, considering the complexities. The teacher facilitated a class discussion to consolidate students' learning, addressing any remaining questions or concerns (Table 3.2).

3.9 The Instrument's Validity

In order to determine whether the materials are in accordance with the SHS syllabus, the exam items were submitted to specialists in science education. They checked if the materials had:

1. no factual errors
2. no grammatical errors
3. content that follows the syllabus

3.10 Pilot Study

The pilot study was conducted in one of the senior high schools in the Ahanta West municipality. The school was chosen for the pilot study as the school offered general science. The pilot study was necessary as it was used to determine the reliability of the instrument before administration. Goals of the research was made known to students during the pilot study, how the data obtained will be used and students have the option of opting out of the pilot study if they wanted to. Genetic content knowledge test was administered to the students. Interventions was based on the result of the pilot study. Cognitive conflict teaching strategy was used to teach the students. Classes was held during the normal school hours. 60 minutes was the duration of each lesson and a total of 3 lessons was conducted. A post test was conducted after the administration of the intervention.

3.11 Reliability of the Instrument

Reliability is the degree to which an instrument consistently measures what it claims to measure at any given moment. The dependability coefficient is a measure of index dependability (Usman, 2000). To determine the instruments' dependability, data from the pilot study was examined. According to Mohammad (2007), a test is considered reliable if it yields essentially the same results when repeated measurements are taken with it.

In this research, the test consisted of two parts, multiple choice questions and subjective questions. The multiple-choice questions consisted of 30 questions. Analysis of the multiple-choice results using Cronbach's Alpha produced an outcome of 0.75 showing internal consistency. This is in line with Qualter & Smith (2019) who argues that, a Cronbach’s Alpha Coefficient of 0.70 or higher is known to be acceptable for internal consistency, showing the items are measuring the same construct with reasonable reliability. The essay part was examined using inter-rater reliability. It was then analyzed using Cohen’s Kappa on SPSS which produced a result of 0.79, showing a high level of agreement between raters. According to Field (2018), a Kappa value of 0.79 shows a substantial agreement between rater.

3.12 Data Analysis

Research question 1 sought to find the out the effects of cognitive conflict teaching strategy on students’ performance in genetics. Quantitative data was collected through pretest and posttest. The test was then analysed using Paired Sample T-test. Paired sample t-test was chosen for the analysis as it is used to analyse the mean of a group that was tested twice (Bobbitt, 2022).

Research question 2 sought to find out the differences in performance between students taught genetics using cognitive conflict teaching and those taught using the conventional approach. A pretest was conducted to find out if both groups were at par with each other. The control group were exposed to the traditional method of teaching whiles the experimental group were exposed to the cognitive conflict teaching methodology. A post test was conducted and the data analysed using independent sample T-test. Independent sample t test was used for the analysis to compare the means of the two groups. This was aimed at finding out which group performance were superior after the intervention.

Research question 3 sought to find out the effectiveness of cognitive conflict teaching strategy on the sex of the students when taught using genetics. Data collected from students exposed to cognitive conflict were analysed using independent Sample T-test. The mean scores of both groups are compared to find out which group performed better

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

The aim of this research was to explore the effectiveness of cognitive conflict teaching approach on students' achievement in genetics concepts in Ghanaian senior high schools. The results and discussion of the research are presented in this chapter. The research questions were used as a guide to present the results. The following are the research questions:

1. How does the cognitive conflict teaching approach affect the genetics performance of senior high school biology students?
2. How do senior high school biology students who were taught genetics using the cognitive conflict teaching strategy perform differently from those who were taught using the traditional method?
3. What is the effect of cognitive conflict teaching approach on the sex of senior high school biology students when taught genetics?

Research Question 1: What cognitive conflict teaching approach affect the genetics performance of senior high school biology students?

Research question one seeks to find the effects of cognitive conflict teaching strategy on students' performance in genetics. To find out if there was an improvement in students' performance after they have been exposed to the intervention, Paired Sample T-test was used to analyse the pretest and post test scores. In the run up to the analysis of the paired sample t-test, the data was tested to check for violations of assumptions. Table 4.1 presents the results for test for assumptions

Table 4.1: Findings from the Test for normality

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
	.087	66	.200	.978	66	.279

The outcome of the Paired sample t-test pretest-post test scores is shown in table 4.2.

Table 4.2: Results of paired sample t-test on the pre-test and posttest on the effect of cognitive conflict on students' performance in genetics

	Mean	**N**	**SD**	**df**	**t**	***P***
Pretest scores	14.85	66	7.989	66	14.577	0.001
Posttest Scores	31.17	66	7.513			

The pretest scores was ($M=14.45$, $SD = 7.989$) and posttest ($M=31.17$, $SD= 7.513$, $t(66)=14.577$, $p<0.05$) using paired sample t-test showed a statistically significant difference in performance after the intervention. The results indicate an upward adjustment of students' performance after they have been exposed to the cognitive conflict teaching strategy. An eta squared value of 0.765 signifies a large effect, suggesting the magnitude of the difference is large. Prior to the introduction of the intervention, students had a mean of 14.85, indicating a lower performance as compared to the means score of the posttest which is 31.17. The t-test came up with a t-value of

15.986 and a p-value of 0.001, indicating a statistically significant difference in performance.

Research Question 2: What is the difference between SHS students taught genetics using the cognitive conflict teaching strategy and those who are taught using the traditional method?

The purpose of research question two was to determine how students who received instruction in genetics using the cognitive conflict strategy performed differently from those who were taught using the traditional method. Analysis of data was done to check for normality to see if assumptions have been violated or not. Below is the table for normality indicating that, to the run up to the test, no assumptions were violated.

Table 4.3: Results for test of normality of Independent Sample T-Test

	Kolmogorov-Smirnov			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Cognitive Conflict	.007	66	.200	.976	66	.231
Conventional	.116	66	.028	.960	66	.034

The independent sample t-test was used to analyze the performance difference. The results of the independent sample t-test (pre-test) are displayed in Table 4.4.

Table 4.4: Comparing independent sample t-test (pretest) of students taught with cognitive conflict strategy with those taught with the traditional method

Pre-test	N	Mean	Std. Deviation	T	df	*p*
Conventional method	66	13.97	8.019	.344	132	.731
Cognitive conflict	68	14.46	8.310			

As shown in Table 4.5, the post test score between the conventional teaching approach (M=13.97, SD=8.019) and the cognitive conflict teaching strategy (M=14.46, SD= 8.310; t(132)=.344, p>.05) in the student using the independent sample t-test revealed no statistically significant difference between the two groups. This suggests that before the intervention, the students in the two groups performed similarly. This condition gives an excellent rationale for comparing students' post-test performance.

There were no violations in the run-up test for normality and homogeneity of variance.

An independent sample t-test was further conducted on the posttest performance of students taught using cognitive conflict teaching strategy and those taught using conventional method. Table 4.5 displays the results.

Table 4.5: Results of independent sample t-test (posttest) between students taught with cognitive conflict strategy and those taught using the conventional approach

Post test	N	Mean	Sd	T	Df	*P*
Conventional approach	66	14.94	6.542	14.299	131	.001
Cognitive Conflict Strategy	67	32.64	7.681			

The post test score of conventional approach showed (M=14.94, SD=6.542) differed from the cognitive conflict teaching strategy (M=32.64, SD=7.681; $t(131)= 14.299$, $p<0.05$). Students using the cognitive conflict technique did better than those using the conventional approach, thus comparing mean scores, and the disparity was statistically significant. An Eta squared valued of 0.60 was obtained, showing a representing a large effect size. This suggest that, when students are exposed to cognitive conflict approach, there is an upward adjustment in the performance of students. The considerable difference in the mean suggests that the cognitive conflict technique not only outperformed the traditional method, but also helped students gain a better knowledge of genetic content.

Research Question 3: What is the effect of cognitive conflict teaching strategy on the sex of senior high school biology students when taught genetics?

The third research question sought to find out the effect of cognitive conflict teaching technique on the sex of the students. To do this, an independent sample t-test was performed on the pretest for genetics students. The goal is to determine whether males and females are performing at a comparable level before to the intervention.

Table 4.6: Results of test for normality for independent sample T- test

	Kolmogorov-Smirnov			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Male	.007	22	.200	.976	66	.231
Female	.116		.028	.960	66	.034

Table 4.7: Results of independent sample t-test (pretest) between male and females who were taught using cognitive conflict teaching strategy.

Pre test	N	Mean	Sd	T	df	*P*
male	22	16.68	7.990	14.299	64	.426
Female	44	13.57	8.287			

The pre-test scores between males (M=16.68, SD=7.990) and female (M=13.57, SD=8.287; t(64), M=29.68, SD=6.447) showed no statistically significant difference in students' performance. This is an indication that, before the implementation of the intervention, students from both groups were performing at similar levels. This was enough grounds to test students' post-test results. Normality and homogeneity of variance were not violated prior to running the data using independent sample t-test. Below is the table for normality.

Table 4.8: Results of independent sample t-test (posttest) between male and females who were taught using cognitive conflict teaching strategy

Post test	N	Mean	Sd	t	df	*p*
Male	22	29.68	6.447	1.247	64	.214
Female	44	32.14	8.016			

In the table 4.8, the posttest scores of the males (M=29.68, SD=6.447) and females (M=32.14, SD=8.016; t(64)=14.299, p>0.05) showed no statistically significant difference when the cognitive conflict teaching strategy was introduced. This clearly suggests that, the performance of males and females are at par and the intervention is gender friendly.

4.2 Discussion of the Study

This section of the chapter discusses the study's findings. The discussion is organized in accordance with the research questions.

4.2.1 Effects of Cognitive Conflict on Students Performance in Genetics

The first research question sought to find out the effect of cognitive conflict teaching strategy on learners' achievement in genetics. After the intervention, the results showed a statistically significant difference in performance. The results indicate an upward adjustment of students' performance after they have been exposed to the cognitive conflict teaching strategy with a large effect size.

The results from the research question one reaffirms the finding of Chen el at., (2018), who emphasized that, students improve in critical thinking significantly when they are taught using the cognitive conflict, showing how students are able to establish connections between pieces of information rather than memorizing facts. Establishment of meaning, fostering self-sufficiency and deeper comprehension is what is required of learners as they engage with content. This aligns with the view that cognitive conflict acts as a catalyst for deeper learning, prompting individuals to question assumptions and refine their problem-solving strategies (TeachThought, 2023).

The use of cognitive conflict as a teaching methodology tries to solve the issue of complex and abstract concepts. The improvement of the learners scores in research question one is a clear indication of how cognitive conflict stimulates students' curiosity and encourages learners to explore to find out answers for themselves (Kozbelt et al., 2016). Chi (2018) supports this assertion by stating that contradictions lead to an enhanced improvement as learners try to makes make of conflicting outcomes. Learners' ability to solve problems, make sound decisions based on new information and come up with conclusions are all enhanced (Kazeni, 2012) .

The difference is performance could also be attributed to the teaching methodology employed in teaching the learners. Because learners in the experimental group were taught using cognitive conflict and places the learner in the center of the lessons, there was an upward adjustment in their performance. Research indicates that conceptual change occurs when teachers employ the cognitive conflict teaching technique (Orji & Madu, 2015; Akman et al., 2018; Labobar et al., 2017;). The teaching methodology is also found to enhance students' competence level (Gunawam et al., 2021). Teachers may change how lessons are planned to accommodate learners' prior knowledge, as a conflict between what they already know and new information before them motivates learners, leading to a considerable effect on learners conceptual understanding (Makhrus & Hidayatullah, 2021).

The ability of cognitive conflict teaching strategy to bring about conceptual understanding has also been upheld by some researchers. Orji and Madu, (2015) suggested that, the understanding level of students is highly hinged on teaching interventions aligned with principles. This statement has been corroborated by other researchers such as (Mustafa, 2006, Chi, 2008, Agumouh 2010, and Lee and Byun (2011) stating that, effective instruction is key for fostering conceptual change and reducing misconceptions among students. The process of learning is more important than the outcome of learning from a constructivist point of view. The learner's role as an active participant in a cognitive conflict classroom breeds high performance.

One of the numerous benefits of the cognitive conflict as a teaching strategy is its ability to actively engage students in the learning process, as posited by Vosniadou (2018). Active engagement enhances deeper comprehension of concepts, contrasting sharply with teaching methods that learners find difficulty in grappling materials. As learners face uncertainty in the face of new information that conflicts with their existing knowledge, they are prompted to reassess their beliefs, knowledge and restructure their understanding actively. The collaborative nature of cognitive conflict permits learners to discuss and resolve conflicting ideas with their peers, which inherently supports academic work and promotes social skills (Johnson & Johnson, 2017). A good classroom structure will promote student's autonomy and responsibility to find out things for themselves, making them feel they own the learning process (Arisoy et al., 2016).

The challenges posed by cognitive conflict are noticed when students' inner beliefs are confronted with scientific concepts (DiSessa, 2006). This teaching strategy allows opportunities for inquiry-based learning, which aids in better grasp of scientific principles.

The purpose of the second research question was to determine how senior high school biology students who were taught genetics using the cognitive conflict teaching strategy performed differently from those who were taught using the traditional method. The results demonstrated a statistically significant difference, with a 0.61 effect size demonstrating that students taught cognitive conflict strategies did better than their counterparts taught the standard manner. This is consistent with Madu and Orji (2015), who reiterate the value of the cognitive conflict strategy in raising academic achievement and developing problem-solving abilities. Cognitive conflict as a teaching strategy enhanced deeper understanding of genetics concepts, in contrast with traditional teaching methods that often results in enhanced results.

The traditional approach tends to see the teacher as the sole repository of knowledge, fostering a passive learning and leading to struggle with engagement and how to apply knowledge. Learners in traditional classrooms tend to prioritize rote learning without understanding (Bartsch and Cobern, 2003) which ends up in shallow learning and challenges in applying to real world situations according to Rohrrer & Pashler (2012). Students performance as showed in this research correlates with quality instruction, as suggested by Hattie, (2016) traditional teaching tends to overlook the different backgrounds and experiences of students, which can lead to a dissatisfaction of the learning materials (Tomlinson, 2001; Kumar et al., 2017). The individual educational needs of the learners are not met as the traditional methods fails to address the varied cognitive profiles of learners.

In contrast to passive learning settings, cognitive conflict creates an enduring classroom where learners can engage in critical conversations and collective dialogues. Particularly in science education, cognitive conflict where misconceptions are common, past research has shown that cognitive conflict as a teaching strategy has had positive impacts on correcting learners misconceptions (Lederman & Gess-Newsome, 2017). While misconceptions have been one of the many factors affecting students' performance, cognitive conflict enables leaners to tackle the situation head-on, fostering adaptation and comprehension of relevant concepts

4.3.2 Effect of Cognitive Conflict Strategy on Gender

The third research question sought to determine the effect of cognitive conflict teaching methodology on the sex of senior high school biology students when taught genetics. The results of the study showed no statistically significant difference in the performance of both sexes when the cognitive conflict teaching strategy was used to teach. This is an indication that cognitive conflict teaching strategy is gender friendly as both genders benefited from the strategy. This is collaborated by Vosniadou (2013) who highlights that, the cognitive conflict teaching strategy creates a conducive learning environment which encourages students to take part in dialogues that challenges their notions regardless of gender. Vosniadou (2013) further adds that, the teaching strategy does not only bring about conceptual change but also breeds an environment that is egalitarian that urges leaners to voice out their perspectives and puts the status quo to the test.

Cognitive conflict teaching strategy bridges the gap of gender bias that has been created by the traditional teaching method in a classroom (Duit and Treagust, 2012). By putting individual perspective, thought processes and personal resolutions to conflict into focus, the teaching strategy urges learners to go beyond societal stereotypes that admittedly defines what can and cannot be done by a certain gender. Predetermination of success is not determined by gender as students interact with materials, allowing learners an equal opportunity to excel.

Research conducted in the field of STEM has indicated that, female students might also benefit from cognitive conflict teaching strategy which is predominantly dominated by males. The teaching strategy gives room for females to put their views across which builds their confidence through self-expression and justifying reasoning (Tytler & Symington, 2017). This is an important areas of study where women are underrepresented and can foster a relationship that aims to bridge the gap by fostering a supportive environment.

A study conducted by Lee and Buxton (2013) maintained that, teachers are required to be aware of the different cultural and gender differences learners bring to the classroom in a cognitive classroom. Knowledge of the different dynamics in the classroom will enable the teacher to implement an inclusive curriculum that accepts different experiences and viewpoints. For cognitive conflict teaching strategy to be effective, teachers are to monitor the dynamics in the classroom to ensure fairness, giving equal chance for every student to be part of the classroom discussion and activities. When students are given equal chance and opportunities to express themselves, they learn to respect diverse viewpoints and build a common understanding, which eradicates bias and promotes gender inclusiveness.

Despite the benefits associated with cognitive conflict teaching strategy, it is imperative to implement the teaching strategy thoughtfully, as cognitive dissonance that is not managed well might reinforce negative thought if educators fail to provide appropriate guidance and support (Francis & Skelton, 2016). Therefore, teachers who wish to employ cognitive conflict teaching strategy to enhance learner's academic performance focus on gender inclusivity and sensitivity, as it is imperative to harness the benefits and potential of cognitive conflict strategies. By making individual and personal connections to what is being learnt, cognitive conflict teaching strategy is capable of alleviating anxiety related to gender expectation. This approach is in line with constructivist who belief that, knowledge and understanding is built on personal experience, limiting intimidation and bringing about responsive teaching methods (Gay, 2010).

In a supportive classroom, Smith and Lloyd (2019) reported that, learners from gender-diverse backgrounds showed an increase in engagement and academic resilience when exposed to cognitive conflict strategies. The results confirm the significance of a thoughtful implementation that considers vulgarity of gender identity and expression. Educators must remain positive and responsive to the special needs of the students, giving room for students to explore and learn.

Finally, in promoting gender inclusivity within the educational sector, cognitive conflict teaching strategy shows a lot of promise by fostering an environment that allows dialogue and reflection.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, RECOMMENDATIONS, AND FURTHER RESEARCH DIRECTIONS

The study is summarized in this chapter. Additionally, it wraps up the research with recommendations for educational practice and policy. It concludes with three suggestions for further study. The purpose of this study was to determine how cognitive conflict teaching strategy affects students' performance in genetics are the effect of cognitive conflict teaching strategy on students' performance in genetics at the SHS level.

5.1 Summary of Findings

The three research questions that guided the research are outlined below

1. What is the effect of cognitive conflict teaching strategy on students' performance in genetics?
2. What is the difference in performance between students taught genetics using cognitive conflict teaching strategy and those taught with the conventional approach?
3. What is the effect of cognitive conflict teaching strategy on the sex of the students when taught genetics?

Research question 1 sought to determine the effect of cognitive conflict teaching strategy on learners' performance in genetics at the senior high level. The results of the study show that, there was a significant difference in the student's performance when the students are taught using the cognitive conflict teaching approach. An eta squared value of 0.765 indicated a large effect size.

The purpose of the second research question was to determine how students who were taught using the cognitive conflict teaching strategy performed differently from those who were taught using the traditional method. Analysis from the results indicated that, students taught using the cognitive conflict teaching approach outperformed students taught using the conventional method with a *p* value of 0.001 which indicates a statistically significant difference between the two groups in favour of the students taught with cognitive conflict strategy. An eta squared value of 0.61 shows the magnitude of the difference is large.

The third research question evaluated the impact of the cognitive conflict teaching technique on students' sex. Results from an independent sample t-test showed no statistically significant difference between the two groups. This implies that the cognitive conflict strategy could not discriminate the sex of the students.

5.2 Conclusions

The main purpose of this study was to find out the effect of cognitive conflict teaching strategy on students' performance in genetics in senior high schools in Ghana. The study has revealed that, Cognitive conflict teaching approach is effective in changing students' misconceptions in biology to a more scientific conception. Misconception has been a barrier between student achievement and learning outcomes, and the adoption of innovative teaching strategies will curb the menace of misconception among students. The findings also highlight the importance of ensuring students develop a deep and enduring understanding of complex scientific concepts.

The data suggest that when teachers use a teaching technique that keeps students interested, their performance improves. This study supports the findings of Al-Mahdi's 2017 study on cognitive conflict training strategies. The current study has added to the body of knowledge regarding how well students succeed when using the cognitive learning technique.

Learners who receive instruction using the cognitive conflict teaching technique typically perform better academically than those who receive standard instruction. The findings highlight the importance of introducing teaching methods that brings students on board through the learning process, without neglecting their existing knowledge.

The study has further showed that males and females perform at similar levels when taught with cognitive conflict teaching strategy since cognitive conflict strategy is gender friendly.

5.3 Recommendations

Based on the findings of the study, the following recommendations were made:

1. Teachers in the Ahanta West municipal should adopt the cognitive conflict teaching strategy to improve students understanding of genetics. This strategy

enables students to think critically, fosters problem solving skills and conceptual understanding and promotes deeper learning outcomes.

2. Teachers should endeavor to create an atmosphere that allows students to thrive through active learning and critical thinking. The attainment of a sound learning environment can be achieved when students are active participants of the class, engages in discussions, as well as granting students the chance to question, challenge and doubt their existing schema.
3. Cognitive teaching strategy was able to change students existing knowledge (misconceptions) to a more scientific concept. It would therefore not be out of place to encourage biology teachers to explore the use of the teaching strategy to enhance student's performance.

5.4 Further Research Directions

1. Additional study is required to determine the effect of cognitive conflict teaching in other parts of the country to address students' misconception and its efficacy
2. The current study examined the effects of cognitive conflict teaching strategy on the academic performance of students. It is therefore recommended that, a future study be conducted to look at misconception teachers might have before coming to the classroom, and its impact on students' performance.

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APPENDICES

APPENDIX A

GENETICS CONTENT KNOWLEDGE TEST (GCKT)

School Name: ____

Student's Number:____

Sex: Male Female Time Allowed: 30 Minutes

Instruction: Attempt all questions by circling the correct option

1. Which of the statements below is true about heredity?

A. Transmission of characters from grandparents to offspring.

B. Characters transmitted cannot be controlled by genes.

C. Environmental factors cannot change genotype

D. Brings about only differences between parents and offspring.

2. An organism with two sets of chromosomes is said to be ………………………

A. polyploid

B. diploid

C. haploid

D. hybrid

3. The genotype ratio of 1:2:1 in the offspring of a hybrid cross illustrate the law of

A. use and disuse.

B. dominance

C. segregation.

D. linkage.

4. The haploid number of chromosomes in man is ………………

   A. 48

   B. 46

   C. 24

   D. 23

5. If a cross is made between a pure breeding red flower plant and a pure breeding white flower plant where R is dominant for red flower and r is recessive for white, the most likely F1 generation will be ……………………..

   A. 75% red flowers and 25% white flowers.

   B. 100% all red flowers.

   C. 50% red flowers and 50% white flowers.

   D. 75% white flowers and 25% red flowers

6. Which of the following represents the phenotypic ratio when a plant Rr is crossed with another plant Rr, assuming that the gene R for round seed is dominant and wrinkled r is recessive?

   A. 1:2:1

   B. 2:2:1

   C. 2:2

   D. 3:1 7)

7. All hereditary characters in a cell are passed on from parent-cell to daughter-cell through the process of ……………..

   A. mitosis

B. meiosis

C. fertilization

D. gestation

8. When gametes from pure breeding parents with contrasting features such as tallness and shortness are involved in monohybrid cross, the offspring in the first filial generation are usually ……………………

A. pure bred

B. heterozygous

C. homozygous

D. co-dominance

9. The genetic make-up of an organism is known as the ………………

A. phenotype

B. genotype

C. character

D. gene

10. Which of these is not hereditary?

A. Poliomylietis

B. Blood group

C. Sickle cell anaemia

D. Shape of face and nose

11. An individual with blood group AB can receive blood from those in blood group(s) …………….

A. AB only

B. A and B only

C. AB and O only

D. A, B, AB and O

12. Which of the following is the unit of transmission of hereditary traits in living organisms?

A. Nucleus

B. Nucleolus

C. Gene

D. Chromosome

13. Blood group and tongue rolling are examples of …………………..

A. Continuous variation

B. Discontinuous variation

C. Variation due to environment

D. Adaptive variation

14. If a black guinea pig of genotype BB is crossed with a white guinea pig of genotype bb; what will be the phenotype of the F1 generation?

A. Half of the offspring would be black while the other half would be white

B. All the offspring would be black

C. All the offspring will be grey

D. One-third of the offspring would be black while two-third would be white

15. The process that results in gamete formation is …………………………….

A. Mitosis

B. Fertilization

C. Pregnancy

D. Meiosis

16. Which of the following is NOT an example of continuous variation?

A. Height of plant

B. Ability to roll tongue

C. Skin colour

D. Length of fingers

17. Morphological variation deals with ………………………..

A. organism_s genotype

B. organism_s phenotype

C. organism_s Chromosome numbers

D. organism_s skin colour

18. The paternity of a child, which is in dispute, can be ascertained by comparing the child’s …………….

A. phenotype with that of the father and mother

B. genotype with that of the father alone

C. genotype with that of the mother and father

D. genotype with that of his grand parents

19. Variation is the study of ……………………………..

A. differences in height and weight of organisms

B. differences in the number of males and females

C. the observable differences between parents and offspring

D. the observable differences in the rich and the poor

20. Which of the following diseases or disorders can be prevented by application of the knowledge of heredity through marriage counseling?

A. sickle cell anemia

B. haemophilia

C. diabetis mellitus

D. colour blindness

21. How many chromosomes are found in the human ovum?

A. 46

B. 23

C. 33

D. 13

22. The branch of science which deals with resemblance, origin and expression of biological variations is called …………………………………...

A. Embryology

B. Ecology

C. Entomology

D. Genetics

23. The offspring produced when pure strains interbreed is described as ……… character.

A. dominance

B. phenotype

C. genotype

D. hybrid

24. A sudden loss of black pigments from the skin of an African can be attributed to

A. blending of black and white genes

B. recombination of genes

C. loss of the epidemis

D. mutation in the skin gene cells

25. Which of the following statements is not correct about sex determination?

A. females contribute half of the sex chromosomes

B. males contribute an X or Y chromosomes

C. males contributes half of the sex chromosomes

D. the sex of an individual is determined by the contribution of the male and female

Use the following human characteristics to answer question 39 and 40

I Complexion

II Height

III Blood Rhesus factor

IV Colour blindness

26. Which of the above human characteristics are discontinuous variations?

A. I and III only

B. II and III only

C. II and IV only

D. III and IV only

27. Which of the characteristics can be expressed phenotypically?

A. I and II only

B. I, II and IV only

C. I, III, and IV only

D. I, II, III and IV

28. Which of the following determines a normal male offspring?

A. M X

B. YX

C. XX

D. XY

29. Variation is important in human life and can be used for the following activities except …………………..

A. crime detection

B. population distribution

C. blood transfusion

D. determination of sickle cell anemia

30. Which of the following is the correct allelic pair of a homozygous pure-stock of garden pea plants that is round and yellow?

A. RyRy B. Ryry C. ryry D. RYRY

Part B

1. Describe the Structure of the DNA
2. Describe Mendel's law of segregation
3. Explain the concept of genetic Variation.
4. Explain the role of DNA in inheritance

APPENDIX B

LESSON PLAN FOR THE EXPERIMENTAL GROUP EXPOSED TO COGNITIVE CONFLICT INSTRUCTIONAL MODEL

Lesson 1 - WEEK 1

Class Level SHS 3 Subject: Biology

TOPIC: Transmission and Expression of characters in organism

Duration: 90 minutes

Instructional Materials - Biology textbook, activity sheet, cardboard paper, pencils & eraser.

SPECIFIC OBJECTTIVES: At the end of the lesson students should be able to:

1. Define genetics;
2. Differentiate heredity and variation;
3. Draw a crossing in genetics

STEP I: Introduction: The teacher will start the lesson by grouping the students into 5 groups, each group with at least one Biology text book and activity sheet.

STEP II: Students' activity (Using cognitive conflict instructional model)

Stage i: The teacher asks the students the following questions that trigger students conception and set them into cognitive conflict, such as:

a) Why do we look like our parents?

b) What is responsible for our resemblance?

Stage ii: creation of cognitive conflict with anomalous situation as follows;

c) Black man and white man look alike because they are of the same species, does it mean that donkey and zebra look alike because they are of the same species? What is responsible for their differences?

Stage iii: Students' interaction: the students interact with each other by sharing ideas and using Biology textbook in their group and report their findings or answers in the activity sheet. For example;

a. We look like our parents because we inherit some genes from our parents.

b. Genes are responsible for our resemblance.

c. Zebra and donkey are not the same species, because they cannot mate. Organisms of the same species mate and during mating there is transfer of genes from parents to daughter cells which causes inheritance and variation.

STEP III. Discussion/summary: the teacher uses the reports and guides the discussion as; what is the difference between genetics and heredity?

Group (a): Genetics is the study of heredity and variation.

Heredity is the study of transfer of traits or characters from the parents to its offspring from one generation to another.

Variation is the difference which exists in individuals or organisms of the same specie at corresponding stages of their life cycle. For instance, the difference between a child and his or her grandfather or grandmother.

Teacher: what is gene?

Group (b): Gene is the basic unit of inheritance.

Group (c): Gene is the physical unit of inheritance transmitted from one generation to another and it is responsible for developing and controlling character or traits in the new organism.

Group (d): Gene is a segment of deoxyribonucleic acid (DNA) molecule that usually codes for the synthesis of polypeptides chains (protein) that eventually determines the nature of an organism.

Group (e): what is genotype?

Group(a): genotype is the sum of total genes present in the cells of an organism. The genotype character is not externally visible but responsible for controlling physiological activities or characteristics.

Group(c): what is phenotype?

Group(b): Phenotype is the physical observable (visible) expression of the gene present in an organism. The phenotypic character is as a result of the interaction of genetic materials and the surrounding of the environmental condition.

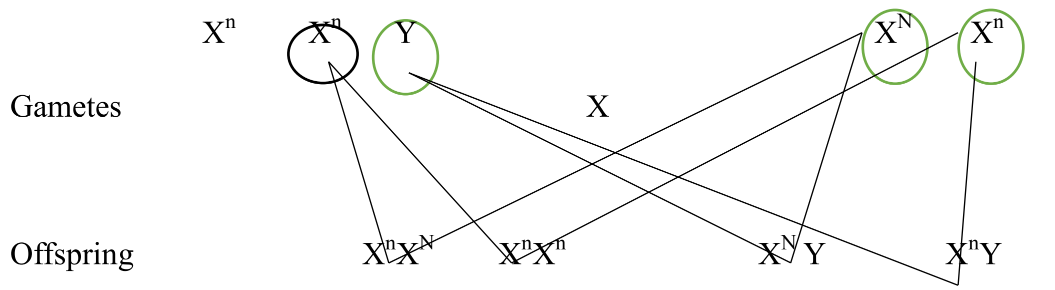
Group(d): what is chromosome?

Group(e): Chromosomes are strands of genetic materials which becomes obvious or visible during cell division (meiosis). Chromosomes are usually found in the nucleus of a cell and always carry a gene. They consist of deoxyribonucleic acid (DNA) and protein. Each specie or organism has a peculiar characteristic number of chromosomes. For example, the human being has 23 pairs of chromosomes.

Teacher: the teacher guides the students on determining where students will link gene factors using diagram.

Sex-linked character: these are characters determined by a gene located on either X or Y chromosome. For instance, haemophilia and colour blindness are recessive characters located on “X^n” chromosome. That is the reason why only male human organism suffers from the disease while the female is a carrier.

Group (a): Male (colour blind) X Female(carrier)



Group(b): what is mutation?

Group (c): Mutation is a permanent change in DNA structure that alters or destroys a given character resulting into a new character. For instance, when pure-line stocks of red and white pea plants are crossed and the result of F1 self-pollinated to produce a phenotypic pink pea plant at F2 generation. The pink plant is as a result of mutation. Sickle-cell anaemia, haemophilia, colour blindness and blood groups etc. are example of mutation. What are alleles?

Group (d): Allelesare two or more alternative forms of gene. For instance, the gene for tallness is represented as _TT‘ or dwarfness as tt‘ is referred to as allele‘. If they are in pair is referred to as alleles‘.

Group (e): what is locus?

Group (b): Locus is the location of a gene on a chromosome. In other words, it is a position on the chromosome where the gene is located or placed.

Group (c): what is pure-line?

Group(a): Pure-line is a homologous pair of allelic gene of a character. For instance, tall plants TT and short plant (dwarf) tt.

Teacher: what is the different between homozygous and heterozygous?

Group (b): Homozygous are two dissimilar alleles for a particular character in an organism. For instance, Tt for heterozygous tall plant. This means that, the tall plant has a recessive gene for shortness, that is, small t.

Summary: The teacher summarizes the discussion by explain the meaning of Gamete as a haploid sperm cell or ova which fuses together to produce a zygote. It is usually the half number of chromosomes, that is, 23 that each parent contributes during meiosis to gamete formation. Zygote is the cells formed as a result of the fusion of haploids cells of a male and female. The zygote can be described as diploid cell having 46 numbers of chromosomes.

STEPIV: Evaluation: Based on the activities carried out by the students, the teacher evaluates the students as follows:

1) What is genetics?

2) Differentiate between genetics and variation

3) Using genetic crossing draw a crossing between a dominant character DD and recessive character dd.

Lesson 2 - WEEK 2

Class Level SHS 3 Subject: Biology

TOPIC: Mendalian Laws and heredity

Duration: 90 minutes

Behavioral Objective: At the end of the lesson students should be able to:

I. State Mendel‘s first law of segregation of genes

II. State Mendel‘s second law of independent assortment of genes

III. Differentiate between transmissible and non-transmissible characters

Identify non-transmissible character

STEP I: Introduction: The teacher starts the lesson by grouping the students into 5 groups, each group with at least one biology textbook and activity sheet.

STEPII: Students' activity (using cognitive conflict instructional model)

Stage i: The teacher asks the students the following questions that will trigger student's conception and set them into cognitive conflict, such as:

a) Are all characters from parents transmissible to their offspring?

b) What forms the genetic constitution of a gamete?

c) Is segregation of a gene pair depending on other gene pair?

Stage ii: creation of cognitive conflict with anomalous situation as follows;

A newly married couple took their ill twin daughters to hospital. One of the twin daughters was

diagnosed with pneumonia and the other twin sister is sickle cell patient.

The couples are physically healthy although the mother has a history of pneumonia disease; but now none of the parent neither sickle cell nor pneumonia patient. Now, how did the twin daughters get such diseases?

Stage iii: Student's interaction: the students interact with each other by sharing ideas in their group and report their findings or answers in the activity sheet. For example; a. Pneumonia is non-transmissible disease, it is an infection. So, the twin daughter was infected with pneumonia not inherited from her mother.

b. Sickle cell is a hereditary disease, even though the parents are not sickle cell patients they are carriers. The twin daughter inherited the sickle cell disease from her parent.

STEP III: Discussion/summary: the teacher guides the discussion by naming and showing photographs of Gregor Mendel (1822-1884) an Austrian Monk who in 1856 conducted a precise experiment on heredity using garden pea plants (Pisiumsativum) which he used in formulating the basic laws of genetics.

Mendel worked with the following contrasting character;

a) Height of the stem (tallness and shortness)

b) Flower colours (red and white)

c) Pods colours (green and yellow)

d) Surface of pods (smooth and constricted)

e) Surface of testa (round and wrinkled)

f) Colour of seeds (yellow and green)

What is the other name of mendel's first law of heredity?

Group (a): Mendel's first law of heredity is also known as law of segregation.

Group (b): what is Mendel's first law of segregation?

Group(c): Mendel's first law of segregation states that, during gamete formation each allelic pair separates from the other member to form the genetic constitution of the gamete.

Group(d): Illustration of Mendel's First Law of segregation

Pure Line stock DD (Tall Pea Plant) X dd (Short Pea Plant)

D d

F1 generation genotype Dd

Teacher: the teacher guides the students to illustrate self-fertilization of F1 generation genotype using crossing as done by group (e)

Group (e): Self-fertilization of F1: D d (genotype) X D d (genotype)

DD Dd Dd dd

Genotype ratio of F2 1DD: 2Dd: 1dd (3D:1dd)

Phenotype ratio of F2 3 tall: 1 short

Teacher: the teacher guides the students to explains Principles of Segregation of Genes as done by group (a)

Group (a): principles of segregation of Genes

i. The heredity character of an organism are determined by genes

ii. Genes for a character have alternative forms (alleles)

iii. In a diploid organism, each character is controlled by a pair of identical alleles (homozygous) or different alleles (heterozygous)

iv. In a diploid organism, or heterozygous character, the two alternative alleles segregate during meiosis, each going randomly to a different gamete.

What is the Mendel's second law of independent assortment of gene?

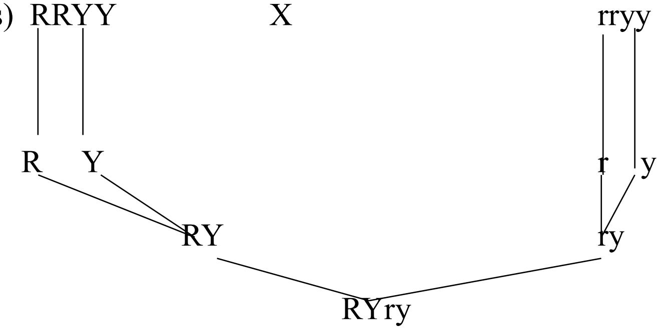
Group (b): Mendel's Second Law of Independent Assortment of Genes states that, the segregation of a gene pair occurs independently of any other gene pair.

This law can be stated as for two characteristics, the genes are inherited independently. This law however applies to allelic gene pairs on different homologous chromosomes.

The teacher guides the group to show the Illustration of the Mendel's second law on the board, as follows;

Round and Yellow seed color (RRYY) X Wrinkled and green seed color (rryy)

(homozygous) RRYY X rryy (homozygous)



Group (c): explain the Transmissible Characters as characters carried in the genes of the parent. The dominant genotype genes manifest outwardly over recessive genes. Examples of transmissible characters are; skin color, ability to roll tongue, dimple cheek etc. transmissible diseases are sickle-cell anemia, hemophilia, color blindness etc.

What are non-transmissible characters?

Group (d): non-transmissible characters are those characters that cannot be transmitted through genetic materials from parents to their offspring. For instance, loss of eye by accident,

development of muscles by weight lifting etc.

STEP IV: Evaluation: The teacher evaluates the students based on the activities carried out by

the students as follows;

I. State Mendel's first law of segregation of genes

II. What is the Mendel's second law?

III. Differentiate between transmissible and non-transmissible characters

IV. Mention ten (10) non-transmissible characters.

APPENDIX C

Effect Size of Paired Sample T-Test

Formula:

$$\text{Eta Squared} = \frac{t^2}{t^2+N-1}$$

$$= \frac{14.577^2}{14.577^2+66-1} \qquad = \frac{212.28}{277.48}$$

$$= 0.765$$