AN EVALUATION OF TEACHER'S CONTENT KNOWLEDGE ON DIFFICULT GENETICS CONCEPTS IN BIOLOGY

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DEPARTMENT OF CURRICULUM AND INSTRUCTIONAL TECHNOLOGY

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CERTIFICATION

We, the undersigned, certify hereby certify that this research work was carried out by **EHIMARE DIVINE AKUGBE,** with matriculation **EDU2106216** in the Department of Curriculum and Instructional Technology, Faculty of Education, University of Benin, Benin City.

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DEDICATION

With a thankful heart, I dedicate this work to God Almighty, who saw me through, sustained me, and helped me throughout my stay in school. His abundant grace has carried me, and He has remained my constant source of strength.

ACKNOWLEDGEMENTS

I wish to express my profound gratitude to my supervisor, Dr. (Mrs.) E.O. Eromosele, for her unwavering guidance, insightful suggestions, and invaluable support throughout the course of this research. Thank you, Ma, for your mentorship and dedication.

I am also grateful to the Dean, Prof. Osamede Kingsley Omorogiuwa, for his exemplary leadership and for fostering an enabling academic environment. I further acknowledge the Head of Department, Prof. F.O. Idehen, for his guidance, understanding, and contributions. My sincere appreciation extends to my lecturers—Dr F.O Idiaghe, Dr(.Mrs).I.K Oteze,Dr I.L Osemwegie,Dr Wellington.O.Jesuorobo ,Dr M.O Osasuyi ,Dr Igbineweka M.N and Dr.Iniobong J.Umoh—for their mentorship and the knowledge imparted, which significantly contributed to the successful completion of this project. I am equally thankful to all academic and non-academic staff of the University of Benin, particularly those in the Department of Curriculum and Instructional Technology, whose support in various capacities has positively impacted my academic journey.

I am deeply indebted to my parents, Mr. and Mrs. Ehimare, for their unwavering prayers, financial support, and moral encouragement throughout my studies. My heartfelt gratitude also goes to my siblings—Raphael, Humphery, and Harry—for their continuous encouragement, love, and keen interest in my academic progress.

To my remarkable friends who became family—David, Victory, Jane, Blessing, Peter, Michael, Gift, and Amose—I am sincerely grateful for your love, care, prayers, and support throughout my time in school. Finally, to all my course mates who have assisted me in any way during this study, I say: may the Lord bless you all.

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ABSTRACT

This study investigated Biology teachers' content knowledge of difficult concepts in Genetics and examined whether sex, educational qualification, and teaching experience influence their mastery of these concepts. The study was motivated by persistent challenges observed in the teaching and learning of genetics in secondary schools, particularly the difficulty teachers face in applying advanced genetic principles during instruction.

A descriptive survey research design was adopted, and data were collected using a validated questionnaire achievement test administered to Biology teachers. The population comprised all Biology teachers in Egor Local Government Area secondary schools, and the sampling technique involved administering the questionnaire to all available teachers. Responses were analyzed using descriptive statistics, t-test, and ANOVA to determine the level of teachers' content knowledge and the significance of demographic variables on performance.

Findings revealed that Biology teachers possess adequate knowledge of basic genetic concepts such as Mendelian inheritance, blood group determination, and simple crosses. However, many struggled with advanced and applied genetics, including multigenic inheritance, prediction of genetic outcomes, and interpretation of human hereditary traits. Results further showed that sex did not significantly influence teachers' content knowledge, while higher educational qualifications and, to a lesser extent, teaching experience showed limited but positive influence on performance in complex areas.

The study concludes that while teachers demonstrate strength in foundational genetics, there is a need for targeted capacity-building programs to improve mastery of advanced and application-based concepts. Recommendations were made for professional development, improved instructional resources, and continuous assessment of teachers' content knowledge.

CHAPTER ONE

INTRODUCTION

Background to the Study

Biology as a science occupies the middle position in the Nigerian secondary school curriculum because the subject deals with the study of life and the interaction of living organisms with the environment. Olatunde and Okebukola (2021) state that biology is the systematic study of life processes and the relationship between organisms and their environment. Similarly, Adebayo and Salami (2023) envision biology as a life science that equips students with the knowledge and competencies required for sustainable living, health sciences innovation, and environment management. The two definitions accentuate the disciplinary and utilitarian importance of biology in placing students at the forefront of scientific inquiry and problem-solving.

The importance of Biology in secondary school education cannot be overemphasized, as it serves as a prerequisite for careers in medicine, pharmacy, agriculture, biotechnology, and related fields. Despite its significance, the performance of students in Biology at the secondary school level in internal and external examinations has persistently remained very poor. The WAEC Chief Examiners' reports of 2020 to 2024 have repeatedly identified students' weaknesses in difficult and abstract concepts such as genetics, ecology, and evolution. In 2020, the WAEC Chief Examiners' Report revealed that over

62% of the candidates could not define or utilize appropriately simple genetic terms such as genotype, phenotype, and allele to respond to questions. In 2021, the report revealed that about 58% of the students had poor marks in ecology-based questions due to their inability to interpret food chains, energy flow, and ecological pyramids. The 2022 report particularly noted that more than 60% of the candidates avoided evolution questions, and those who attempted them poorly understood natural selection and adaptation. WAEC also noted in 2023 that more than 55% of biology candidates could not effectively apply Mendelian laws of inheritance to solve genetic questions. The recent 2024 Chief Examiners' Report noted that 59% of the candidates failed to explain biological terms and processes, especially molecular genetics and ecological succession, to the satisfaction of the examiners (WAEC, 2020–2024).

The persistent underperformance of students raises the question of where the problem originates. The Chief Examiners' observations show that students' weaknesses over the years are the same, particularly in areas that involve abstract thinking, visualization, and application of concepts rather than memorization. Research has persistently attributed this poor performance to the ineffectiveness of teachers in delivering difficult concepts (Ndirika & Okorie, 2022; Eze & Ibrahim, 2023).

Teaching, according to Adeyemi (2021), is the organized process of transferring knowledge, skills, and values from the teacher to the learner with the aim of developing intellectual and behavioral growth. In this process, the teacher is the key player. A teacher, according to Oduro and Mensah (2022), is a professional educator who is responsible for facilitating learning, removing misconceptions, and ensuring learners attain mastery of concepts.

In teaching biology specifically, teachers are expected to possess both content knowledge (CK) and pedagogical content knowledge (PCK). Shulman's (1986) model, which is still relevant today, affirms that what teachers know about their subject matter directly affects the quality of instruction and student achievement (Anyanwu & Eze, 2020). The Federal Republic of Nigeria (FRN, 2013, as cited in Nwankwo, 2019) also asserts that the quality of an educational system cannot rise above the quality of its teachers.

Research evidence suggests that some Biology concepts are not only difficult for students to learn but also challenging for teachers to teach effectively (Nwagbo & Okeke, 2020). Such topics often require abstract reasoning, visualization, or mathematical application, which many teachers themselves struggle with. Genetics, for instance, has consistently been highlighted as a topic where both teachers and students face significant difficulties (WAEC, 2021).

Teachers, therefore, play a dual role: they must first understand the concepts deeply before they can simplify and communicate them effectively to students. The relevance of teachers' content knowledge becomes most evident in these difficult areas, where any deficiency on their part translates directly into student failure. The essence of teaching biology is to evoke curiosity, problem-solving abilities, and scientific literacy among students. This essence is, however, lost when the teachers themselves are unable to decode and simplify difficult concepts. WAEC (2024) explains that such weak teachers are predominantly those who have had minimal exposure to current scientific training, poor qualifications, or few opportunities for professional development. It is, therefore, critical to examine biology teachers' content knowledge of difficult topics—particularly in genetics, ecology, and evolution.

The essence of this study is to ensure that necessary interventions, such as in-service training, are provided for teachers found wanting in specific areas, so they remain abreast of new methods for effectively teaching difficult concepts. If teachers continually skip or inadequately address such topics, students will persistently struggle with understanding them, leading to recurring failure in examinations. Identifying teachers who lack mastery in these areas places the government and stakeholders in a better position to provide lasting remedies.

Statement of the Problem

Despite the importance of Biology as a core science subject in secondary schools, students' performance in public examinations has remained unsatisfactory, particularly in topics identified as difficult such as Genetics, Ecology, and Evolution. WAEC Chief Examiners' Reports (2020–2024) consistently reveal that many candidates demonstrate shallow understanding, poor explanations, and misconceptions when answering questions from these areas.

Several studies (Nwagbo & Okeke, 2020; Anyanwu & Eze, 2020) have also noted that some Biology concepts are inherently abstract and difficult for learners to grasp. The difficulty of these concepts, however, is not limited to students alone; teachers also struggle with content knowledge in these areas. When teachers lack sufficient mastery, they may either avoid teaching such topics or teach them superficially, which further worsens student performance.

This situation calls for an urgent evaluation of teachers' content knowledge in difficult concepts of Biology. Addressing this problem requires determining whether teachers truly possess the depth of knowledge necessary for effective teaching. Hence, this study seeks to evaluate Biology teachers' content knowledge in difficult concepts, with the aim of identifying gaps that may be contributing to students' poor performance.

Research Questions

The study will be guided by the following research questions:

1. To what extent do Biology teachers possess adequate content knowledge of difficult concepts such as Genetics?

2. Does Biology teachers' content knowledge of difficult concepts significantly differ based on sex?
3. Does Biology teachers' educational qualification influence their content knowledge of difficult concepts?
4. Does Biology teachers' content knowledge of difficult concepts significantly differ based on teaching experience?

Research Hypotheses

H_{02}: There is no significant differences on content knowledge of genetics between male and female teachers'

H_{03}: Teachers, educational qualification does not significantly influence their content knowledge of genetics.

H_{04}: Teaching experience does not significantly influence teacher's content knowledge of genetics

Purpose of the Study

The main purpose of this study is to evaluate Biology teachers' content knowledge of difficult concepts in Biology at the secondary school Level. The specific objectives are to:

1. Determine the extent to which Biology teachers possess adequate content knowledge of difficult concepts such as Genetics.

2. Determine whether Biology teachers content knowledge of difficult concepts differs based on gender
3. Examine the influence of teachers' educational qualifications on their content knowledge of difficult concepts.
4. Determine whether Biology teachers content knowledge of difficult concepts differ based on teaching experience

Significance of the Study

This research is significant as it provides evidence regarding how Biology teachers' content knowledge, teaching experience, and certification influence the effective delivery of difficult subjects such as Evolution, Ecology, and Genetics:

- For students, the study is relevant because greater teacher content proficiency will lead to clearer teaching and better classroom communication. If teachers possess enough knowledge on challenging Biology subject matter, they will be more likely to understand, remember, and apply the knowledge themselves, potentially leading to them performing better academically on exams.
- For teachers, the findings of the research will offer a mirror of their strengths and weaknesses in content to instruct. Teachers will be capable of developing professionally on the basis of areas of gaps found in their mastery of demanding Biology content. The research will also motivate educators to accommodate

continuous learning and professional development opportunities, thereby improving their general teaching pedagogy.

- For the curriculum developers and school leaders, this study provides evidence-based suggestions to design targeted training, workshops, and seminars to address certain content gaps for Biology teachers. These interventions will make the teachers more capable of handling difficult concepts and hence improve the quality of science teaching in secondary schools.
- For the government and policymakers, the study suggests the imperative of providing the instructors with greater access to subject mastery exposures. This may be by sponsoring the instructors to undertake postgraduate studies, in-service education, and professional development courses and facilitating greater access to e-learning systems that allow the instructors to update their knowledge on an ongoing basis as per prevailing trends in teaching Biology. By investing in teacher development, the government can raise the level of science education and, in turn, the national performance on Biology exams.
- Lastly, for researchers, the study is one more contribution to the growing body of literature on teacher content knowledge and its role in efficient science subject instruction. It will also prove to be a valuable guide document for subsequent research on teacher proficiency, lesson planning, and science education reforms in Nigeria and elsewhere.

In summary, the significance of this study is that it will be able to promote Biology learning and teaching by improving the teaching capacity, enriching the learners' knowledge, guiding the curriculum development, and informing policies in which teacher professional development is given priority in science education, hence contributing to long term Improvement in student achievement in Biology.

Scope and delimitation of the Study

This study is delimited to evaluating Biology teachers’ content knowledge of difficult concepts in Biology at the senior secondary school level, such as Genetics. The study covers Biology teachers in secondary schools within Egor local government area, Edo State, Nigeria, without extending to other science subjects such as Chemistry or Physics.

The study is further delimited to examining teachers’ content knowledge in relation to variables such as gender, teaching experience, and educational qualifications. It does not cover other factors that may influence students’ learning outcomes, such as school facilities, instructional materials, or students’ attitudes toward Biology.

By narrowing its scope in this way, the study aims to provide a focused evaluation of Biology teachers’ mastery of difficult concepts and how this mastery may differ across teacher characteristics.

Operational Definition of Terms

- Biology Teacher: A professional educator who teaches Biology at the senior secondary school level and is responsible for facilitating students' understanding of biological concepts.
- Content Knowledge: The depth of understanding Biology teachers possesses regarding difficult concepts such as Genetics.
- Difficult Concepts in Biology: Topics within the Biology curriculum that are abstract, complex, or challenging for both teachers to teach effectively and students to understand (e.g., Genetics, Ecology, and Evolution)
- Gender: The biological and social classification of teachers as male or female, used in this study to examine differences in content knowledge.
- Teachers' Qualifications: The highest level of academic attainment of Biology teachers, such as Nigeria Certificate in Education (NCE), Bachelor of Science (B.Sc.), Bachelor of Education (B.Ed.), or Master of Science (M.Sc.).
- Teachers' Experience: The number of years Biology teachers have been teaching the subject at the senior secondary school level.
- Evaluation: A systematic process of assessing Biology teachers' adequacy of content knowledge and examining the influence of their gender, qualifications, and teaching experience on mastery of difficult concepts.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The literature was reviewed under the following subheading;

Theoretical Framework

Concept of Teachers' Content Knowledge in Difficult Concepts of Biology

- Genetics Knowledge and Teacher's understanding

Concept Influencing Teachers' Content Knowledge

- Educational Qualification & Teacher's Contents Knowledge
- Empirical Studies on Teachers' Educational Qualification and Content Knowledge
- Gender & Teachers Contents Knowledge
- Empirical Studies on Gender Issues in Teachers' Content Knowledge
- Teaching Experience & Teachers Content Knowledge

Summary of reviewed related literature

Theoretical Framework

Shulman's Content Knowledge Theory (1986)

Shulman (1986) came up with the idea that teachers must possess a rich and well-structured knowledge of the subject matter they teach, which he referred to as Content Knowledge (CK). Content Knowledge goes beyond the simple recalling of facts; it is the deep understanding of concepts, principles, theories, and the relationships that exist in a discipline. For Biology teachers, CK is being familiar with the fundamental and advanced concepts of the subject, like genetics.

In Biology education, content knowledge is essential because the subject matter deals with abstract and typically difficult concepts that students will struggle with. For example, topics such as molecular genetics or hereditary relationships require teachers to be not just familiar with the facts but also to fully comprehend the processes and relationships therein. Teaching professionals with strong CK can accurately represent these concepts, correct misunderstandings, and relate them to the everyday contexts that make learning meaningful. Conversely, if educators lack sufficient CK, they may provide partial or incorrect explanations, thereby confusing learners and establishing deep-rooted misconceptions.

Shulman's theory emphasizes that teaching will not be effective if the subject matter is not adequately mastered. CK is therefore an essential foundation for teaching since it controls teachers' confidence in teaching, their ability to respond to students' questions, and their ability to move classroom discussion beyond memorization. In Biology, a teacher who has good CK is more capable of guiding students through inquiry-based learning, engaging them in problem-solving, and enabling them to build scientific reasoning.

The relevance of Shulman's content knowledge framework to this study is in the way it stresses the direct correlation between students' learning outcome and the knowledge of teachers about difficult concepts. If teachers of Biology are deficient in CK in areas like genetics, ecology, or evolution, students will also perform badly, develop negative attitudes towards the subject, and not be able to manage exams. Measuring teachers' CK is therefore important, as it provides an insight into how well prepared, they are to instruct difficult content and how their knowledge base influences student learning.

Concept of Teachers’ Content Knowledge in Difficult Concepts of Biology

In this study, teachers' content knowledge (CK) in troublesome areas of Biology is the dependent variable since it is the indicator of what is being measured. CK is an indicator of teachers' knowledge of subject matter like genetics, ecology, and evolution in terms of depth, precision, and completeness. Current research has established that teachers have been finding many of these theoretical domains of Biology troublesome, and their mastery level has a direct impact on the quality of how they teach them.

For instance, Adeyemo and Akinola (2024) reported that Oyo State Biology teachers had rated challenging topics such as genetics and molecular biology as extremely difficult to teach, attributing this to the abstractness of the concepts as well as their own insufficient knowledge of the subject matter. This is an indication that teachers can handle less complex subjects such as food chains or respiration quite easily, but they are often short on confidence and extent in more specialized areas of the course. Similarly, Eze and Ibrahim (2023) also observed that students' poor performance in ecology-based courses was linked to shallow explanations and misconceptions on the part of teachers, theorizing that poor mastery by teachers is transferred directly to students.

Comparative studies also show that qualifications for teachers play an important role in establishing content knowledge. Ndirika and Okorie (2022) found that those teachers who had more qualifications in the form of a Bachelor's or Master's degree in Biology had much stronger CK than those who had only a Nigeria Certificate in Education (NCE). This is in accordance with Oduro and Mensah (2022) pronouncement that professional training and advanced studies in training reinforce mastery of the topic. Additionally, Anyanwu and Eze (2020) further re-emphasizing that student poor performance in genetics and evolution was largely due to lecturers who never lectured them because they had limited mastery.

Another factor that determines CK is teaching experience. Experienced teachers will often show a stronger grasp of central concepts, yet studies have now revealed that experience does not guarantee mastery over abstract and high-level material. According to Adeyemi (2021), even highly experienced teachers with 10 or more years of teaching still voiced low confidence in teaching Mendelian genetics, specifically where problem-solving or application-type questions were involved. This highlights the reality that ongoing training is needed regardless of the years one has spent in service as a teacher.

Gender disparities have also been investigated, albeit in a mixed fashion. For example, Adebayo and Salami (2023) failed to find any gender disparity in CK among Biology teachers in Lagos, suggesting qualification and training rather than gender determines mastery of hard concepts. However, Nwagbo and Okeke (2020) found minimal variations with male teachers performing better in abstract topics such as genetics, while female teachers showed superior mastery of human biology and ecology. By way of conclusion, teachers' content knowledge of the difficult Biology ideas remains a pressing concern in science education during 2020 to 2025. Research continues to confirm that CK is spread unequally among teachers, qualifications and training exposure being more regular predictors than years of teaching or gender. Since CK is the dependent variable within the current study, its measurement will help elicit existing gaps and inform interventions for improving Biology teaching and learning performance in Nigerian secondary schools.

The Concept of Genetics Knowledge and Teachers Understanding

Genetics is always ranked as one of the most challenging secondary school Biology subjects, not only for the pupils but also for teachers. It involves mastery of conceptual and problem-solving knowledge, for example, understanding basic words like gene, allele, genotype, and phenotype to the use of Mendelian laws of inheritance for monohybrid and dihybrid crosses. Outside of such foundations, genetics splits into molecular genetics and the use of probability for forecasting patterns of heredity, which require powerful reasoning skill and use of mathematics.

Existing research shows long-term challenges among teachers to understand these issues. For instance, Eze and Ibrahim (2023) reported that over 55% of northern Nigerian Biology teachers could not accurately define or distinguish between the gene and allele terms, leading to shallow classroom explanations that accounted for students' misconceptions. Similarly, in their study, Adeyemo and Akinola (2024) found that only 46% of Oyo State secondary school Biology teachers were capable of solving dihybrid cross problems, whereas nearly 60% of them avoided these questions while teaching out of their own lack of confidence.

WAEC Chief Examiners' Reports (2020–2024) corroborate this issue, consistently reporting that over half of the students performed inheritance questions poorly, especially those related to the application of probability or Mendelian law explanations. In 2023, for example, WAEC reported that 55% of the candidates were unable to correctly apply Mendel's second law, and in 2024, approximately 59% struggled with molecular genetics and could not explain significant processes like DNA replication and transcription. These weaknesses strongly suggest that teachers themselves may not possess the requisite mastery to effectively teach these courses.

Ndirika and Okorie (2022) conducted a study which revealed that postgraduate degree holders performed better on molecular genetics content tests compared to those with only NCE or B.Sc. degrees. In a similar study, Adebayo and Salami (2023) found that newly graduated young teachers outperformed veteran teachers in molecular genetics, largely because they were more recently exposed to advances in genetic science. These findings indicate that both recentness of training and higher qualifications impact the depth of teachers' knowledge.

Teaching experience alone, though, is not sufficient to guarantee sound mastery of genetics. Adeyemi (2021) illustrated that even the more experienced teachers who had more than ten years of teaching experience avoided the questions on inheritance and probability while less experienced teachers with fewer than five years of experience but greater formal training performed better. This indicates that regular professional development in novel areas of biology is essential for all teachers irrespective of the level of experience. As a whole, teachers' own understanding of genetics—namely in areas like Mendelian laws, dihybrid crosses, molecular genetics, and the use of probability—varies. While the majority are located at high levels of mastery, a significant proportion are still lacking in depth to effectively teach these abstract and problem-solving concepts. This deficit in content knowledge feeds directly into students' ongoing sub-performance in genetics in both internal and external exams.

Concept Influencing Teachers' Content Knowledge

Teachers' content knowledge (CK) is shaped by several interconnected factors that establish the quality with which they know and can teach subject matter. For Biology, such factors matter particularly because the subject involves abstract and conceptually demanding topics like genetics, ecology, and evolution. In the last five years, literature has consistently shown that teacher-related, institutional, and systemic variables all play an important role in determining the extent of CK possessed by teachers.

i.. Teachers Educational Qualification & Contents Knowledge

One of the most influential is teacher qualification and training. Empirical observations reveal that teacher qualification via higher degrees or specialist training in Biology reflects greater control over advanced concepts. For example, Yusuf and Okonkwo (2021) found that Nigerian bachelor degree holders of pure sciences scored an average of 18% higher than education-trained teachers on CK tests. For example, a cross-sectional survey by Mensah (2022) in Ghana found that teachers who attended professional workshops in genetics and ecology had much better conceptual understanding than their peers who did not attend.

The other important predictor of CK is teaching experience. Experience is commonly thought to be correlated with expertise, but findings are equivocal. Olatunji and Adeyemi (2023) reported that teachers with over 10 years of experience had higher scores (mean score 72%) than novice teachers (mean score 58%). Nevertheless, they also noted that without continuous professional learning, experience alone cannot guarantee accurate knowledge since some misconceptions are retained even after several years of teaching. A South African study by Dlamini and Khoza (2024) confirmed this, showing that even long-standing teachers still maintained antiquated Lamarckian ideas of evolution, albeit experienced teachers.

Exposure to instructional materials and access to resources also affect teachers' CK. Teachers working in their environments where they are exposed to high-quality instructional materials, laboratory centers, and updated curricula have a more vigorous CK. Singh and Rao (2023) of India, for instance, discovered that teachers in resource-rich schools scored higher than teachers in resource-poor schools by 21% in ecology-themed CK tests. In Nigeria, Okoye and Ibrahim (2022) also underscored that limited laboratory facilities significantly reduced the ability of teachers to demonstrate energy flow and patterns of genetic inheritance practically and led to poor performance in CK. Gender has also been shown to be a moderating variable in learning CK. Several studies document small but significant gender differences. For example, Uche and Bello (2022) reported that Lagos male teachers were more confident in teaching genetics, but objective test results indicated that there was no significant difference in CK between males and females. Contrarily, Adebayo and Olatunji (2025) in a large-scale South-West Nigeria study had found female teachers to be more competent in ecology-related CK and males in genetics. These findings suggest that gender differences may be less related to inborn ability and more related to access, training, and specialization of interest.

Empirical Studies on Teachers' Educational Qualification and Content Knowledge

Nwagbo & Okeke (2020), in their work on Biology teachers' proficiency in genetics, Nwagbo and Okeke (2020) found that most of the teachers lacked proper understanding of basic concepts such as Mendelian inheritance, genotype-phenotype relationship, and dihybrid crosses. These concepts are normally hard to operationalize in instructional practice by the teachers, which thus results in the prevalence of misconceptions and poor understanding by the students. This finding is particularly relevant to the current study as it specifies how content knowledge gaps, specifically genetics, one of the most conceptual and quantitative subjects in Biology, directly limit students to perform effectively in class and in external exams.

Anyanwu and Eze (2020) also researched teachers' knowledge in ecology and evolution and established that teachers' lack of mastery of the subjects was a significant cause of students' repeated failure in the subjects. They elucidated that with insufficient knowledge of content, the teachers could not provide accurate explanations or correct students' misconceptions, which worsened learning outcomes. This research is in line with the current study in that it shows teachers' inadequate knowledge is not only an individual deficit but a systemic problem that has implications for students' comprehension of challenging Biology concepts.

Ahmed (2021) conducted a classroom-based study in Pakistan and observed that Biology teachers often lacked adequate grasp of ecological principles, including food chains, energy flow, and population dynamics. Their teaching was therefore not in-depth, leading to long-lasting misconceptions and rote learning on the students' part. The implication of this finding to the present study is clear, as it shows that inadequate teacher content knowledge in ecology is a widespread phenomenon across contexts, not only in Nigeria, and directly influences the levels of students' comprehension.

Black and Harrison (2020) found that some teachers in the United Kingdom avoided teaching evolution in detail because of its abstract nature and the possibility of cultural or religious conflict. Avoidance of the topic by teachers often resulted in inadequate handling in classrooms and students' poor exam performance. This study is pertinent to the present research in that it shows how teacher mastery deficiencies, in combination with contextual limitations, reduce the effect of Biology teaching in core areas such as natural selection and speciation.

Oketch (2021) studied Kenya secondary school Biology teachers and found that some intentionally avoided addressing complex questions of genetics during lessons and reworks. This exclusion left students unprepared for exams that require higher-order thinking in genetics and applications of probability. The finding rings within this study because it illustrates how teacher insecurity, often based on gaps in knowledge in the subject, translates into selective pedagogical behavior that is detrimental to students, especially in external exams.

Oduro and Mensah (2022) analyzed the relationship between teachers' subject matter mastery and qualifications in Ghana. They concluded that teachers with higher academic qualifications, i.e., master's levels, had significantly more knowledge of principles in ecology and evolution than first-degree or diploma holders. This finding directly relates to the present study because it emphasizes the importance of qualifications in education for building teachers' content knowledge and suggests that further training equips teachers with competencies necessary to simplify complex concepts for students.

Eze and Ibrahim (2023) examined the influence of teaching experience on Biology teachers' confidence in addressing difficult concepts. Based on their findings, the greater the number of years of experience the teachers had, the greater the confidence level in explaining genetics, ecology, and evolution was. However, the study also showed that experience was not always a factor in providing correct information as even experienced teachers exhibited misconceptions in basic principles of genetics. It has very critical implications to the ongoing research in that it increases the significance of ongoing professional development to complement teaching experience and ensure subject matter expertise.

WAEC Chief Examiners' Reports (2020–2024), West African Examinations Council (WAEC) Chief Examiners' Reports, 2020–2024 repeatedly identified poor teaching and poor mastery of difficult topics such as genetics, ecology, and evolution as major determinants of poor student performance in Biology across the sub-region. Reports indicated that many teachers could not adequately explain dihybrid crosses, energy transfer through ecosystems, or evolution evidence, leaving students unprepared for quizzes. Formal reports are particularly valuable because they provide uniform, large-scale data over a period of years, demonstrating the systemic character of the problem this study seeks to evaluate.

ii. Gender & Teacher's Contents Knowledge

The gender element in influencing teachers' content knowledge (CK) of difficult Biology topics has attracted considerable academic attention, though evidence has proved inconclusive. The all-important question is whether male and female teachers show considerable differences in the mastery of difficult areas such as genetics, ecology, and evolution.

Some recent evidence suggests that male teachers report greater confidence with handling abstract topics like genetics and molecular biology, but this does not always enhance assessment outcomes. For instance, Uche and Bello (2022) found that while 64% of male Biology lecturers in Lagos reported having confidence in teaching Mendelian genetics, their mean CK test score (58%) was hardly significantly better than that of females (56%). Similarly, Oladele (2020) earlier wrote that discrepancies in confidence levels of men and women have a tendency to overestimate discrepancies in real performance.

There are, nonetheless, other research that documents infinitesimal variations in the direction of female instructors. Adebayo and Olatunji (2025) observed that female instructors in South-West Nigeria performed better in ecology-related knowledge tests, with a mean score of 69%, compared to 62% for males. This was attributed to female instructors' high application of cooperative teaching techniques and situational examples, which enhanced their own ecological system knowledge. On the other hand, male teachers in the same experiment outperformed females in genetics questions (71% average score compared to 65%), which shows that gender-based inclinations or training histories can influence competence in specific areas of Biology.

In Ghana, Mensah (2022) reported no statistically significant gender difference in overall CK among males and females, although he established that males were likely to dominate classroom discussions on evolution and females showed better ability to explain ecological interaction. Similarly, Dlamini and Khoza (2024) in South Africa found little gender difference for knowledge of evolution where both male and female teachers struggled equally with modern evolutionary synthesis.

Kamau (2022) conducted a study in Kenya and found that male teachers had more exposure to professional training workshops on evolution and genetics, which partially explained their better performance in these subjects. However, Okoye and Ibrahim (2022) in Nigeria reported that the limited provision for continuous teacher education resulted in little discernible variation in content knowledge by gender. Studies conducted between 2020 and 2025 further corroborate that while small gender differences in content knowledge are sometimes observed, they are neither consistent across countries nor across Biology sub-disciplines. Overall, there is a general consensus that structural factors such as teacher education, resource availability, and in-service training influence teachers’ content knowledge more than gender.

Empirical Studies on Gender Issues in Teachers’ Content Knowledge

Oladele (2020) examined gender differences in mastering Biology teachers' genetics and established no statistically significant difference between male and female teachers. Both showed equal levels of proficiency of Mendelian laws, interactions of alleles, and uses of genetic probability. The study also revealed that male and female teachers differed, though, in classroom interaction styles, with male teachers being more dominant and female teachers being more nurturing. This finding is relevant to the present research since it suggests that gender will not directly affect content proficiency but may impact the mode of presentation of knowledge to learners.

On ecology instruction, Kola and Sunday (2021) indicated that male Biology instructors tended to present in class with greater confidence when instructing abstract concepts like energy flow and ecological pyramids. Yet when their content mastery was actually measured, minimal variation existed between male and female instructors. The implication of the finding for the present study is that confidence of delivery need not mirror depth of subject knowledge, i.e., gender differences in teaching style need not automatically equate with differences in actual mastery of content.

Abiola and Yusuf (2022) discovered that more female teachers showed greater content presentation in evolution-related subject matter like natural selection, adaptation, and fossil evidence. They speculated that the superiority can be explained by the fact that female teachers have a higher attention to detail and conservative explanation habits. For the present study, this is significant in that it suggests that while overall levels of content knowledge may appear to be equal across the two genders, there may still be specific areas where female teachers are indeed stronger, thereby invalidating the gender-neutral performance assumption in all areas.

Mensah and Oduro (2022) tested gender differences in content knowledge of ecology among Ghanaian Biology teachers. They mentioned that the female teachers were marginally higher in recall examinations on content such as food chains, energy transfer, and biogeochemical cycles. But the difference was not large enough to assume superiority of one gender over the other. This study is relevant to the present research because it illustrates that if gender differences in content knowledge exist at all, they are minor and context-dependent.

Eze and Ibrahim (2023) conducted a broader study of Biology teachers' content knowledge in genetics, ecology, and evolution and reached the conclusion that overall, there were no gender variations in performance. Instead, the study identified professional training, workshop exposure, and continued professional development as much stronger indicators of teachers' mastery of content than gender. This finding can be used directly in the present study because it shows that efforts to improve content knowledge should focus on training and professional development rather than gender issues.

Similarly, Dlamini and Khoza (2024) in South Africa found that postgraduate teachers were more effective instructors of evolution-related topics, as their students achieved 12% higher average pass rates than those taught by teachers with only undergraduate qualifications.

iii. Teaching Experience & Teacher's Content Knowledge

Teaching experience, the number of years a teacher has been teaching Biology at the secondary level, is typically regarded as among the more significant markers for the mastery of difficult concepts. With this assumption being that longer periods of instruction in topics such as genetics, ecology, and evolution equip teachers with more in-depth understanding and confidence. However, new evidence suggests that while greater teaching experience generally promotes mastery, its impact is heavily moderated by exposure to professional development and continuous learning opportunities.

In Nigeria, Okafor and Eze (2021) discovered that Biology teachers with fewer than five years of experience averaged 49% on a content knowledge (CK) test of genetics and ecology, and those with 6–15 years scored much higher at 64%. Those with more than 15 years of experience averaged 70% due to increased exposure to challenging concepts. Similar, Uche and Bello (2022) also recorded that experienced teachers (over 10 years) were more accurate in explaining ecological pyramids and population dynamics than novice teachers by an average of 11 percentage points.

Current studies, however, caution that experience in the absence of continuous training is likely to generate improvements only sometimes. Eze and Ibrahim (2023) established that some experienced Northern Nigerian teachers were still showing persistent misconceptions in Mendelian genetics despite over a decade of teaching practice. Their study identified that the teachers who had attended a minimum of two professional workshops in five years scored considerably higher (74%) than the ones who solely relied on teacher years (58%).

Findings from other African contexts corroborate the same trends. In Ghana, Mensah (2022) noted a greater CK score in genetics among teachers with 6–10 years of experience (71%) compared to in-experienced teachers with fewer than three years of experience (55%). However, performance tailed off after 15 years, suggesting declining returns unless alongside professional development. In Kenya, Kamau (2022) observed that teachers with experience of over 20 years performed worse on modern evolutionary synthesis than their equivalents with 10–15 years of experience, attributing this to outdated training curricula and lack of exposure to contemporary scientific developments.

There is also evidence of a subtle trend in South Africa. Dlamini and Khoza (2024) concluded that experienced teachers were more self-assured with handling classical evolutionary topics such as Darwinism, but less experienced teachers with up to five years of service were more familiar with molecular approaches to evolution, perhaps due to recent exposure at university. This suggests that experience alone may be sustaining outdated ways unless reinforced withresher training. Overall, studies between 2020 and 2025 indicate that teaching experience aids learning material to some degree, but is only optimized when teachers engage in continuous professional development. In other words, perpetual classroom practice helps teachers refine explanations of tricky Biology concepts, but without recent training, experience can serve to reinforce misunderstandings rather than overcome them.

Summary of Reviewed Related Literature

The review of the literature reaffirms that teacher content knowledge (CK) lies at the heart of effective teaching and learning. Theoretical models, as proposed by Shulman (1986), emphasize that a teacher's mastery of subject matter forms the foundation for effective teaching. Teachers with insufficient depth of knowledge cannot assist learners in developing meaningful understanding, particularly where abstract concepts are concerned.

Conceptually, the review establishes that difficult topics in Biology—especially genetics, ecology, and evolution—remain persistently problematic in secondary school teaching and learning. These topics are characterized by abstract concepts, technical terms, and complex processes, which require a high level of mastery for effective delivery. Most teachers, however, do not simplify these concepts, rendering the students vulnerable to misconceptions and poor performance.

Empirical evidence from different contexts bears witness to this challenge. Reports of research conducted in Nigeria, Ghana, Kenya, Pakistan, and the United Kingdom all indicate Biology teachers' gaps in content knowledge and how they handle difficult ideas. The studies all cite inadequate teacher knowledge as a significant source of learners' poor performance in Biology, both at the level of classroom learning and in external examinations. The review also investigated gender issues in teachers' content knowledge. The evidence is inconclusive: while there has been no difference found by some studies between male and female teachers, others have found small differences either in content mastery or pedagogy. This would mean that while gender may have a part to play in the way knowledge is communicated, it is not an automatic determining factor in Biology content mastery.

Despite these observations, there is a large gap in the literature. Although studies have been conducted abroad as well as in Nigeria, few have systematically evaluated Biology teachers' content knowledge in Edo State, particularly in genetics, ecology, and evolution. Furthermore, little attention has been given to how teacher variables such as gender, qualification, and teaching experience influence their mastery of these concepts. It is against this background that the present study tries to fill this gap by evaluating the state of Biology teachers' content knowledge in Edo State, precisely on difficult concepts in genetics, ecology, and evolution, and also examining the influences of gender, academic qualification, and teaching experience on their mastery.

CHAPTER THREE

METHODOLOGY

Introduction

This chapter presents the methodology adopted in evaluating Biology teachers' content knowledge on difficult concepts in Biology at the secondary school level. It describes the research design, population of the study, sample and sampling technique, research instrument, validity and reliability of the instrument, method of data collection, and method of data analysis.

- Introduction
- Research Design
- Population of the Study
- Sample and Sampling Technique
- Research Instrument
- Validity of the Instrument
- Reliability of the Instrument
- Method of Data Collection
- Method of Data Analysis

Research Design

The study adopted a descriptive survey research design. This design was chosen because it allows the researcher to collect data from a sample population and describe the existing conditions without manipulation of variables. It is suitable for examining how teachers' characteristics such as gender, educational qualification, and teaching experience influence their knowledge of difficult Biology concepts such as Genetics.

Population of the Study

The population of this study comprised all senior secondary school Biology teachers in public secondary schools within Egor Local Government Area of Edo State. According to data obtained from the Edo State Ministry of Education (2024), there are 17 Biology teachers currently teaching at the senior secondary school level across all public secondary schools in the area. Hence, the study population consisted of these 17 teachers.

Sample and Sampling Technique

Given that the total number of Biology teachers in Egor Local Government Area is small (17), the entire population was used as the sample for this study. This approach is referred to as a census sampling technique, where every member of the population is included to ensure complete coverage and eliminate sampling error. Therefore, all 17 Biology teachers formed the sample for this study.

Research Instrument

The main instrument used for data collection in this study was a structured questionnaire titled Biology Teachers' Content Knowledge of Difficult Concepts Questionnaire (BTCKDCQ). The questionnaire was carefully designed to capture information relevant to the study objectives to enable the quantification of teachers' responses and facilitate statistical analysis.

Validity of the Instrument

The draft questionnaire was subjected to expert review by two lecturers from the Department of Science Education and one Biology curriculum specialist. They evaluated the instrument for clarity, relevance, and alignment with the objectives of the study. Their feedback was used to refine the final questionnaire to ensure content and face validity.

Reliability of the Instrument

The responses were tested for internal consistency using Cronbach's Alpha, and the reliability coefficient obtained was 0.82. This indicates that the instrument is reliable for use in the main study.

Method of Data Collection

Permission was sought from school principals through an introductory letter from the Department of Science Education. The questionnaires were administered by the researcher with the help of trained research assistants. The teachers were assured of confidentiality and anonymity, and they were requested to provide honest responses. The entire data collection process lasted for two weeks.

Method of Data Analysis

The data collected from the respondents were coded and analyzed using the Statistical Package for the Social Sciences (SPSS) Version 25. Descriptive statistics such as frequency counts, percentages, means, and standard deviations were employed to summarize and present the responses in a clear and concise manner. In addition, inferential statistics were applied to test the stated hypotheses. The independent samples t-test was used to examine gender differences in teachers' content knowledge of difficult Biology concepts, while Analysis of Variance (ANOVA) was employed to determine the influence of educational qualifications and teaching experience on teachers' content knowledge. Furthermore, a regression model was specified to establish the combined effect of the independent variables on content knowledge.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, AND INTERPRETATION

Introduction

This chapter presents the results of the study, analyzes the data collected, and interprets the findings in line with the research objectives and questions. The analysis focuses on examining respondents' responses to each item in the questionnaire and determining the influence of demographic factors such as sex, qualification, and experience on these responses. The chapter includes descriptive statistics, frequency distributions, and inferential statistics such as t-tests and ANOVA to test the hypotheses of the study. The interpretation provided highlights patterns, trends, and significant differences in the data, offering insights into the phenomena under investigation.

Presentation of Results

Table 1: Teachers' Content Knowledge on genetics in Biology

S/N	Statement	Responses	Frequency	Percentage (%)
1.	In an organism where the 2n number of chromosomes is 16, the number of	FAIL	4	23.5

	chromosomes in each gamete will be			
		PASS	13	76.5
2.	An individual in AB blood group is a universal recipient for blood donation because	FAIL	3	17.6
		PASS	14	82.4
3.	F1 and F2 results of a monohybrid cross between pure line normal winged and short winged *Drosophila* flies, where normal wing is dominant	FAIL	5	29.4
		PASS	12	70.6
4.	Greatest contribution to genetic studies	PASS	17	100.0
5.	Exchange of genes between homologous chromosomes is called	FAIL	4	23.5
6.	When two heterozygotes mate, the dominant trait appears in	FAIL	7	41.2
		PASS	10	58.8

7.	Women do not suffer from colour blindness because	FAIL	8	47.1
		PASS	9	52.9
8.	During blood transfusion, agglutination may occur when	FAIL	6	35.3
		PASS	11	64.7
9.	If a man with colour blindness marries a normal woman, percentage of children who are sufferers, carriers, and normal	FAIL	11	64.7
		PASS	6	35.3
10.	If a woman's genotype is TtQqRr, gene content of her egg	FAIL	13	76.5
		PASS	4	23.5
11.	People with sickle cell anemia have hemoglobin	FAIL	7	41.2
		PASS	10	58.8

12.	Sons of a colourblind woman will be colourblind regardless of father because	FAIL	8	47.1
		PASS	9	52.9
13.	F1 of cross between tall & dwarf plants is tall. F2 from F1, how many of 120 plants will be dwarf	FAIL	8	47.1
		PASS	9	52.9
14.	Man with blood group A marries woman with blood group A. Possible blood groups of three children	FAIL	12	70.6
		PASS	5	29.4
15.	Character not sex-linked	FAIL	7	41.2
		PASS	10	58.8
16.	Correct increasing order of size for cell component responsible for heredity	FAIL	8	47.1
		PASS	9	52.9

17.	A sex-linked character cannot be passed directly from	FAIL	10	58.8
		PASS	7	41.2
18.	Offspring of cross between brown mouse (bb) & black mouse (BB) interbreed, number of genotypes	FAIL	11	64.7
		PASS	6	35.3
19.	Blood grouping in humans is derived from combination of	FAIL	6	35.3
		PASS	11	64.7
20.	Both recessive and dominant characters are found	FAIL	8	47.1
		PASS	9	52.9
21.	The first four children of the couple are all girls. Probability fifth child will also be a girl	FAIL	6	35.3
		PASS	11	64.7
22.	Genetic counseling is important when marriage	FAIL	8	47.1

	is planned between			
		PASS	9	52.9
23.	Proportion of offspring from two heterozygous parents exhibiting recessive phenotype	FAIL	13	76.5
		PASS	4	23.5
24.	DNA strand TCA, complementary strand is	FAIL	10	58.8
		PASS	7	41.2
25.	Man & wife both heterozygous for sickle cell trait, percentage of offspring that are carriers or sticklers	FAIL	9	52.9
		PASS	8	47.1
26.	If the pair of alleles for badness is given Bb, a female carrier will be denoted as	FAIL	7	41.2
		PASS	10	58.8
27.	Sex-linked genes are located	FAIL	7	41.2
		PASS	10	58.8

28.	Mendelian cross of red & white varieties of four o'clock plants, F1 shows incomplete dominance (flower colour)	FAIL	5	29.4
		PASS	12	70.6
29.	Yellow maize planted; all fruits yellow seeds. Crossbred, 3 yellow	FAIL	3	17.6
		PASS	14	82.4
Total		FAIL	31	36.5
		PASS	54	63.5

From Table 1, analysis of items 1 through 30 shows that Biology teachers demonstrated mixed levels of mastery of difficult genetic concepts. Performance varied widely across topics, revealing areas of strength and notable knowledge gaps.

Teachers performed best on items involving basic Mendelian genetics, simple crosses, and blood group inheritance. Items 2, 8, 12, 20, 29, and 30 recorded the highest pass rates (above 58%), indicating that most teachers understand fundamental inheritance patterns, blood transfusion compatibility, sickle-cell hemoglobin, and dominance relationships. These results suggest that teachers are generally comfortable with concepts that are routinely taught in the Biology curriculum.

However, several items recorded high failure rates, especially those requiring advanced reasoning or application of multiple genetic principles. Items 11, 15, 18, 19, 24, and 26 had failure rates above 50–76%, showing weak understanding of dihybrid and multigene inheritance, prediction of genotypic ratios, and interpretation of human genetic traits such as sickle-cell carriers and blood group outcomes. These areas appear to be the most challenging for teachers.

Some items (e.g., 7, 9, 10, 13, 17, 21, and 23) showed moderate performance, with teachers demonstrating partial but inconsistent understanding of sex-linked inheritance, Mendelian ratios, and hereditary components. This indicates that while teachers may know theoretical concepts, many struggle with applying them correctly in problem-solving situations.

Overall, the findings indicate that Biology teachers generally possess adequate knowledge of difficult concepts in Genetics, as shown by the overall pass rate of 63%. While some questions revealed weaknesses—especially in multi-gene inheritance and applied human genetic prediction—the majority of teachers demonstrated satisfactory understanding of core genetic principles. This shows that teachers are reasonably grounded in Genetics, and only specific complex areas require targeted professional development to further strengthen their competence.

Table 2: Relationship between Teacher's content knowledge on genetics and sex

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
ITEM1	Equal variances assumed	.188	.671	.208	15	.838	.05000	.24002	-.46160	.56160

	Equal variances not assumed			.209	7.632	.840	.05000	.23884	-.50543	.60543
ITEM2	Equal variances assumed	8.281	.012	-1.584	15	.134	-.31667	.19995	-.74286	.10952
	Equal variances not assumed			-1.224	4.955	.276	-.31667	.25874	-.98358	.35024
ITEM3	Equal variances assumed	.956	.344	-.588	15	.566	-.15000	.25528	-.69411	.39411
	Equal variances not assumed			-.540	6.408	.607	-.15000	.27757	-.81886	.51886

ITEM5	Equal variances assumed	2.745	.118	-1.003	15	.332	-.23333	.23270	-.72932	.26265
	Equal variances not assumed			-.866	5.768	.421	-.23333	.26949	-.89925	.43258
ITEM6	Equal variances assumed	5.956	.028	1.120	15	.280	.30000	.26791	-.27104	.87104
	Equal variances not assumed			1.198	8.803	.262	.30000	.25045	-.26850	.86850
ITEM7	Equal variances assumed	.015	.903	-.657	15	.521	-.18333	.27885	-.77770	.41103

	Equal variances not assumed			-.640	7.137	.542	-.18333	.28652	-.85823	.49157
ITEM8	Equal variances assumed	.194	.666	-.247	15	.808	-.06667	.27025	-.64270	.50937
	Equal variances not assumed			-.235	6.864	.821	-.06667	.28320	-.73902	.60569
ITEM9	Equal variances assumed	3.959	.065	-.818	15	.426	-.21667	.26496	-.78142	.34808
	Equal variances not assumed			-.869	8.677	.408	-.21667	.24919	-.78359	.35026

ITEM10	Equal variances assumed	.441	.517	-.355	15	.728	-.10000	.28166	-.70035	.50035
	Equal variances not assumed			-.348	7.227	.738	-.10000	.28762	-.77581	.57581
ITEM11	Equal variances assumed	.188	.671	-.208	15	.838	-.05000	.24002	-.56160	.46160
	Equal variances not assumed			-.209	7.632	.840	-.05000	.23884	-.60543	.50543
ITEM12	Equal variances assumed	.188	.671	-2.291	15	.037	-.55000	.24002	-1.06160	-.03840

	Equal variances not assumed			-2.303	7.632	.052	-.55000	.23884	-1.10543	.00543
ITEM13	Equal variances assumed	.015	.903	-.657	15	.521	-.18333	.27885	-.77770	.41103
	Equal variances not assumed			-.640	7.137	.542	-.18333	.28652	-.85823	.49157
ITEM14	Equal variances assumed	.015	.903	-.657	15	.521	-.18333	.27885	-.77770	.41103
	Equal variances not assumed			-.640	7.137	.542	-.18333	.28652	-.85823	.49157

ITEM15	Equal variances assumed	2.745	.118	1.862	15	.082	.43333	.23270	-.06265	.92932
	Equal variances not assumed			1.608	5.768	.161	.43333	.26949	-.23258	1.09925
ITEM16	Equal variances assumed	.188	.671	-2.291	15	.037	-.55000	.24002	-1.06160	-.03840
	Equal variances not assumed			-2.303	7.632	.052	-.55000	.23884	-1.10543	.00543
ITEM17	Equal variances assumed	.441	.517	.355	15	.728	.10000	.28166	-.50035	.70035

	Equal variances not assumed			.348	7.227	.738	.10000	.28762	-.57581	.77581
ITEM18	Equal variances assumed	154.412	.000	-2.485	15	.025	-.58333	.23472	-1.08362	-.08304
	Equal variances not assumed			-3.924	11.000	.002	-.58333	.14865	-.91050	-.25616
ITEM19	Equal variances assumed	3.959	.065	-.818	15	.426	-.21667	.26496	-.78142	.34808
	Equal variances not assumed			-.869	8.677	.408	-.21667	.24919	-.78359	.35026

ITEM20	Equal variances assumed	.194	.666	-.247	15	.808	-.06667	.27025	-.64270	.50937
	Equal variances not assumed			-.235	6.864	.821	-.06667	.28320	-.73902	.60569
ITEM21	Equal variances assumed	1.403	.255	-1.824	15	.088	-.46667	.25589	-1.01209	.07876
	Equal variances not assumed			-1.902	8.292	.092	-.46667	.24536	-1.02903	.09569
ITEM22	Equal variances assumed	.092	.766	-2.934	15	.010	-.63333	.21585	-1.09341	-.17325

	Equal variances not assumed			-2.761	6.682	.029	-.63333	.22940	-1.18107	-.08560
ITEM23	Equal variances assumed	.015	.903	-.657	15	.521	-.18333	.27885	-.77770	.41103
	Equal variances not assumed			-.640	7.137	.542	-.18333	.28652	-.85823	.49157
ITEM24	Equal variances assumed	2.745	.118	1.003	15	.332	.23333	.23270	-.26265	.72932
	Equal variances not assumed			.866	5.768	.421	.23333	.26949	-.43258	.89925

ITEM25	Equal variances assumed	.194	.666	.987	15	.339	.26667	.27025	-.30937	.84270
	Equal variances not assumed			.942	6.864	.378	.26667	.28320	-.40569	.93902
ITEM26	Equal variances assumed	.441	.517	-.355	15	.728	-.10000	.28166	-.70035	.50035
	Equal variances not assumed			-.348	7.227	.738	-.10000	.28762	-.77581	.57581
ITEM27	Equal variances assumed	5.956	.028	1.120	15	.280	.30000	.26791	-.27104	.87104

	Equal variances not assumed			1.198	8.803	.262	.30000	.25045	-.26850	.86850
ITEM28	Equal variances assumed	.015	.903	.060	15	.953	.01667	.27885	-.57770	.61103
	Equal variances not assumed			.058	7.137	.955	.01667	.28652	-.65823	.69157
ITEM29	Equal variances assumed	.956	.344	-.588	15	.566	-.15000	.25528	-.69411	.39411
	Equal variances not assumed			-.540	6.408	.607	-.15000	.27757	-.81886	.51886

ITEM30	Equal variances assumed	.092	.766	-.154	15	.879	-.03333	.21585	-.49341	.42675
	Equal variances not assumed			-.145	6.682	.889	-.03333	.22940	-.58107	.51440

The Independent Samples t-test examined whether male and female biology teachers differed significantly in their scores on genetics items. For most items (1–11, 13–17, 19–21, and 23–30), the Sig. values were above 0.05, meaning there was no significant difference between male and female teachers. This shows that both groups performed similarly across the majority of genetics concepts.

However, four items—ITEM12, ITEM16, ITEM18, and ITEM22—showed Sig. values below 0.05, indicating a statistically significant difference. In these items, female teachers had higher mean scores than male teachers, suggesting better understanding of those specific concepts.

Overall, the results show that sex does not substantially influence teachers' content knowledge on difficult genetics concepts, although female teachers demonstrated a slight edge on a few individual items. Both groups generally possess comparable levels of knowledge.

Table 3: Teacher's Content Knowledge on Genetics and Educational Qualification Biology

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
ITEM1	Between Groups	.170	2	.085	.412	.670
	Within Groups	2.889	14	.206		
	Total	3.059	16			
ITEM2	Between Groups	.971	2	.485	4.529	.030

	Within Groups	1.500	14	.107		
	Total	2.471	16			
ITEM3	Between Groups	.474	2	.237	1.086	.365
	Within Groups	3.056	14	.218		
	Total	3.529	16			
ITEM4	Between Groups	.000	2	.000	.	.
	Within Groups	.000	14	.000		
	Total	.000	16			
ITEM5	Between Groups	1.059	2	.529	3.706	.051
	Within Groups	2.000	14	.143		
	Total	3.059	16			
ITEM6	Between Groups	.784	2	.392	1.647	.228
	Within Groups	3.333	14	.238		
	Total	4.118	16			
ITEM7	Between Groups	.402	2	.201	.734	.498

	Within Groups	3.833	14	.274		
	Total	4.235	16			
ITEM8	Between Groups	2.160	2	1.080	8.780	.003
	Within Groups	1.722	14	.123		
	Total	3.882	16			
ITEM9	Between Groups	1.660	2	.830	5.229	.020
	Within Groups	2.222	14	.159		
	Total	3.882	16			
ITEM10	Between Groups	.013	2	.007	.022	.979
	Within Groups	4.222	14	.302		
	Total	4.235	16			
ITEM11	Between Groups	.225	2	.113	.557	.585
	Within Groups	2.833	14	.202		
	Total	3.059	16			
ITEM12	Between Groups	.784	2	.392	1.647	.228

	Within Groups	3.333	14	.238		
	Total	4.118	16			
ITEM13	Between Groups	.402	2	.201	.734	.498
	Within Groups	3.833	14	.274		
	Total	4.235	16			
ITEM14	Between Groups	.680	2	.340	1.338	.294
	Within Groups	3.556	14	.254		
	Total	4.235	16			
ITEM15	Between Groups	.141	2	.070	.290	.752
	Within Groups	3.389	14	.242		
	Total	3.529	16			
ITEM16	Between Groups	1.895	2	.948	5.971	.013
	Within Groups	2.222	14	.159		
	Total	4.118	16			
ITEM17	Between Groups	.013	2	.007	.022	.979

	Within Groups	4.222	14	.302		
	Total	4.235	16			
ITEM18	Between Groups	1.618	2	.809	4.529	.030
	Within Groups	2.500	14	.179		
	Total	4.118	16			
ITEM19	Between Groups	1.160	2	.580	2.983	.083
	Within Groups	2.722	14	.194		
	Total	3.882	16			
ITEM20	Between Groups	.993	2	.497	2.407	.126
	Within Groups	2.889	14	.206		
	Total	3.882	16			
ITEM21	Between Groups	1.346	2	.673	3.262	.069
	Within Groups	2.889	14	.206		
	Total	4.235	16			
ITEM22	Between Groups	.993	2	.497	2.407	.126

	Within Groups	2.889	14	.206		
	Total	3.882	16			
ITEM23	Between Groups	.402	2	.201	.734	.498
	Within Groups	3.833	14	.274		
	Total	4.235	16			
ITEM24	Between Groups	.170	2	.085	.412	.670
	Within Groups	2.889	14	.206		
	Total	3.059	16			
ITEM25	Between Groups	.562	2	.281	1.107	.358
	Within Groups	3.556	14	.254		
	Total	4.118	16			
ITEM26	Between Groups	.513	2	.257	.965	.405
	Within Groups	3.722	14	.266		
	Total	4.235	16			
ITEM27	Between Groups	.062	2	.031	.107	.899

	Within Groups	4.056	14	.290		
	Total	4.118	16			
ITEM28	Between Groups	.562	2	.281	1.107	.358
	Within Groups	3.556	14	.254		
	Total	4.118	16			
ITEM29	Between Groups	.641	2	.320	1.552	.246
	Within Groups	2.889	14	.206		
	Total	3.529	16			
ITEM30	Between Groups	.248	2	.124	.782	.476
	Within Groups	2.222	14	.159		
	Total	2.471	16			

The ANOVA analysis was conducted to examine whether teachers' qualifications influenced their responses to the 30-item genetics questionnaire. The results show that for most items, there were no significant differences across qualification levels ($p > 0.05$), indicating that qualifications generally did not affect overall performance. For example, ITEM1 (F = 0.412, p = 0.670) and ITEM3 (F = 1.086, p = 0.365) demonstrated no significant variation.

However, a few items—ITEM2 (F = 4.529, p = 0.030), ITEM8 (F = 8.780, p = 0.003), ITEM9 (F = 5.229, p = 0.020), ITEM16 (F = 5.971, p = 0.013), and ITEM18 (F = 4.529, p = 0.030)—showed significant differences, suggesting that teachers with higher or different qualifications performed better on these specific concepts.

Overall, while qualification does not consistently affect teachers' content knowledge in genetics, it may provide an advantage on certain challenging items, highlighting areas for targeted professional development.

Table 4: Teacher's Content Knowledge on Genetics and Experience

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
ITEM1	Between Groups	.042	2	.021	.098	.907
	Within Groups	3.017	14	.215		
	Total	3.059	16			
ITEM2	Between Groups	.204	2	.102	.630	.547
	Within Groups	2.267	14	.162		

	Total	2.471	16			
ITEM3	Between Groups	.463	2	.231	1.056	.374
	Within Groups	3.067	14	.219		
	Total	3.529	16			
ITEM4	Between Groups	.000	2	.000	.	.
	Within Groups	.000	14	.000		
	Total	.000	16			
ITEM5	Between Groups	.742	2	.371	2.242	.143
	Within Groups	2.317	14	.165		
	Total	3.059	16			
ITEM6	Between Groups	1.718	2	.859	5.010	.023
	Within Groups	2.400	14	.171		
	Total	4.118	16			
ITEM7	Between Groups	.419	2	.209	.768	.483
	Within Groups	3.817	14	.273		
	Total	4.235	16			
ITEM8	Between Groups	1.532	2	.766	4.564	.030
	Within Groups	2.350	14	.168		
	Total	3.882	16			
ITEM9	Between Groups	2.282	2	1.141	9.985	.002

	Within Groups	1.600	14	.114		
	Total	3.882	16			
ITEM10	Between Groups	.169	2	.084	.290	.752
	Within Groups	4.067	14	.290		
	Total	4.235	16			
ITEM11	Between Groups	.459	2	.229	1.235	.321
	Within Groups	2.600	14	.186		
	Total	3.059	16			
ITEM12	Between Groups	.951	2	.475	2.102	.159
	Within Groups	3.167	14	.226		
	Total	4.118	16			
ITEM13	Between Groups	.169	2	.084	.290	.752
	Within Groups	4.067	14	.290		
	Total	4.235	16			
ITEM14	Between Groups	1.169	2	.584	2.668	.104
	Within Groups	3.067	14	.219		
	Total	4.235	16			
ITEM15	Between Groups	.263	2	.131	.563	.582
	Within Groups	3.267	14	.233		
	Total	3.529	16			

ITEM16	Between Groups	.351	2	.175	.652	.536
	Within Groups	3.767	14	.269		
	Total	4.118	16			
ITEM17	Between Groups	.419	2	.209	.768	.483
	Within Groups	3.817	14	.273		
	Total	4.235	16			
ITEM18	Between Groups	.968	2	.484	2.150	.153
	Within Groups	3.150	14	.225		
	Total	4.118	16			
ITEM19	Between Groups	.482	2	.241	.993	.395
	Within Groups	3.400	14	.243		
	Total	3.882	16			
ITEM20	Between Groups	.066	2	.033	.120	.887
	Within Groups	3.817	14	.273		
	Total	3.882	16			
ITEM21	Between Groups	.419	2	.209	.768	.483
	Within Groups	3.817	14	.273		
	Total	4.235	16			
ITEM22	Between Groups	.866	2	.433	2.009	.171
	Within Groups	3.017	14	.215		

	Total	3.882	16			
ITEM23	Between Groups	.069	2	.034	.115	.892
	Within Groups	4.167	14	.298		
	Total	4.235	16			
ITEM24	Between Groups	.042	2	.021	.098	.907
	Within Groups	3.017	14	.215		
	Total	3.059	16			
ITEM25	Between Groups	.968	2	.484	2.150	.153
	Within Groups	3.150	14	.225		
	Total	4.118	16			
ITEM26	Between Groups	.319	2	.159	.569	.578
	Within Groups	3.917	14	.280		
	Total	4.235	16			
ITEM27	Between Groups	.618	2	.309	1.235	.321
	Within Groups	3.500	14	.250		
	Total	4.118	16			
ITEM28	Between Groups	.618	2	.309	1.235	.321
	Within Groups	3.500	14	.250		
	Total	4.118	16			
ITEM29	Between Groups	.263	2	.131	.563	.582

	Within Groups	3.267	14	.233		
	Total	3.529	16			
ITEM30	Between Groups	.571	2	.285	2.102	.159
	Within Groups	1.900	14	.136		
	Total	2.471	16			

The ANOVA analysis was conducted to determine whether respondents' years of experience significantly influenced their responses to the thirty items in the questionnaire. This analysis compares variation in responses between different experience groups with variation within each group to assess whether experience has a statistically significant effect.

The results indicate that, for most items, experience does not have a significant effect on respondents' answers. Specifically, items ITEM1, ITEM2, ITEM3, ITEM4, ITEM5, ITEM7, ITEM10, ITEM11, ITEM12, ITEM13, ITEM14, ITEM15, ITEM16, ITEM17, ITEM18, ITEM19, ITEM20, ITEM21, ITEM22, ITEM23, ITEM24, ITEM25, ITEM26, ITEM27, ITEM28, ITEM29, and ITEM30 all had p-values greater than 0.05. This suggests that respondents' level of experience did not significantly influence their responses to these items, indicating general consistency across experience groups.

However, a few items demonstrated statistically significant differences based on experience. ITEM6 ($p = 0.023$), ITEM8 ($p = 0.030$), and ITEM9 ($p = 0.002$) had p-values below the 0.05 threshold, indicating that responses to these items were significantly influenced by respondents' experience levels. In these cases, individuals with different experience levels likely perceive or respond to the questions differently, possibly due to their practical exposure or familiarity with the subject matter.

Overall, the analysis shows that teaching experience does not significantly affect responses for the majority of questionnaire items. This indicates that most genetics concepts are uniformly understood by teachers regardless of their years of experience. Only a few items showed minor differences, suggesting that practical experience may offer a slight advantage in specific cases, but generally, experience does not influence teachers' content knowledge in this study.

Interpreting Hypotheses Based on The Tables

SEX (t-test and ANOVA results)

- Most items (e.g., ITEM1, ITEM3, ITEM5, etc.) have p-values > 0.05 → fail to reject H_0 → gender does not significantly influence responses.
- Some items (e.g., ITEM12, ITEM18, ITEM22) have p-values < 0.05 → reject H_0 → gender significantly influences responses.

- Interpretation: Gender matters for a few items but not for the majority, suggesting that male and female respondents generally answered similarly.

QUALIFICATION (ANOVA results)

- *Many items (e.g., ITEM1, ITEM3, ITEM5) have p-values > 0.05 → fail to reject H_0 → qualification does not significantly affect responses.*
- *Some items (e.g., ITEM2, ITEM8, ITEM9, ITEM16, ITEM18) have p-values < 0.05 → reject H_0 → qualification significantly affects responses.*
- Interpretation: Respondents' level of education influences performance on a few challenging items, but overall, qualification does not substantially affect content knowledge in genetics.

EXPERIENCE (ANOVA results)

- *Most items (e.g., ITEM1, ITEM2, ITEM3, ITEM4) have p-values > 0.05 → fail to reject H_0 → experience does not significantly affect responses.*

- Some items (e.g., ITEM6, ITEM8, ITEM9) have p-values < 0.05 → reject H_0 → experience significantly affects responses.
- Interpretation: Experience has little effect on the majority of items, indicating that teachers' years of teaching do not substantially influence their mastery of genetics concepts, though minor differences exist on select items likely due to practical familiarity**.**

Discussion of Findings

RQ1: To what extent do teachers possess adequate content knowledge of genetics?

The analysis of teachers' responses to items 1 through 30 revealed mixed levels of mastery of difficult genetic concepts. Teachers generally performed well on items involving basic Mendelian genetics, simple crosses, and blood group inheritance, with pass rates above 58% for items 2, 8, 12, 20, 29, and 30. These results indicate that teachers have a sound understanding of fundamental inheritance patterns, dominance relationships, blood transfusion compatibility, and sickle-cell hemoglobin. This aligns with prior findings by Adeyemo and Akinola (2024), who reported that Nigerian Biology teachers were confident in teaching foundational genetic concepts. Similarly, Anyanwu and Eze (2020) emphasized that teachers can adequately handle core Mendelian inheritance topics, while Nwagbo and Okeke (2020) found that teachers demonstrated reasonable knowledge of basic genetics, though gaps exist in more complex areas.

However, items requiring advanced reasoning or application of multiple genetic principles—such as ITEM11, ITEM15, ITEM18, ITEM19, ITEM24, and ITEM26—recorded high failure rates, between 50–76%. These included dihybrid and multigene inheritance, prediction of genotypic ratios, and interpretation of human genetic traits, highlighting gaps in teachers' applied knowledge. Partial understanding was observed in items such as 7, 9, 10, 13, 17, 21, and 23, indicating inconsistent mastery of sex-linked inheritance and Mendelian ratios.

Overall, the findings suggest that while teachers demonstrate adequate content knowledge of core genetics concepts (overall pass rate of 63%), specific complex areas require targeted professional development. This observation confirms Shulman's (1986) assertion that teachers' mastery of subject matter underpins effective teaching. Adeyemi (2021) also emphasized that inadequate mastery of high-level genetic content among experienced teachers contributes to students' misconceptions and poor performance. Similarly, Eze and Ibrahim (2023) and Ndirika and Okorie (2022) found that teachers' knowledge gaps in advanced genetics directly affect the quality of instruction and students' learning outcomes.

RQ2: Does teachers' content knowledge of genetics significantly differ based on sex?

Analysis of gender differences revealed that for most items, there were no significant differences ($p > 0.05$). Only ITEM12, ITEM18, and ITEM22 showed significant differences, suggesting that gender influences performance in isolated areas but not overall mastery. This corroborates the findings of Uche and Bello (2022), who reported that although male teachers may be slightly more confident in teaching Mendelian genetics, their actual knowledge is comparable to female teachers. Similarly, Oladele (2020) found no significant gender differences in teachers' content knowledge, indicating that confidence does not necessarily translate into better understanding.

The isolated items showing gender differences may reflect differences in prior exposure or specialization rather than innate ability. Adebayo and Olatunji (2025) reported minor variations, with males slightly better in applied genetics and females slightly better in theoretical interpretation. Overall, the study suggests that gender is not a major determinant of content knowledge in genetics, and interventions should target both male and female teachers equally to strengthen mastery in difficult areas.

RQ3: Does teachers' content knowledge of genetics significantly differ based on educational qualifications?

Teachers' educational qualifications had little impact on most items ($p > 0.05$), though some items—ITEM2, ITEM8, ITEM9, ITEM16, ITEM18—showed significant differences. Higher qualifications appeared to enhance performance on challenging or applied genetics items, but did not uniformly affect all areas of mastery.

This aligns with findings by Ndirika and Okorie (2022) and Oduro and Mensah (2022), who reported that teachers with advanced degrees generally perform better in molecular genetics and probability-based inheritance questions. Adeyemo and Akinola (2024) similarly noted that teachers with higher qualifications demonstrate stronger understanding of dihybrid crosses and applied genetics. Nevertheless, Eze and Ibrahim (2023) emphasized that advanced qualifications alone are insufficient for ensuring mastery of all complex genetic topics, highlighting the need for ongoing professional development to supplement formal education.

RQ4: Does teachers' content knowledge of genetics significantly differ based on teaching experience?

Analysis showed that years of teaching experience had minimal effect on most items ($p > 0.05$), though items such as ITEM6, ITEM8, and ITEM9 revealed significant differences. Experienced teachers sometimes performed better on applied questions, likely due to familiarity with classroom problem-solving, but overall, experience did not guarantee comprehensive mastery.

This finding is consistent with Adeyemo (2021) and Eze and Ibrahim (2023), who observed that even teachers with over ten years of experience often struggle with multi-gene inheritance and probability applications. Dlamini and Khoza (2024) reported similar patterns in South Africa, where experienced teachers were competent in classical genetics but less proficient in recent scientific developments.

However, the findings contradict Nwankwo (2018), who asserted that experienced teachers consistently perform better on all levels of genetics assessment. The current study suggests otherwise, showing that experience without retraining does not ensure mastery of advanced topics. Hence, the results demonstrate that teaching experience alone does not significantly improve teachers' mastery of difficult Biology concepts, especially complex genetics.

In summary, the findings collectively indicate that teachers' content knowledge in genetics is adequate for core Mendelian concepts but weak in advanced areas such as dihybrid crosses, multigene inheritance, and applied human genetics. Gender differences are minimal and largely inconsequential, while higher qualifications and teaching experience provide limited advantages only on specific challenging items.

These results underscore the need for structured professional development programs targeting difficult areas of genetics, as well as the importance of continuous learning to supplement both formal qualifications and classroom experience. In accordance with Shulman's (1986) content knowledge theory, mastery of subject matter is essential for effective teaching and for minimizing student misconceptions. Previous studies by Adeyemo and Akinola (2024), Eze and Ibrahim (2023), and Ndirika and Okorie (2022) further support this conclusion, demonstrating that teachers' content knowledge directly influences the quality of instruction and students' learning outcomes in genetics.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary of Findings

This study was carried out due to persistent challenges in teaching Genetics in secondary schools, with evidence suggesting gaps in teachers' mastery of complex concepts. The purpose was to examine Biology teachers' content knowledge of Genetics and explore the influence of sex, educational qualifications, and teaching experience.

Data were collected using a structured questionnaire and analyzed using t-tests and ANOVA to determine differences across demographic factors, with emphasis on identifying areas where teachers demonstrated strength or struggled. It also explored whether sex, qualification, and teaching experience influenced teachers' performance.

Overall, findings show that teachers possess strong mastery of foundational Biology concepts, especially topics that are frequently taught and assessed in school settings. Items related to basic inheritance patterns, blood group compatibility, and simple genetic crosses recorded high correct responses, indicating confidence in handling straightforward biological ideas. This aligns with studies such as Akinyemi & Alabi (2023) and Okeke (2020), who also reported strong teacher competence in foundational concepts.

In contrast, teachers displayed moderate understanding on items requiring deeper reasoning—such as sex-linked traits, dihybrid ratios, and the roles of cellular components in heredity. Responses were almost evenly split between correct and incorrect choices, suggesting challenges in transferring theoretical knowledge to application-based problems. This supports findings by Eze and Oladipo (2019), who noted that teachers often recall theory but struggle with applied tasks.

More importantly, the study found significant gaps in advanced and applied genetics, particularly in predicting gametes from complex genotypes, identifying carriers in genetic disorders, and interpreting inherited traits in real-life contexts. These results agree with Okafor and Ibe (2021), who identified weaknesses in teachers' applied genetics knowledge.

Regarding demographic factors, sex did not significantly influence teachers' performance. Qualification showed a positive effect on mastery of difficult items, as teachers with higher academic qualifications performed better. Years of teaching experience had a mild but inconsistent effect across concepts.

Overall, the pattern indicates that teachers are strong in basic concepts, moderate in mid-level theory, but limited in advanced and applied biological reasoning, pointing to the need for structured professional support.

Conclusion

Based on the findings this study concludes that Biology teachers generally have adequate mastery of foundational concepts but exhibit notable deficiencies in complex and applied topics, especially in genetics. While qualification and experience contribute positively to content knowledge, their influence is not uniform across all areas. Addressing these gaps is essential for improving classroom instruction and enhancing students' understanding of Biology.

Recommendations

In light of the findings and conclusions, the following recommendations are proposed:

- Targeted Professional Development: Workshops, seminars, and refresher programs should be organized focusing on complex and problem-based Biology topics.
- Improved Curriculum Support: Teachers should be provided with detailed guides, models, illustrations, and simplified resources for teaching abstract concepts.

- Peer Mentorship: Schools should encourage collaborative teaching, where experienced teachers support colleagues struggling with specific concepts.
- Regular Assessment of Teacher Knowledge: Continuous evaluation can help identify weaknesses and guide tailored training interventions.
- Use of Practical and Interactive Approaches: Incorporating experiments, demonstrations, and real-life examples will aid deeper understanding of difficult topics.
- Further Inquiry: Additional studies should evaluate how teacher knowledge influences student outcomes and test effective strategies for teaching challenging Biology concepts.

Suggestions for Further Studies

Future research should explore:

- The effect of teachers’ content knowledge on students’ academic performance and interest in Biology.

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APPENDIX

Questionnaire on Biology Teachers' Content Knowledge of Difficult Concepts (BTCKDCQ) Note: This questionnaire is designed purely for research purposes on the topic:

"An Evaluation of Biology Teachers' Content Knowledge on Difficult Concepts in Biology: Genetics"

Responses will be kept confidential and used only for academic purposes. Kindly answer honestly.

Section A: Demographic Information

Please tick (✓) the option that applies to you.

1. Sex

☐ Male ☐ Female

2. Highest Educational Qualification

☐ NCE ☐ B.Ed. / B.Sc. (Ed) ☐ M.Ed. / M.Sc. (Ed) ☐ Ph.D.

3. Teaching Experience

☐ Less than 5 years ☐ 5–10 years ☐ 11–15 years ☐ Above 15 years

Section B: Achievement Test (Genetics)

Instruction: Choose the one correct option (A–D).

1. In an organism where the 2n number of chromosomes is 16, the number of chromosomes in each gamete will be:

A. 32 (B) 16

C. 8 (D) 4

2. An individual in AB blood group is a universal recipient for blood donation because:

A. All the red blood cells do not carry antigen B

B. All the red blood cells carry antigen A

C. All the red blood cells carry antigen B

D. There are no antigen A and antigen B bodies in the serum

3. F1 and F2 results of a monohybrid cross between pure line normal winged and short winged Drosophila flies, where normal wing is dominant:

A. F1 all short winged; F2 all short winged

B. F1 all normal winged; F2 all short winged

C. F1 all short winged; three-quarter of F2 short winged

D. F1 all normal winged; three-quarter of F2 normal winged

4. Greatest contribution to genetic studies:

A. Thomas Morgan (B) Gregor Mendel

C. Charles Darwin (D) Robert Hooke

5. Exchange of genes between homologous chromosomes is called:

A. Test cross B. Back cross

C. Crossing over D. Mutation

6. When two heterozygotes mate, the dominant trait appears in:

A. The F1 generation only. (B) The F2 generation only

C. Both F1 & F2. (D.) Neither F1 nor F2

7. Women do not suffer from color blindness because:

A. The trait is sex-linked

B. Only men are color blind

C. The genes are recessive and sex-linked

D. The gene occurs on both X and Y chromosomes

8. During blood transfusion, agglutination may occur when:

A. Contrasting antigens react with contrasting antibodies

B. Similar antigens react with contrasting antibodies

C. Two different antigens react with each other

D. Two different antibodies react with each other

9. If a man with color blindness marries a normal woman, what percentage of children will be sufferers, carriers, and normal in f2 generation;

A. 25% & 50% (B) 25%, 50%, 25%

C. 50%, 25%, 25% (D). 25%, 37.5%, 37.5%

10. Sex-linked defect in which a slight cut produces severe bleeding:

A. Anemia (B). Anorexia

C. Hemophilia (D) Hemolysis

11. If a woman's genotype is TtQqRr, gene content of her egg:

A. TQr, tqr (B). TQR, tqr

C. TqR, tQr (D). tQr, TQR

12. People with sickle cell anemia have hemoglobin:

A. A and are homozygous recessive

B. A and are heterozygous recessive

C. S and are homozygous recessive

D. A and are homozygous recessive

13. Sons of a colorblind woman will be colorblind regardless of father because:

A. The egg determines the phenotype of the son

B. Sons inherit X chromosome of mother

C. The father's sex chromosome is weaker in sons

D. Sex-linked traits express dominance in females

14. F1 of cross between tall & dwarf plants is tall. F2 from F1, how many of 120 plants will be dwarf:

A. 30 B. 60

C. 90 D. 120

15. Man with blood group A marries woman with blood group A. Possible blood groups of three children:

A. B, A, AB (B). O, A, B

C. B, AB, AB. (D). A, O, A

16. Character not sex-linked:

A. Albinism B. Badness

C. Hemophilia D. Colorblindness

17. Correct increasing order of size for cell component responsible for heredity:

A. Chromosome, DNA, Nucleus, Gene (B)DNA, Gene, Chromosome, Nucleus

C. Chromosome, Nucleus, DNA, Gene (D) DNA, Gene, Nucleus, Chromosomes

18. A sex-linked character cannot be passed directly from:

A. Father to son B. Mother to daughter

C. Mother to son D. Father to daughter

19. Offspring of cross between brown mouse (bb) & black mouse (BB) interbreed, number of genotypes:

A. 2 B. 3

C. 4 D. 5

20. Blood grouping in humans is derived from combination of:

A. Two different alleles B. Four different alleles

C. Three different alleles D. Two different genes

21. Both recessive and dominant characters are found:

A. At the same locus of homologous chromosome

B. At different locus of homologous chromosome

C. On different chromosomes in the cell

D. On the same chromatid in a chromosome

22. The first four children of the couple are all girls. Probability fifth child will also be a girl:

A. $1/3$ B. 1/2

C. $1/5$ D. 1/4

23. Genetic counseling is important when marriage is planned between:

A. RH- woman & RH- man B. RH- woman & RH+ man

C. RH+ woman & RH- man D. RH+ woman & RH+ man

24. Proportion of offspring from two heterozygous parents exhibiting recessive phenotype:

A. 4/4 B. 3/4

C. ½ D. 1/4

25. DNA strand TCA, complementary strand is:

A. ATG B. AGT

C. CAG D. GAT

26. Man & wife both heterozygous for sickle cell trait, percentage of offspring that are carriers or Sickler's:

A. 75% B. 50%

C. 25% D. 100%

27. If the pair of alleles for badness is given Bb, a female carrier will be denoted as:

A. X^bY. B. X^BY^B

C. X^BY D. X^BY^b

28. Sex-linked genes are located:

A. Y-chromosome (B). X- & Y-chromosomes

C. Homologous chromosomes (D) X-chromosome

29. Mendelian cross of red & white varieties of four o'clock plants, F1 shows incomplete dominance (flower color):

A. White (B)Red

C. Pink (D.) Multicolored

30. Yellow maize planted; all fruits yellow seeds. Crossbred, 3 yellow: 1 white. Yellow seed is:

A. Non-heritable (B). Sex-linked

C. An excessive trait (D). A dominant trait