BIOLOGY TEACHERS' CONTENT KNOWLEDGE ON THE CONCEPT OF ECOLOGY IN BIOLOGY

Blessing EFE
EDU2101998

DEPARTMENT OF CURRICULUM AND INSTRUCTIONAL TECHNOLOGY
FACULTY OF EDUCATION
UNIVERSITY OF BENIN
BENIN CITY

NOVEMBER, 2025

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A PROJECT SUBMITTED TO THE DEPARTMENT OF CURRICULUM AND INSTRUCTIONAL TECHNOLOGY, FACULTY OF EDUCATION, UNIVERSITY OF BENIN, BENIN CITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE EDUCATION DEGREE B.Sc. Ed. IN BIOLOGY.

NOVEMBER, 2025

CERTIFICATION

We, the undersigned, certify that this project is adequate in scope and was carried out by **Blessing EFE** with matriculation number **EDU2101998** in the Department of Curriculum and Instructional Technology, Faculty of Education, University of Benin, Benin City, Edo State, Nigeria. In partial fulfilment for the award of B.Sc. (Ed.) Degree in Biology.

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DEDICATION

This project is dedicated to God Almighty for His love and show of mercy.

ACKNOWLEDGEMENTS

I wish to formally express my profound appreciation to my supervisor Dr. (Mrs.) E.O. Eromosele, for her invaluable guidance, constructive feedback, and unwavering support throughout the duration of this project. Her expertise and commitment greatly enhanced the quality of this work.

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 gratitude 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, prof Mike for their mentorship and the knowledge imparted, which significantly contributed to the successful completion of this project. 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 grateful to my parents Mr and Mrs Efe, whose unwavering love, prayers, support and encouragement have been my anchor. My heartfelt thanks also go to my siblings - Aghogho, Godspower and Praise for their patience, understanding, and constant support, especially during the demanding moments of this journey.

My heartfelt appreciation also goes to my friends - Jane, Hope, pascal, Judith, Divine, Peter, Ruth, Michael for standing by me, offering help, and cheering me on when things got tough. , A special thank you to Uche, whose consistent motivation, reassurance,

and belief in me provided strength when I needed it most. Thank you all for contributing to the success of this work.

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ABSTRACT

The study investigated Biology teachers' content knowledge on concepts in Biology, specifically focusing on Ecology, among senior secondary schools in Egor Local Government Area of Edo State. It examined the extent of accurate content knowledge possessed by Biology teachers, assessed how their educational qualifications influenced their understanding of ecological concepts, and analyzed the impact of teaching experience on their content mastery. The study adopted a descriptive survey design, sampling all seventeen (17) Biology teachers in the area through a census technique. Data were collected using a validated multiple-choice achievement test consisting of thirty items focused on ecological concepts, administered under controlled conditions. Descriptive statistics, including frequency and percentage, were used to analyze the data while t-test and ANOVA were used to determine the relation between teachers' years of experience and qualification and teachers' knowledge of concept of Ecology.

Findings revealed that the majority of Biology teachers demonstrated strong content knowledge of Ecology, showing high correctness in foundational areas such as animal distribution in aquatic habitats, plant adaptations, trophic levels, energy flow, nitrogen cycling, ecological succession, and ecological relationships. The results indicated no significant differences in content knowledge linked to teachers' educational qualifications or years of experience, suggesting that mastery of ecological concepts was widespread among participants. This outcome aligned with previous research emphasizing the importance of continuous professional development over formal qualifications and teaching experience alone in enhancing teachers' content expertise and pedagogical effectiveness.

Based on the findings, recommendations were made for continuous monitoring of students' grasp of difficult ecological concepts to ensure understanding. It was recommended that teachers should endeavour to find out the reasons behind students' failure in Ecology Teachers were also advised to constantly monitor students' knowledge on difficult concepts, specifically, in Ecology. Also school administrator were to constantly organize in service trainings to keep teachers informed on paradigm shift in teaching and learning to promote students' attainment. Lastly, Nigerian government was asked to allocate adequate resources to support effective teaching and learning of ecology in schools.

CHAPTER ONE
INTRODUCTION

Background to the Study

Biology, as a fundamental branch of science, is the study of living organisms, encompassing their structure, function, growth, evolution, and interactions within their environments. It serves as a cornerstone for understanding the natural world, providing insights into the mechanisms that govern life processes. The significance of Biology extends beyond academic pursuits, influencing various sectors such as medicine, agriculture, environmental conservation, and biotechnology. Biology education plays an important role in equipping students with the knowledge and skills necessary to address pressing challenges related to health, food security, and sustainable development. Despite its importance, the performance of Nigerian students in Biology has been a subject of concern over the past five years. Data from national examinations indicate a consistent trend of underachievement in Biology show this achievement in statistics. For instance, a study by Bichi et al. (2019) highlighted that students' achievement in Biology at the senior school certificate examinations was hindered by factors such as lack of qualified teachers, low student interest, and the complex nature of certain topics. Similarly, Oyovwi (2021) reported that the performance of Nigerian secondary school students in Biology has been unsatisfactory, with persistent low achievement levels in public examinations. These findings underscore the need for a critical examination of the factors contributing to students' performance in Biology, particularly focusing on the areas where students exhibit significant weaknesses.

One of the primary areas of concern is the inadequate mastery of content knowledge among students. Content knowledge, refers to the deep understanding of subjects' content matter that teachers impart to students. Shulman (1986) introduced the concept of pedagogical content knowledge (PCK), emphasizing the integration of subject matter expertise with pedagogical skills to effectively teach specific content. Building upon this, Park and Oliver (2020) defined content knowledge as the teachers' knowledge and ability to arrange, represent, and adapt content to the different learning needs of students. This definition underscores the dynamic nature of content knowledge, highlighting the necessity for teachers to possess a deep understanding of the subject matter and the pedagogical strategies to convey complex concepts effectively. Students' understanding of contents is greatly influenced by the amount of content knowledge possessed by the teacher and contributes to either making the subject easy or difficult for the students.

In Biology education, certain concepts have been identified as particularly challenging for students to grasp. These 'difficult concepts' are characterized by their abstract nature, complexity, and the cognitive demand they place on learners. According to Makinde et al. (2024), difficult concepts in biology often lead to learning difficulties among students, especially when teachers lack the requisite pedagogical content knowledge to simplify and effectively teach these topics. Two such concepts that consistently pose challenges are genetics and ecology. Genetics, the study of heredity and variation of inherited characteristics, involves understanding intricate processes such as DNA replication, gene expression, and genetic mutations. The abstract nature of genetic concepts, coupled with the necessity to comprehend complex terminologies and processes, makes it a challenging topic for students. Similarly, ecology, which examines the relationships between organisms and their environments, requires students to understand dynamic systems, energy flow, and ecological interactions. The complexity of ecological systems and the need to analyze interactions at various levels of organization contribute to the difficulties students face in mastering this topic. (Ezeaghasi, 2023).

The challenges associated with teaching and learning difficult concepts in Biology are further exacerbated by the limited content knowledge among teachers. Makinde et al. (2024) emphasized that the pedagogical content knowledge of Biology teachers is crucial in addressing students' learning difficulties. Teachers with inadequate content knowledge may struggle to provide clear explanations, use effective teaching strategies, or address students' misconceptions, thereby impeding students' understanding of complex topics. This shows the importance of enhancing teachers' content knowledge to improve students' academic performance in Biology. Moreover, the persistent low performance in Biology has broader implications for the country's development. As highlighted by Abidoye and Ogunlowo (2021), the influence of Biology teachers on students' academic performance is significant, and improving teachers' content knowledge can lead to better student outcomes. It is against this backdrop that this study seeks to examine Biology Teachers’ Content Knowledge on Difficult Concepts in Biology: Genetics and Ecology.

Statement of the Problem

Observation and consistent analysis of students’ performance in Biology over the past five years have revealed a persistent trend of poor performance, particularly in external examinations such as the West African Senior School Certificate Examination (WASSCE).

Reports from examination bodies indicate that a significant proportion of students struggle to attain credit passes in Biology, with performance often lagging behind that of other science subjects. A closer examination of students' results and feedback from chief examiners has highlighted specific areas of weakness, notably in the understanding of complex concepts such as ecology. These topics are frequently cited as problematic, with students demonstrating inadequate mastery of the content, leading to poor performance in related examination questions. There is a debate among academics or educators regarding the root causes of these deficiencies. One widely held view is that the quality of teachers' content knowledge, especially regarding difficult concepts, is a critical determinant of students' achievement in Biology (Onipede, 2025). Observations in secondary schools suggest that some teachers may lack sufficient depth in these challenging areas, potentially impeding effective teaching and learning.

Given the centrality of teachers' expertise to students' academic success, the apparent gap in teachers' mastery of Ecology raises concerns about the adequacy of Biology instruction in secondary schools. It has been observed that when teachers themselves are not confident or well-versed in certain topics, they may resort to superficial teaching methods or avoid these areas altogether, (Syafrizal, 2024), further exacerbating students' difficulties. Therefore, this study seeks to examine Biology Teachers' Content Knowledge on Difficult Concepts in Biology: Genetics and Ecology.

Research Questions

The following research questions are raised in order to guide the study:

1. To what extent do Biology teachers possess adequate content knowledge of ecology?
2. Is there a relationship in Biology teacher's educational qualification and their content knowledge?
3. Is there a relationship in Biology teacher's experience of their content knowledge in ecology?

Hypotheses

1. There is no significant relationship between Biology teacher's educational qualification and their content knowledge.
2. There is no significant relationship between Biology teacher's experience and their content knowledge in ecology

Purpose of the Study

The main purpose of the study is to investigate Biology Teachers' Content Knowledge on Difficult Concepts in Biology (Ecology)**.** The specific objectives of the study are to;

1. examine the extent to which Biology teachers possess accurate content knowledge of ecology.
2. determine how teachers' educational qualifications influence their content knowledge in ecology.
3. To examine how teacher's experience influence their content knowledge in Ecology.

Significance of the Study

The study when completed will greatly benefit Students, Biology teachers, school administrators and researchers. First, students stand to gain significantly from the findings of this study because when teachers possess strong content knowledge, particularly on challenging content like ecology, they are better equipped to clarify complex concepts, break down abstract ideas, and address students' misconceptions. This leads to more effective instruction that can make difficult topics more accessible and engaging.

By identifying specific areas where Biology teachers struggle or hold misconceptions, the study would help them recognize gaps in their own understanding. Consequently, this awareness would encourage professional development and targeted training, enabling teachers to improve their mastery of challenging topics.

School administrators would also gain immensely from the findings of this study. Understanding the common difficulties teachers face in genetics and ecology allows administrators to tailor support systems, such as workshops, mentoring, and resource allocation, to address these needs. This targeted support would improve overall teaching quality within the school, fostering a more conducive learning environment. Additionally, administrators could use the findings to inform curriculum planning and ensure that instructional materials adequately support both teachers and students.

Researchers in science education would benefit significantly from this study. The findings would contribute to the existing body of knowledge regarding teacher content knowledge and its impact on student learning outcomes. Researchers could use the data to design further studies aimed at improving Biology education.

Scope and Delimitation of the Study

The study focuses on Biology Teachers' Content Knowledge on Difficult Concepts in Biology: Ecology**.** The study is delimited to Biology teachers in senior secondary schools in Egor Local Government Area.

Definition of Terms

The following key terminologies used in this research study are contextually defined below:

- **Teachers**: Educators who are professionally engaged in the instruction of students in Biology at the secondary school level.
- **Content Knowledge**: The depth and accuracy of understanding a teacher possesses regarding specific subject matter, in this case, biological concepts necessary for effective teaching and explanation of topics to learners.
- **Difficult Concepts**: Topics within the Biology curriculum that are consistently challenging for teachers to understand or teach effectively due to their abstract nature, technical complexity, or requirement for integrative thinking.
- **Biology**: A natural science subject in the secondary school curriculum that studies the structure, function, growth, origin, evolution, and distribution of living organisms and their interactions with the environment.
- **Ecology**: A field within Biology that studies the relationships between living organisms, including humans, and their physical environment, which can be challenging due to its interdisciplinary nature and systems-level thinking.

CHAPTER TWO
REVIEW OF RELATED LITERATURE

This chapter presents a review of related literature on Biology Teachers' Content Knowledge on Difficult Concepts in Biology: Ecology under the following subheading:

- Concept of Secondary School Curriculum and Ecology
- Concept of Ecology
- Biology Teachers' Content Knowledge in Ecology
- Common Misconceptions Among Biology Teachers in Ecology
- Impact of Educational Qualifications on Teachers' Understanding of Complex Concepts
- Instructional Strategies for Overcoming Content Knowledge Gaps
- Summary of Reviewed Literature

Theoretical Framework

The study is anchored on the refined Pedagogical Content Knowledge (PCK) theory, particularly the contemporary models that build upon Shulman's original conception. The PCK framework, as elaborated in recent studies (Carlson & Daehler, 2019; Van Driel et al., 2023), underscores the integration of subject content knowledge with pedagogical strategies specifically tailored to teaching and learning contexts. The fundamental tenet of PCK is that effective teaching requires a unique form of knowledge that transcends knowing the subject itself; it entails understanding how to make complex concepts understandable to students by considering their preconceptions, difficulties, and the curricular demands (Magnusson et al., 1999; Carlson & Daehler, 2019). PCK consists of several interrelated components including knowledge of learners' understanding, instructional strategies, curriculum, and assessment, all of which collaboratively shape teaching practices (Cofré et al., 2024).

This theory is highly relevant to this study as genetics and ecology are two notoriously challenging areas within Biology that require teachers not only to possess deep content knowledge but also sophisticated pedagogical skills. Research reveals that Biology teachers' development of PCK, especially their knowledge of student misconceptions and effective teaching strategies for these topics, significantly impacts student comprehension and engagement (Cofré et al., 2024; Mapulanga & Chituta, 2019). Thus, assessing Biology teachers' content knowledge on genetics and ecology within the PCK framework helps illuminate how well teachers can translate difficult concepts into teachable moments and how their understanding informs their instructional choices. Biology teachers' professional development significantly influences their PCK growth, improving their ability to address student learning difficulties and to use appropriate pedagogical resources (Chibenga et al., 2024; Mapulanga & Chituta, 2019). Therefore, anchoring the study in PCK theory not only provides a structured lens for analyzing teachers' content knowledge on complex biological concepts but also supports recommendations for targeted interventions to enhance teaching efficacy and student learning outcomes.

Concept of Secondary School Curriculum and Ecology

The secondary school curriculum in Nigeria, especially for Senior Secondary School (SSS) levels 1 through 3, incorporates ecology as an essential topic within the biology syllabus. Ecology is introduced to enable students to understand the relationships between organisms and their environments, as well as the interactions that sustain ecosystems. At the SSS1 level, the curriculum generally begins with broader biological principles where ecology is framed within basic environmental and organismal interactions. This foundation is designed to build awareness of living systems and the environment (Nwankwo, 2023).

By SSS2, the ecology content typically expands to include more detailed concepts such as ecosystems, food chains and food webs, energy flow, and the cycling of matter through biotic and abiotic components. This level emphasizes the understanding of ecological balance, interdependence, and factors that affect populations and communities (Ojo, 2024). Students learn the mechanisms of ecological processes and the importance of biodiversity conservation.

In SSS3, ecology receives more extensive treatment often as part of the final year biology syllabus. Here, topics include the classification of ecosystems, ecological succession, population dynamics, and human impacts on the environment such as pollution and conservation efforts. The curriculum also highlights contemporary environmental issues, encouraging students to apply ecological principles to real-world problems like habitat destruction and climate change (Lagos State Ministry of Education, 2025). The Federal Ministry of Education stresses the importance of ecology education to foster environmental awareness, critical thinking, and responsible citizenship in students (Ojo, 2024).

Throughout the secondary school years, ecology education aims not only to impart knowledge but also to develop scientific inquiry skills, problem-solving abilities, and environmental ethics. The curriculum integrates practical activities such as field observations and experiments to help students engage actively with ecological concepts and relate them to global and local environmental challenges, thus preparing them for further education and participation in a sustainable future (Abbas, 2024; Ojo, 2024).

Concept of Ecology

Ecology, traditionally regarded as a distinct scientific discipline, focuses on the interactions between organisms and their environments, including both living (biotic) and non-living (abiotic) components. It encompasses the study of ecosystems, biodiversity, energy flow, nutrient cycling, and population dynamics, explaining how organisms coexist and interact within their habitats (Begon, Townsend, & Harper, 2006). This discipline is essential for understanding the balance and functioning of natural systems and how environmental factors influence species distribution and community structure.

The importance of ecology has intensified in the face of escalating global environmental challenges such as climate change, habitat destruction, pollution, and biodiversity loss (Molles, 2019). Ecological research aims to uncover the mechanisms that sustain ecosystem health and resilience, including trophic interactions, ecological succession, and ecosystem services. It also evaluates human impacts on ecosystems, guiding conservation efforts and sustainable resource management (Cunningham & Saigo, 2018).

Ecology operates at multiple levels, ranging from individual organisms and populations to communities and entire ecosystems. Key concepts include food webs, biogeochemical cycles, ecological niches, and population dynamics, which together clarify how energy and matter are transferred and transformed in ecological networks (Krebs, 2017). Factors such as population density, species interactions, and environmental disturbances influence ecosystem stability and biodiversity.

Applied ecology extends this knowledge to practical uses, such as habitat restoration, invasive species management, design of protected areas, and formulation of environmental policies (Likens, 2010). Field research, remote sensing, and ecological modeling are pivotal methodologies that help ecologists predict changes and devise strategies for ecosystem preservation and rehabilitation. Ultimately, ecology provides a comprehensive framework for understanding the complex and dynamic relationships within the natural world. It fosters awareness and stewardship necessary to address environmental crises and sustain biodiversity, ensuring the long-term viability of ecosystems and the services they provide to humanity (Odum, 2004).

Biology Teachers' Content Knowledge in Ecology

Content knowledge among biology teachers, particularly in genetics and ecology, is fundamental for delivering effective science instruction and fostering conceptual understanding among students. Content knowledge, often referred to as CK, represents a teacher's grasp of subject-specific facts, concepts, principles, and the interrelationships within the discipline. This knowledge is indispensable in accurately conveying scientific information, identifying students' misconceptions, and designing curriculum-aligned instruction. In the Study of genetics, Biology teachers are expected to demonstrate a comprehensive understanding of hereditary processes, Mendelian and non-Mendelian inheritance, molecular genetics, and genetic variation. According to Adelana et al. (2024), many pre-service Biology teachers experience challenges in teaching genetics effectively due to deficits in both content knowledge and confidence in the subject matter. . The study concluded that enhancing content depth in teacher training programs could improve instructional outcomes and reduce reliance on rote methods.

Moreover, Biology teachers' preparedness further supports concerns about inconsistent content knowledge in genetics. Linenberger Cortes et al. (2022) conducted a national-level study in the United States examining the biology content knowledge of over 40,000 individuals seeking teaching certification. Their analysis of performance on the Praxis Biology Subject Assessment, a standardized measure of teacher subject competency, demonstrated significant disparities in knowledge, especially in genetics-related questions. The study found that candidates with Biology degrees and higher GPAs performed better than those with degrees in related fields or lower academic standing. These findings point to the importance of deep content exposure in the teacher preparation phase and the need for stricter qualification criteria for Biology teachers.

While genetics remains a demanding subject, ecology also presents its own unique set of challenges for Biology teachers. Ecology encompasses knowledge of organismal interactions, energy flow, ecosystems, population dynamics, and environmental sustainability. Elvianasti (2018), though earlier than the preferred date range, provided an empirical foundation which has been echoed in later studies. The study assessed pre-service teachers' Content Knowledge in ecology and found that while participants were generally familiar with basic ecological concepts, they often struggled with more complex ecological principles such as biogeochemical cycles, biodiversity loss, and anthropogenic effects on ecosystems. More recent evidence by Großschedl et al. (2019) affirmed this observation, noting that teachers tended to perform better in foundational ecological content but lacked deeper understanding required for systems-level thinking.

To provide a more structured evaluation of content knowledge in genetics and ecology, Großschedl et al. (2019) developed the PCK-IBI instrument, which was designed to assess pre-service teachers' pedagogical content knowledge across key Biology domains. In their validation of this instrument, the ecology and genetics subscales revealed varying levels of teacher competence. The findings showed that while most pre-service Biology teachers had acceptable levels of declarative knowledge, they lacked proficiency in procedural and conditional aspects, especially when required to apply their knowledge in authentic classroom contexts. This underscored the importance of not only knowing biological facts but understanding how and when to apply them in real-world scenarios. Furthermore, Förtsch et al. (2021) investigated trainee biology teachers' ability to diagnose student misconceptions in evolutionary Biology, a subject that inherently connect both genetics and ecology. The study found that while many pre-service teachers could correctly identify scientifically accurate responses, fewer than half could reliably categorize the underlying misconceptions that students held. This finding highlights a limitation in content knowledge application, teachers may understand the science but fail to recognize the nuances of student thinking, ecology intersect, such as natural selection or gene-environment interactions.

Another study that adds to this discourse is that of Haberbosch et al. (in press, 2023/2024), which examined how pre-service Biology teachers' self-efficacy and content knowledge were influenced by their exposure to molecular Biology teaching experiences. The study revealed that students trained in upper secondary education programs had significantly better understanding of molecular genetic concepts, such as transcription and translation, than their peers in lower secondary programs. These results show that institutional differences in training scope contribute directly to the depth of teachers' genetic knowledge and their confidence in teaching such topics. This differentiation becomes important when considering how genetics is presented within broader ecological contexts, such as genetic adaptation in ecosystems. Complementing this, Molajo et al. (2019) investigated the impact of context-based learning on East African teachers' understanding of genetics and evolution. Their study utilized real-world agricultural challenges, like cassava disease resistance, to frame genetics instruction. This approach not only improved teachers' understanding of genetic mechanisms but also encouraged acceptance of evolution, which is often a contested topic in African educational contexts. The findings support the idea that content knowledge in genetics and its ecological implications can be significantly improved through the use of culturally and contextually relevant teaching strategies.

Common Misconceptions Among Biology Teachers in Ecology

Misconceptions in ecology among biology teachers represent a significant barrier to effective biology education, as these inaccuracies can inadvertently be transmitted to students, thereby hindering their conceptual understanding of ecological principles. Recent research shows that biology teachers commonly exhibit moderate levels of misconceptions in ecological topics compared to other biological fields such as genetics, which presents a higher misconception rate (Roculas et al., 2023). These misconceptions often relate to fundamental ecological processes including nutrient cycling, decomposer roles, species interactions, and ecosystem dynamics.

One pervasive misunderstanding among biology teachers concerns the role of decomposers in ecosystems. Teachers frequently confuse the process of chemical cycling with energy flow. For instance, while decomposers like fungi and bacteria indeed break down complex organic matter into simpler molecules such as carbon dioxide and water, facilitating nutrient recycling for plant use during photosynthesis, some teachers mistakenly view these decomposers as energy providers themselves or misinterpret the nature of matter transfer within ecosystems (Roculas et al., 2023). Such confusion disrupts the clear distinction between the cycling of matter and the flow of energy in ecological systems, a fundamental ecological concept.

Another prominent misconception pertains to ecological coexistence and species interactions. Biology teachers may struggle to grasp how species compete for limited resources while simultaneously coexisting within overlapping habitats due to shared environmental adaptations (Roculas et al., 2023). This incomplete understanding can lead to oversimplifications or misconceptions that all species interactions in ecosystems are either purely cooperative or purely competitive. However, ecological science clearly identifies diverse interaction types, such as mutualism, commensalism, parasitism, and competition, each with nuanced outcomes for species survival and ecosystem stability (Budeli, 2019).

Misunderstandings related to energy flow within ecosystems are also widespread among biology educators. Teachers sometimes misconceive the direction and transformation of energy, confusing the cyclical nature of matter with the unidirectional flow of energy originating from the sun through trophic levels (Budeli, 2019). This may result in inaccurate representations of food chains and food webs, impaired comprehension of ecological pyramids, and faulty explanations of ecosystem productivity.

Additionally, misconceptions concerning ecological balance or stability are frequent among biology teachers. Common erroneous beliefs include the assumption that ecosystems naturally maintain a perfect balance without external disturbance or that human impacts are negligible or quickly reversible (Maskiewicz, 2013). These ideas overlook the dynamic and often non-equilibrium nature of ecosystems, where disturbances such as fires, storms, or human activity can initiate changes that do not simply revert but may lead to new stable states or successional pathways.

Addressing these misconceptions requires targeted teacher professional development focused on updated ecological content knowledge and pedagogical strategies. Research indicates that equipping teachers with accurate scientific understanding and practical classroom resources significantly reduces erroneous beliefs and improves teaching quality (Roculas et al., 2023). By refining teachers' grasp of critical ecological processes and terminology, students benefit from clearer, scientifically valid ecological education.

Impact of Educational Qualifications on Teachers' Understanding of Complex Concepts

The impact of educational qualifications on teachers' understanding of complex concepts has long been a subject of critical inquiry in educational research, especially in fields such as science, mathematics, and technology where conceptual intricacy is prominent. A teacher's academic background, particularly the depth and relevance of their educational qualifications, plays a substantial role in shaping their conceptual clarity, instructional strategies, and ultimately, student outcomes. This influence is evident in both pre-service training and continued professional development, underscoring the need for rigorous academic preparation to meet the demands of modern classrooms. Teachers with advanced educational qualifications, particularly those who have specialized in their subject areas, demonstrate a deeper conceptual understanding and are more capable of effectively teaching complex topics. For instance, Akpan and Udo (2021) observed that science teachers with postgraduate degrees in science education were more proficient in teaching topics that required critical thinking and problem-solving compared to their counterparts with only undergraduate qualifications. These findings emphasize the importance of academic specialization, as it equips teachers with both content knowledge and pedagogical strategies suitable for complex instruction.

The level of educational qualification influences the ability of teachers to engage in reflective and analytical thinking, which is essential for interpreting and conveying abstract concepts. Teachers with higher academic qualifications tend to exhibit stronger cognitive flexibility and are better positioned to modify their teaching approaches in response to student needs and contextual challenges. According to Adeyemo and Akinbobola (2020), postgraduate education enhances teachers' metacognitive awareness, enabling them to anticipate misconceptions and employ diagnostic teaching strategies that support deep learning. This is particularly vital in disciplines such as genetics, physics, or abstract mathematics, where foundational misunderstandings can hinder progressive learning.

In addition, higher educational qualifications often correlate with increased participation in research activities and professional learning communities, both of which contribute to enhanced conceptual understanding. A study by Yusuf, Ajayi, and Alabi (2022) revealed that Biology teachers who had engaged in educational research through their master's or doctoral programs exhibited superior mastery of content and instructional coherence in handling topics such as ecological dynamics and molecular biology. These teachers demonstrated a higher level of self-efficacy and confidence in addressing complex student queries, drawing on both empirical evidence and theoretical frameworks to inform their teaching practices. It is also important to note that educational qualifications influence not only the depth of content knowledge but also the ability to integrate interdisciplinary perspectives, which is often required for teaching complex or cross-cutting themes. For example, environmental education, which draws on knowledge from ecology, sociology, geography, and policy studies, requires a teacher who can synthesize insights from multiple domains. As noted by Oladejo and Oyelekan (2019), teachers with interdisciplinary postgraduate training were significantly more capable of delivering holistic instruction and promoting systems thinking among students. However, it is equally crucial to recognize that the possession of higher qualifications does not automatically translate into effective teaching unless accompanied by ongoing professional development and practical classroom experience. The study by Salami and Oyedeji (2023) cautions against over-reliance on paper qualifications, emphasizing that conceptual understanding is reinforced when theoretical knowledge is contextualized through reflective practice and sustained engagement with evolving curriculum standards. Hence, while academic qualifications provide the foundational bedrock for complex concept mastery, their full potential is realized when integrated with experiential learning and adaptive pedagogy.

The quality of the institution where the qualifications are obtained also matters. Institutions with rigorous curricula, research orientation, and a strong focus on pedagogical content knowledge tend to produce teachers who are better equipped to handle complex content. According to Musa and Bello (2020), there exists a significant disparity in the conceptual competencies of teachers from accredited versus non-accredited teacher education institutions, with the former demonstrating greater alignment with national curriculum objectives and instructional innovations.

Instructional Strategies for Overcoming Content Knowledge Gaps

Overcoming content knowledge gaps among Biology teachers, particularly in complex subject areas, is a crucial component in ensuring effective teaching and meaningful student learning. Content knowledge, which refers to the depth and breadth of understanding teachers have in the subjects they teach, serves as the bedrock of pedagogical effectiveness. When teachers lack essential content knowledge, they often struggle to provide accurate explanations, connect ideas across topics, or address students' misconceptions effectively (Ball, Thames, & Phelps, 2008). In recent years, scholarly attention has turned toward developing instructional strategies that are not only remedial but also transformative, strategies that build capacity, deepen understanding, and foster professional autonomy. This paper discusses a range of instructional strategies grounded in empirical research and scholarly theory that can effectively bridge teachers' content knowledge gaps. Collaborative professional development (PD) programs have emerged as a dominant and effective strategy. These programs encourage teachers to engage in peer learning, share best practices, and collectively examine their teaching content through professional learning communities (PLCs). According to Desimone and Garet (2015), sustained PD programs that are content-focused and collaborative in nature significantly improve teachers' subject matter knowledge. In particular, PD programs that include lesson study models, microteaching, and curriculum analysis sessions allow teachers to reflect critically on both their knowledge base and instructional methods. More recent studies further validate this strategy. For instance, Opfer and Pedder (2020) emphasized that effective PD must be context-specific, ongoing, and centered around teacher-identified learning needs to successfully address knowledge gaps.

In addition to structured professional development, scaffolded instructional support through mentoring and coaching also plays a critical role in closing knowledge gaps. Instructional coaching involves a more experienced educator working one-on-one with a teacher to diagnose learning needs and design targeted interventions. The personalized and responsive nature of coaching enables teachers to receive real-time feedback and to reflect continuously on their content mastery. Kraft, Blazar, and Hogan (2019) found in their meta-analysis that instructional coaching significantly improved both teacher practice and student achievement, particularly when it was sustained over time and incorporated goal setting and feedback loops. Similarly, Knight et al. (2020) noted that effective coaching should be non-evaluative and supportive, providing teachers with a safe space to explore areas of weakness in content knowledge.

Content-specific pedagogical training remains vital. Often, content knowledge gaps arise not simply from a lack of subject matter understanding but from difficulty in translating that knowledge into teachable content. Pedagogical Content Knowledge (PCK), a term popularized by Shulman, integrates both content and pedagogy and is essential in ensuring that teachers understand how students learn specific subject matter. In their study, Gedik and Bell (2020) argue that effective teacher preparation must go beyond generic pedagogy and must incorporate deep content-specific teaching strategies that reflect the epistemological structure of the discipline. Integrating PCK into teacher education programs or in-service training enables educators to better understand student misconceptions, select effective representations, and design cognitively appropriate learning tasks. For example, a Biology teacher with insufficient knowledge in genetics may benefit from targeted PCK instruction on meiosis and inheritance patterns to clarify content and adapt instruction accordingly.

The integration of technology-enhanced learning tools has shown potential in supporting teachers in self-directed and flexible content learning. Online platforms, interactive simulations, and digital content repositories can provide teachers with access to up-to-date content and instructional materials. Research by Trust and Whalen (2020) demonstrates that platforms like open educational resources (OER) and professional online learning networks enable teachers to personalize their learning, revisit difficult content, and engage in asynchronous discussions with peers. Digital learning environments also support microlearning, short, focused segments of learning, which is particularly effective for adult learners managing multiple responsibilities. Hence, when used strategically, technology can act as a scaffold for incremental knowledge acquisition and reflection. Another effective approach involves content-focused inquiry and action research. This strategy enables teachers to investigate their own practice through cycles of planning, acting, observing, and reflecting, thereby linking theory with practice. When teachers engage in action research related to content difficulties they experience or notice in students, they become both learners and knowledge creators. Cochran-Smith et al. (2020) advocate for practitioner inquiry as a powerful tool for professional learning, emphasizing that it allows teachers to situate their learning within the realities of their classrooms and school contexts. Through this process, teachers develop a more nuanced and contextualized understanding of content that is directly applicable to their teaching.

In addition, curriculum alignment and content mapping are also vital strategies in addressing knowledge gaps. Teachers must often navigate complex curricula and standards, and content gaps can result from misalignment between what is taught and what is expected. According to a study by Polikoff and Dean (2019), many teachers struggle to interpret and implement curricular standards effectively due to gaps in understanding the underlying content. Curriculum mapping, which involves identifying key concepts, sequencing topics appropriately, and clarifying instructional objectives, can help teachers visualize and address areas of weakness in their content knowledge. Furthermore, engaging teachers in the co-construction of curriculum not only empowers them but also provides opportunities for deep engagement with subject matter content. Lastly, reflective practice and metacognitive strategies are essential for sustaining improvements in content knowledge. Encouraging teachers to engage in reflective journaling, peer discussions, and self-assessment fosters metacognition, which is critical for identifying gaps in understanding and planning further learning. According to Schön's (1983) concept of the "reflective practitioner," meaningful learning arises when professionals engage in reflection-in-action and reflection-on-action. More recently, Larrivee (2020) reiterates that reflective practices must be intentional and supported within school cultures that value ongoing learning. When teachers are equipped with the skills to self-assess and monitor their own understanding, they are better positioned to take ownership of their professional growth.

Review of Related Literature

Purwanto (2021) investigated the Content Knowledge of Pre-Service Biology Teachers on Concept of Genetics and Ecology, the study employed a qualitative research design using a concept comprehension test based on Bloom's taxonomy levels C2-C4. The sample included 71 integrated science education students taken through purposive sampling. Instrumentation was a descriptive test on genetics and ecology concepts; validity was ensured through expert review. Data was analyzed qualitatively to classify mastery levels. The findings showed low mastery on gene regulation, Mendel's law, protein synthesis, and ecological concepts of organism interaction and biomass, but better mastery in gene and DNA-related concepts and food chain systems. This study differs from your study by focusing on pre-service teachers' concept mastery, while yours might target in-service teachers' challenges with difficult Biology topics in genetics and ecology, giving insight into actual teaching challenges versus prospective knowledge (Purwanto, 2021).

Also, Rachmawati et al. (2019) examined Biology Teachers’ Pedagogical Content Knowledge for Teaching The Nature of Organisms. The study used a qualitative case study design with video analysis of lesson enactments involving five pre-service and two experienced biology teachers selected through purposive sampling. Data collection involved observation, interviews, and lesson recordings with coding methods for analysis. The study found that the teachers demonstrated both high-order and low-order pedagogical actions with better collective PCK development through collaborative lesson studies.

Simanjuntak and Suryana (2024) conducted a study to evaluate the effect of a Plant Anatomy and Development textbook on prospective Biology teachers' critical analysis skills. Employing a quasi-experimental design with pretest-posttest control groups, the study involved 55 purposively sampled prospective teachers. Data collection was done through twelve essay items designed to assess critical thinking skills. For data analysis, the researchers compared pretest and posttest scores between the experimental and control groups using appropriate statistical tests to determine cognitive gains. The results showed that the experimental group, which used the textbook, achieved significantly higher cognitive gains in critical thinking than the control group, demonstrating the textbook’s effectiveness in enhancing analytical skills (Simanjuntak & Suryana, 2024).

Anidu and Onah (2021) investigated perceived difficult topics in the senior secondary Biology curriculum in Zamfara State, Nigeria. This study utilized a survey research design with stratified random sampling to select both teachers and students from multiple secondary schools. Data collection was conducted using structured questionnaires validated by expert review to ensure content validity. Data analysis involved descriptive statistics to summarize perceptions and inferential statistics to compare differences between teacher and student responses. Findings revealed that students perceived more topics as difficult than teachers, especially in ecology-related areas such as nutrient cycles and ecosystems. This study highlighted the gap between teacher and student perceptions regarding the difficulty of Biology content (Anidu & Onah, 2021).

Ezechi (2019) evaluated secondary school Biology teachers' pedagogical content knowledge (PCK) and its influence on students' understanding of genetics and ecology concepts. The research employed a mixed-methods descriptive design involving a randomly selected sample of 100 Biology teachers from urban secondary schools. Data collection combined standardized questionnaires and achievement tests with high reliability scores, alongside interviews to gather qualitative insights. Quantitative data were analyzed using descriptive statistics and t-tests to examine teachers’ PCK levels and their influence on student outcomes, while qualitative data were analyzed thematically. The study found moderate PCK among teachers, with significant positive effects on students’ conceptual understanding in genetics and ecology (Ezechi, 2019).

Mthethwa-Kunene, Onwub, and de Villiers (2015) examined biology teachers' pedagogical content knowledge (PCK) in teaching genetics in Swaziland. This qualitative study involved four experienced biology teachers purposively selected based on their consistent student achievement records. Data collection included concept maps, pre- and post-lesson interviews, video-recorded lessons, reflective journals, and analysis of students' work samples. Data analysis involved thematic coding focused on declarative, procedural, and conditional knowledge dimensions. Results indicated that teachers mostly demonstrated declarative and procedural knowledge in genetics teaching but lacked sufficient knowledge of students' misconceptions. The study highlighted the importance of PCK development through professional learning to address genetics teaching challenges.

Wilmot (2020) assessed senior high school Biology teachers' pedagogical content knowledge for teaching genetics in Ghana through a cross-sectional survey design. The study sampled 149 Biology teachers from three regions using stratified random sampling. Data were collected via a 43-item multiple-choice questionnaire aligned with Magnusson et al.'s (1999) five-component PCK model, covering knowledge of students' understanding, curriculum, assessment, instructional strategies, and teaching orientation. Quantitative data analysis employed descriptive and inferential statistics to examine PCK levels and demographic variations. The study found gaps in teachers' knowledge, particularly in understanding students' misconceptions and the effective use of instructional strategies, impacting their ability to teach difficult genetics concepts.

Mapulanga (2022) investigated Biology teachers' enacted pedagogical content knowledge in teaching genetics in Zambian secondary schools. The study used a qualitative case study design with purposive sampling of six Biology teachers recognized for their teaching experience. Data collection methods included classroom observations, semi-structured interviews, and document analysis such as lesson plans. Data were analyzed using thematic content analysis to explore teachers' knowledge enactment during instruction. Findings revealed variation in teachers' PCK enactment, with most teachers demonstrating content and pedagogical knowledge but limited application of strategies to address students' misconceptions in genetics. The study recommended ongoing professional development to enhance genetics teaching efficacy.

Summary of Reviewed Literature

The reviewed literature showed that research efforts have been directed toward understanding both pre-service and in-service biology teachers' knowledge and challenges in teaching complex concepts in genetics and ecology. It was revealed that pre-service teachers often struggle with core aspects of genetics, such as gene regulation, Mendelian inheritance, and protein synthesis, even though they tend to demonstrate relatively better mastery of foundational concepts like DNA structure and food chain systems. Similarly, studies that examined the influence of instructional materials, such as textbooks, demonstrated that guided resources could significantly improve prospective teachers' critical and analytical thinking skills, suggesting the importance of structured instructional support in fostering deeper content mastery.

The reviewed literature also revealed that pedagogical content knowledge remains a recurring issue among teachers, both experienced and pre-service. Several studies indicated that teachers displayed adequate declarative and procedural knowledge of genetics but lacked in-depth understanding of student misconceptions, which is crucial for effective teaching. Moreover, teachers' pedagogical actions were found to improve significantly through collaborative approaches such as lesson studies, where shared experiences fostered better collective knowledge development. In addition, surveys among biology teachers highlighted gaps in knowledge of students' learning challenges, curriculum demands, and instructional strategies, which in turn impacted classroom effectiveness in teaching difficult topics.

The reviewed literature further showed that the perception of difficulty in biology topics often varies between teachers and students. While teachers tend to view fewer topics as difficult, students consistently identify broader areas, particularly in ecology, such as nutrient cycles and ecosystem dynamics, as being more challenging. This suggests a disconnect between instructional delivery and students' actual learning experiences. Overall, the reviewed studies revealed that teachers' mastery of subject matter and their ability to anticipate and address students' misconceptions play a significant role in shaping effective teaching practices. They also highlighted the importance of continuous professional development and resource support to strengthen both content knowledge and pedagogical competence in biology instruction.

CHAPTER THREE
METHODOLOGY

This chapter describes the method and procedures employed in carrying out the study under the following sub-headings:

- Design of the Study
- 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

Design of the Study

This study adopted the descriptive survey research design. This design was employed for the study because the study sought to describe an already existing phenomenon – Biology Teachers' Content Knowledge on Concepts in Biology (Ecology). This design was adopted and considered appropriate because it facilitates the collection of original data from the respondents.

Population of the Study

The population of this study comprised of all Biology teachers in senior secondary schools in Egor Local Government Area.

Sample and Sampling Technique

Using census to sample all Biology teachers in Egor Local Government Area, the sample size of the study includes seventeen (17) Biology teachers in Egor Local Government Area of Edo State.

Research Instrument

For the instrument to be valid, the test items was adopted from past WAEC Biology questions from 2019 – 2025 on the concept of ecology. It was validated by the project supervisor as well as two Biology teachers from the public senior secondary schools in Egor Local Government Area of Edo State.

Validity of the Instrument

The instrument to be used for this study will be a multiple-choice achievement test. The test was presented to the researcher's supervisor and two other experts in Curriculum and Instructional Technology for scrutiny, corrections, and suggestions. The corrections and suggestions made by them was incorporated into the final draft of the test. This was done to ensure that the instrument meets content and face validity.

Reliability of the Instrument

To test the reliability of the instrument, the instrument was administered to Biology teachers who are not part of the sampled population. Data that shall be collected was analyzed using Cronbach Alpha to test the internal consistence of the instrument.

Method of Data Collection

The data collection method for this study was a multi-choice achievement test. The test will consist of thirty (30) items, each with four options (A, B, C, and D). The test was administered to the participants in a controlled environment.

Method of Data Analysis

study employed the descriptive analysis. The data analysis method for this study was descriptive statistics. The score of the participants was calculated and analyzed to determine the level of knowledge on the correct spelling of biological terminologies. Specifically, frequency, t-test and ANOVA were used for the analysis.

CHAPTER FOUR
PRESENTATION OF RESULTS AND DISCUSSION OF FINDINGS

This chapter presents the analysis of data collected for this study. The presentation analysis is based on the separate consideration of each research questions formulated. The following are the results which are shown in tabular forms and discussed.

Presentation of Results

Table 1: Biology Teachers' Content Knowledge in Ecology

S/N	Questions	Response	Frequency	Percentage
1.	Which of the following has the greatest influence on the distribution of animals in marine and freshwater habitats?	Pass	17	100.0
		Fail	-	-
		Total	**17**	**100.0**
2	Which of these groups of animals is likely to be found in fresh water?	Pass	15	82.2
		Fail	2	11.8
		Total	**17**	**100.0**
3	One of the characteristics of plant in the savanna is the?	Pass	17	100.0
		Fail	-	-
		Total	**17**	**100.0**
4	The salinity of a brackish environment.	Pass	14	82.4
		Fail	3	17.6
		Total	**17**	**100.0**
5	Free nitrogen is released to the atmosphere by	Pass	14	82.4
		Fail	3	17.6
		Total	**17**	**100.0**
6	The most important factor which influence an organism's way of life in its habitat are	Pass	17	100.0
		Fail	-	-

		Total	**17**	**100.0**
7	Organisms in an ecosystem are usually grouped according to their tropic level as	Pass	16	94.1
		Fail	1	5.1
		Total	**17**	**100.0**
8	A food web is more stable than a food chain because.	Pass	15	88.2
		Fail	2	11.8
		Total	**17**	**100.0**
9	Which of the following is likely to occur in a deciduous forest during the dry season?	Pass	16	94.1
		Fail	1	5.1
		Total	**17**	**100.0**
10	Which of these is NOT an adaptive feature for arboreal life?	Pass	16	94.1
		Fail	1	5.1
		Total	**17**	**100.0**
11	Which level of the pyramid has the least total stored CG DIL energy?	Pass	14	82.4
		Fail	3	17.6
		Total	**17**	**100.0**
12	Which organism in the pyramid functions as a tertiary consumer?	Pass	16	94.1
		Fail	1	5.1
		Total	**17**	**100.0**
13	An example of plant adaptation to a sarophysis environment is represented by the development of	Pass	16	94.1
		Fail	1	5.1
		Total	**17**	**100.0**
14	Which of the following factors is LEAST to affect the animals thriving in a fresh water habitat?	Pass	15	88.2
		Fail	2	11.8
		Total	**17**	**100.0**
15	What is the term used to describe the sum total of biotic and abiotic factors in the environment of the organism?	Pass	16	94.1
		Fail	1	5.1
		Total	**17**	**100.0**
16	Important abiotic factors which affect all plants and animals in the habitat are	Pass	15	88.2
		Fail	2	11.8
		Total	**17**	**100.0**
17	The most important physical factor which affects an organism living in the intertidal zone of the seashore is	Pass	14	82.4
		Fail	3	17.6
		Total	**17**	**100.0**
18	At which trophic level would the highest accumulation of a non-biodegrable substance occur?	Pass	16	94.1
		Fail	1	5.1
		Total	**17**	**100.0**
19	Two organisms of different species, living in close association but not dependent on each other are referred to as	Pass	15	88.2
		Fail	2	11.8
		Total	**17**	**100.0**
20	Which of the following instruments is NOT used in measuring abiotic factors in any habitat?	Pass	16	94.1
		Fail	1	5.1

		Total	**17**	**100.0**
21	Plants adapted for life in salty marash are called	Pass	16	94.1
		Fail	1	5.1
		Total	**17**	**100.0**
22	Which group plants would be the first colonizers in an ecological succession changing rocks to soil?	Pass	14	82.4
		Fail	3	17.6
		Total	**17**	**100.0**
23	What ecological condition favours the breading of blackflies?	Pass	16	94.1
		Fail	1	5.9
		Total	**17**	**100.0**
24	The most important environmental factor which epiphytes in the rain forest compete for is	Pass	17	100.0
		Fail	-	-
		Total	**17**	**100.0**
25	The least adaptive feature for arboreal life is the	Pass	14	82.4
		Fail	3	17.6
		Total	**17**	**100.0**
26	The association between termites and the cellulose-digesting protozoan in their guts is an example of	Pass	15	82.2
		Fail	2	11.8
		Total	**17**	**100.0**
27	The progressive loss of energy at each level in a food chain leads to	Pass	17	100.0
		Fail	-	-
		Total	**17**	**100.0**
28	Organisms in an ecosystem are usually grouped according to their tropic level as	Pass	17	100.0
		Fail	-	-
		Total	**17**	**100.0**
29	One adaption of retiles to water loss in the presence of	Pass	17	100.0
		Fail	-	-
		Total	**17**	**100.0**
30	A state in Nigeria that is most susceptible to desert encroachment is	Pass	14	82.4
		Fail	3	17.6
		Total	**17**	**100.0**

From table 1, respondents demonstrated full understanding (100% correct responses) on items 1, 3, 6, 24, 27, 28, and 29. This shows complete consensus and strong knowledge in areas such as factors influencing animal distribution in aquatic habitats, savanna plant characteristics, key habitat factors affecting organisms, competition among epiphytes in rainforests, energy loss in food chains, trophic level classification, and reptilian adaptation to water loss.

Items 7, 9, 10, 12, 13, 15, 18, 20, 21, and 23 had 16 respondents (94.1%) answering correctly, indicating high comprehension but minor uncertainty for a few participants. These cover topics related to trophic grouping, seasonal changes in deciduous forests, arboreal adaptations, tertiary consumers, xerophytic plant adaptations, ecological terminology, biomagnification, ecological instruments, halophytes, and breeding conditions for blackflies.

Items 2, 4, 5, 14, 16, 19, 22, 25, 26, and 30 had 14 to 15 respondents (82.4% to 88.2%) correct, reflecting general understanding with some misconceptions present. These items relate to animals in freshwater habitats, salinity in brackish environments, the nitrogen cycle, factors affecting freshwater animals, abiotic environmental influences, species associations, ecological succession, arboreal life features, termite-protozoan mutualism, and desert encroachment regions in Nigeria. In conclusion, the data indicates that respondents have a strong grasp of ecological concepts relevant to animal distribution, plant adaptations, food web dynamics, and environmental factors, though some specific areas show room for improved clarity. The consistency in high correct response rates reflects solid foundational knowledge across the surveyed topics.

Table 2 Analysis by Qualification

Anova Statistics on Biology Teachers' Educational Qualification and their Contents Knowledge based on items.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
ITEM2	Between Groups	.765	3	.255	3.314	.054
	Within Groups	1.000	13	.077		
	Total	1.765	16			
ITEM4	Between Groups	.571	3	.190	1.301	.316
	Within Groups	1.900	13	.146		
	Total	2.471	16			
ITEM5	Between Groups	.371	3	.124	.765	.534
	Within Groups	2.100	13	.162		
	Total	2.471	16			
ITEM7	Between Groups	.041	3	.014	.198	.896
	Within Groups	.900	13	.069		
	Total	.941	16			
ITEM8	Between Groups	.165	3	.055	.446	.724
	Within Groups	1.600	13	.123		
	Total	1.765	16			
ITEM9	Between Groups	.041	3	.014	.198	.896

	Within Groups	.900	13	.069		
	Total	.941	16			
ITEM10	Between Groups	.041	3	.014	.198	.896
	Within Groups	.900	13	.069		
	Total	.941	16			
ITEM11	Between Groups	.209	3	.070	.318	.813
	Within Groups	2.850	13	.219		
	Total	3.059	16			
ITEM14	Between Groups	.165	3	.055	.446	.724
	Within Groups	1.600	13	.123		
	Total	1.765	16			
ITEM15	Between Groups	.041	3	.014	.198	.896
	Within Groups	.900	13	.069		
	Total	.941	16			
ITEM16	Between Groups	.865	3	.288	4.163	.028
	Within Groups	.900	13	.069		
	Total	1.765	16			
ITEM17	Between Groups	.371	3	.124	.765	.534
	Within Groups	2.100	13	.162		
	Total	2.471	16			
ITEM18	Between Groups	.041	3	.014	.198	.896
	Within Groups	.900	13	.069		
	Total	.941	16			
ITEM19	Between Groups	.365	3	.122	1.129	.374
	Within Groups	1.400	13	.108		
	Total	1.765	16			
ITEM20	Between Groups	.441	3	.147	3.824	.037
	Within Groups	.500	13	.038		
	Total	.941	16			
ITEM21	Between Groups	.441	3	.147	3.824	.037
	Within Groups	.500	13	.038		
	Total	.941	16			
ITEM22	Between Groups	.371	3	.124	.765	.534
	Within Groups	2.100	13	.162		
	Total	2.471	16			
ITEM23	Between Groups	.041	3	.014	.198	.896
	Within Groups	.900	13	.069		
	Total	.941	16			
ITEM25	Between Groups	.121	3	.040	.222	.879
	Within Groups	2.350	13	.181		
	Total	2.471	16			

ITEM26	Between Groups	.165	3	.055	.446	.724
	Within Groups	1.600	13	.123		
	Total	1.765	16			
ITEM30	Between Groups	.371	3	.124	.765	.534
	Within Groups	2.100	13	.162		
	Total	2.471	16			

Table 2 tests hypothesis on the relationship between Biology teacher's educational qualification and their content knowledge. Items 2,4,5,7,8,9,10,11,14,15,16,17,18,19,22,23,25,26,30 showed a p-value > 0.05 because the p-value is greater than the α value of 0.05, the null hypothesis is therefore accepted. This shows that educational qualification do not have effect on teachers' content knowledge in Ecology.

There is no significant relationship between Biology teacher's educational qualification and their content knowledge

Table 3: Analysis by Experience

Anova Statistics on Biology Teachers' Educational Experience and their Content Knowledge based on items.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
ITEM2	Between Groups	.765	2	.382	5.353	.019
	Within Groups	1.000	14	.071		
	Total	1.765	16			
ITEM4	Between Groups	.554	2	.277	2.023	.169
	Within Groups	1.917	14	.137		
	Total	2.471	16			
ITEM5	Between Groups	.221	2	.110	.686	.520
	Within Groups	2.250	14	.161		

	Total	2.471	16			
ITEM7	Between Groups	.025	2	.012	.187	.831
	Within Groups	.917	14	.065		
	Total	.941	16			
ITEM8	Between Groups	.098	2	.049	.412	.670
	Within Groups	1.667	14	.119		
	Total	1.765	16			
ITEM9	Between Groups	.025	2	.012	.187	.831
	Within Groups	.917	14	.065		
	Total	.941	16			
ITEM10	Between Groups	.025	2	.012	.187	.831
	Within Groups	.917	14	.065		
	Total	.941	16			
ITEM11	Between Groups	.059	2	.029	.137	.873
	Within Groups	3.000	14	.214		
	Total	3.059	16			
ITEM14	Between Groups	.098	2	.049	.412	.670
	Within Groups	1.667	14	.119		
	Total	1.765	16			
ITEM15	Between Groups	.025	2	.012	.187	.831
	Within Groups	.917	14	.065		
	Total	.941	16			
ITEM16	Between Groups	.098	2	.049	.412	.670
	Within Groups	1.667	14	.119		
	Total	1.765	16			
ITEM17	Between Groups	.221	2	.110	.686	.520
	Within Groups	2.250	14	.161		
	Total	2.471	16			
ITEM18	Between Groups	.025	2	.012	.187	.831
	Within Groups	.917	14	.065		
	Total	.941	16			
ITEM19	Between Groups	.098	2	.049	.412	.670
	Within Groups	1.667	14	.119		
	Total	1.765	16			
ITEM20	Between Groups	.025	2	.012	.187	.831
	Within Groups	.917	14	.065		
	Total	.941	16			
ITEM21	Between Groups	.025	2	.012	.187	.831
	Within Groups	.917	14	.065		
	Total	.941	16			
ITEM22	Between Groups	.221	2	.110	.686	.520
	Within Groups	2.250	14	.161		
	Total	2.471	16			
ITEM23	Between Groups	.025	2	.012	.187	.831

	Within Groups	.917	14	.065		
	Total	.941	16			
ITEM25	Between Groups	.054	2	.027	.156	.857
	Within Groups	2.417	14	.173		
	Total	2.471	16			
ITEM26	Between Groups	.098	2	.049	.412	.670
	Within Groups	1.667	14	.119		
	Total	1.765	16			
ITEM30	Between Groups	.221	2	.110	.686	.520
	Within Groups	2.250	14	.161		
	Total	2.471	16			

Table 3 test hypothesis on the relationship between Biology teachers' experience and their content knowledge in ecology.

Items 4, 5, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 30, all have p-values > 0.05, indicating no significant relationship between teacher experience and content knowledge in these items. This shows that teachers' experience do not have effect on teachers' content knowledge in ecology.

There is no significant relationship between Biology teacher's experience and their content knowledge in Ecology

Discussion of Findings

The findings reveal a generally strong content knowledge of Biology teachers on ecological concepts, underpinning effective teaching and student understanding. Respondents showed full or high correctness in key areas like factors influencing animal distribution in aquatic habitats, plant adaptations, trophic levels, and energy flow. This concurs with Onipede et al. (2025), who emphasize that teachers' robust pedagogical content knowledge (PCK) significantly enhances student comprehension in complex biology topics such as ecology. Their study demonstrates a positive correlation between enriched teacher content knowledge and students' academic performance.

Similarly, the respondents' consistent ability to identify aspects such as nitrogen cycling, ecological succession, and ecological relationships supports Tran Ho, Lepage, and Fang's (2023) findings that ecological literacy is a critical component of teacher training. They argue ecological literacy equips teachers to impart sustainable environmental perspectives effectively, promoting deeper conceptual understanding among learners. Franzen (2018) also highlights that ecological content proficiency is vital for fostering environmental awareness through science education, reinforcing the importance of teachers' content mastery.

The comprehensive knowledge across diverse ecological topics including halophyte adaptations and physiological mechanisms in desert reptiles reflects well-rounded ecological literacy among teachers. This aligns with Nwankwo (2023), who found that teacher preparedness in difficult biology concepts is crucial for vibrant teaching and learning. Strong content knowledge mitigates student difficulties in understanding complex ecological principles and supports integrating environmental sustainability in curricula, as emphasized by Kozima et al. (2023). They contend Biology teachers must possess advanced knowledge and teaching skills to address global sustainability challenges effectively.

Regarding the influence of teacher qualifications and experience, the rare significant differences in content knowledge suggest that mastery is widespread among the teachers sampled. Waugh (2025) argues that early-career Biology teachers quickly develop PCK and that overall content mastery stabilizes regardless of experience length. This suggests continuous professional development targeting content deepening and pedagogical skills may enhance teacher effectiveness more than qualifications or years of experience alone. Research by Olaoye et al. (2024) supports this by showing competence and pedagogical skills significantly impact student outcomes beyond formal qualifications. Voss et al. (2023) further stress that ongoing learning opportunities and practical teaching skills critically shape teachers' ability to convey content effectively.

The non-significant relationship between teaching experience and most ecological content knowledge items, except one, mirrors findings by Olatunji et al. (2025) and Mensah and Boateng (2023), who note that experience enhances some pedagogical aspects but not necessarily deeper ecological content mastery. Onipede (2025) advocates for continuous professional development focused on content and practical teaching methodology updates as a more effective route to improving biology teachers' efficacy than relying solely on experience. The results thus highlight the importance of professional growth opportunities to sustain and enhance ecological content knowledge critical to effective Biology teaching.

The findings from this research analysis reveal that most Biology teachers have adequate content knowledge in the concept of Ecology. This findings agrees with the findings of Molise (2021) who found that relevant qualifications improve teachers' content knowledge and competence in teaching financial literacy, highlighting the importance of subject specialization in augmenting teacher effectiveness. Similarly, Ene and Ikeh (2024) reported that teacher qualification and teaching experience combined significantly predict effective assessment practices among Biology teachers, indicating that qualifications can influence pedagogical aspects linked with content knowledge mastery. Conversely, some studies highlight minimal direct effects of teacher qualification on content knowledge alone, emphasizing that factors like teaching experience, pedagogical content knowledge (PCK), and practical skills also play crucial roles (Ajayi, 2019; Oladele & Banjo, 2024).

The lack of significant differences in most items suggests that educational qualification alone may not guarantee superior content knowledge and could be complemented by other factors such as continuous professional development, teaching experience, and pedagogical skills. Research by Olaoye et al. (2024) supports this, finding that teaching competence and pedagogical skills significantly contribute to student outcomes in biology beyond formal qualification. Moreover, Voss et al. (2023) emphasize that while formal qualifications provide foundational knowledge, practical teaching skills and ongoing learning opportunities critically shape teachers' capacity to translate content knowledge effectively to students.

The analysis examining the relationship between Biology teachers' teaching experience and their content knowledge in ecology reveals mostly non-significant results. Items 4, 5, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 30 have p-values greater than 0.05, implying no significant relationship between teaching experience and content knowledge for these topics. This evidence suggests that, generally, Biology teachers' experience does not strongly influence their content knowledge in ecology.

This finding echoes results from recent scholarly investigations into the impacts of teaching experience on science teachers' content expertise. For instance, a study by Olatunji and colleagues (2025) found that while experiential teaching positively correlates with pedagogical skills and classroom management, its direct impact on teachers' mastery of ecological content is often limited or inconsistent. Similarly, Mensah and Boateng (2023) reported that extensive teaching experience may enhance how teachers make connections across knowledge components, but does not necessarily improve their mastery of ecological content knowledge itself, supporting the observation that experience alone is not a guarantee of deeper content understanding in Biology. Moreover, Onipede (2025) highlights that practical skills competence, alongside pedagogical content knowledge, plays a more critical role in students' biological concept understanding than years of teaching experience alone. The author recommends that continuous professional development and training focused on updating content knowledge and practical teaching methodologies are more impactful in enhancing teachers' effectiveness than experience without ongoing learning.

The data and corroborating studies thus imply that while teaching experience contributes to various aspects of instructional quality, its direct effect on ecological content knowledge tends to be limited This underscores the importance of targeted in-service training and professional development to constantly refresh and deepen teacher content knowledge, especially in specialized and evolving areas like ecology. It also suggests that educational policy and school administration should balance valuing teaching experience with facilitating access to updated knowledge resources and capacity-building programs to optimize teachers' content competencies.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary of Findings

The study examined Biology Teachers' Content Knowledge on Concepts in Biology (Ecology). Four research questions were raised to guide this study. The study adopted the descriptive survey research design. The population of the study comprised all the Biology teachers while 17 respondents were sampled for the study. The sampling technique is the use of simple random sampling technique. The instrument used for data collection is a self-structured achievement test. This instrument was validated by the project supervisor and other lecturers in the Department of Curriculum and Instructional Technology (CIT), Faculty of Education, University of Benin. The data gathered was analysed using simple percentage, the hypotheses were tested using t-test and ANOVA. The findings from the study are as follows:

1. The study showed that Biology teachers possess generally strong content knowledge on difficult ecological concepts, demonstrating high accuracy in understanding key topics essential for effective teaching and student comprehension.
2. The study revealed that there is no significant effect of Biology teachers' educational qualifications or years of teaching experience on their content knowledge, indicating that mastery of ecological concepts is widespread regardless of these factors.

3. The study demonstrated that specific ecological topics related to environmental sustainability and plant adaptations are especially well understood by Biology teachers, reflecting their readiness to address contemporary environmental challenges within the curriculum.

Conclusion

Based on the findings of the study, it can be concluded that Biology teachers generally demonstrate strong content knowledge on the concept of ecology, which is fundamental for effective teaching and facilitating student understanding. The study showed that most teachers correctly identified and understood critical ecological principles such as animal distribution, plant adaptations, trophic relationships, and energy transfer within ecosystems. This strong content mastery suggests that the teachers are well-equipped to deliver the biology curriculum, especially in complex topics essential to ecological literacy and environmental education. The study also revealed that educational qualification and teaching experience do not significantly impact teachers' overall content knowledge on ecological concepts, reinforcing the idea that knowledge mastery among Biology teachers is generally consistent regardless of these factors. The study demonstrated that Biology teachers are prepared to tackle contemporary environmental issues through their sound grasp of ecological adaptation and sustainability concepts. This readiness positions them well to integrate sustainability education into their teaching, fostering environmental awareness among students.

Recommendation

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

1. Teachers should endeavour to find out the reasons behind students' failure in Ecology.

2. Teachers should constantly monitor students' knowledge on difficult concepts, specifically, in Ecology.

3. School administrator should constantly organize in service trainings to keep teachers informed on paradigm shift in teaching and learning to promote students' attainment.

4. Nigerian government should allocated adequate resources to support effective teaching and learning of ecology in schools.

Suggestions for Further Study

1. More research should assess students' ecological content knowledge and misconceptions to identify specific learning gaps, which can inform targeted interventions and curriculum design.

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APPENDIX
QUESTIONNAIRE
DEPARTMENT OF CURRICULUM AND INSTRUCTIONAL TECHNOLOGY
FACULTY OF EDUCATION
UNIVERSITY OF BENIN, BENIN CITY

QUESTIONNAIRE ON BIOLOGY TEACHERS' CONTENT KNOWLEDGE ON CONCEPTS IN BIOLOGY (ECOLOGY) [BTCKDCBE]

Note: This questionnaire is designed purely for research purposes on the research topic: Biology Teachers' Content Knowledge on Concepts in Biology (Ecology).

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. Gender: Male [ ] Female [ ]
2. Highest Educational Qualification: NCE [ ] PGD [ ] B.Ed/B.Sc (Ed) [ ] B.Sc. [ ] M.Ed/M.Sc (Ed) [ ] Ph.D [ ]
3. Teaching Experience: Less than 5 years [ ] 5 – 10 years [ ] 15 years and above [ ]

Section B: Achievement Test (Ecology)

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

1.Which of the following has the greatest influence on the distribution of animals in marine and freshwater habitats?

A. pH.

B. Salinity

C. Water current

D. Turbidity

2. Which of these groups of animals is likely to be found in fresh water?

A. Blood worm, pond skater and scorpion

B. Bloodworm, pond skater and dragonfly larva

C. Pond skates scorpion and dragonfly larva.

D. Pond skater, bloodworm and ant-lion.

3. One of the characteristics of plant in the savanna is the?

A. possession of thin, smooth barks

B. possession of large tap roots

C. production of seedlings on mother plant

D. possession of thick, flaky barks.

4. The salinity of a brackish environment.

A. increases immediately after rain

B. increases at the end of the rainy season

C. decreases with increase in micro-organisms

D. increases during the dry season

5. Free nitrogen is released to the atmosphere by

A. nitrogen fixing bacteria

B. nitrifying bacteria

C. denitrifying bacteria

D. saprophytic bacteria.

6. The most important factor which influence an organism's way of life in its habitat are

A. the physical and biotic environment

B. food and water availability

C. temperature. water, light and predator- prey relationship

D. Competition for food and space.

7. Organisms in an ecosystem are usually grouped according to their tropic level as

A. carnivores and epiphytes

B. consumers and parasites

C. producers and consumers

D. producers and saprophytes

8. A food web is more stable than a food chain because.

A. it contains more organisms

B. it has greater energy Source

C. it is not easy to destroy

D. every organism has an alternative food source.

9. Which of the following is likely to occur in a deciduous forest during the dry season?

A. New leaves are formed

B The trees die off.

C. The undergrowth increases

D. The ground becomes bare.

10. Which of these is NOT an adaptive feature for arboreal life?

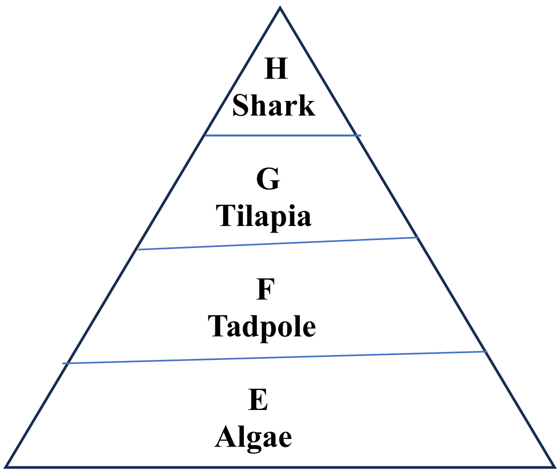
A. Possession of a long tail

B. Possession of claws

C. Possession of teeth

D. Counter shading in coat colour

Use the figure below to answer questions 11 and 12.



11. Which level of the pyramid has the least total stored CG DIL energy?

A. E

B.F

C. G

D. H

12. Which organism in the pyramid functions as a tertiary consumer?

A. Algae.

B. Shark.

C. Tadpole.

D. Tilapia.

13. An example of plant adaptation to a sarophysis environment is represented by the development of

A fleshy tissues and reduced leaves

B broad canopy and extensive surface root system

C thick barks and broad leaves

D. rough leaves and shallow root system.

14. Which of the following factors is LEAST to affect the animals thriving in a fresh water habitat?

A. Turbidity

B. Temperature

C. PH

D. Salinity

15. What is the term used to describe the sum total of biotic and abiotic factors in the environment of the organism?

A Habitat

B. Biome

C. Ecosystem.

D. Ecological

16. Important abiotic factors which affect all plants and animals in the habitat are

A temperature and turbidity

B. rainfall and relative humidity

C salinity and wind direction

D. temperature and rainfall

17. The most important physical factor which affects an organism living in the intertidal zone of the seashore is

A. pH

B. Salinity

C. wave action

D. temperature.

18. At which trophic level would the highest accumulation of a non-biodegrable substance occur?

A. Primary producer

B. Tertiary consumers.

C. Primary consumers

D. Secondary consumer

19. Two organisms of different species, living in close association but not dependent on each other are referred to as

A parasites

B. commensals

C. symbiots

D. autotrophs

20. Which of the following instruments is NOT used in measuring abiotic factors in any habitat?

A. Microscope

B. Thermometer

C. Hygrometer

D. Wind vane

21. Plants adapted for life in salty marash are called

A hydrophytes

B. serophytes

C. halophytes D. epiphytes

22. Which group plants would be the first colonizers in an ecological succession changing rocks to soil?

A. Messes

B. Ferns

C. Lichens

D. Grasses

23. What ecological condition favours the breading of blackflies?

A. Fresh water habitat

B. Water in ponds and Swamps

C. Water in small containers

D. Fast flowing streams

24. The most important environmental factor which epiphytes in the rain forest compete for is

A. Water

B. Nutrient

C. Light

D. Space.

25. The least adaptive feature for arboreal life is the

A. Possession of four limbs

B. Possesion of claws

C. Development of long tail

D. Counter shading of coat colour.

26. The association between termites and the cellulose-digesting protozoan in their guts is an example of

A. Saprophytism

B. Mutualism

C. parasitism

D. Commensalism

27. The progressive loss of energy at each level in a food chain leads to

A. An increase in biomass at each successive level

B. A decreased in biomes at each successive level

C. A increase in the number of organisms at each successive level

D. An increase in the total weight of living matter at each successive level.\

28. Organisms in an ecosystem are usually grouped according to their tropic level as

A. carnivores and epiphytes

B. consumers and parasites

C. producers and consumers

D. producers and saprophytes

29. One adaption of retiles to water loss in the presence of

A. Kertinous scales

B. Claws on limbs

C. Long tails

D. Long sticky tongues

30. A state in Nigeria that is most susceptible to desert encroachment is

A, Kwara

B. Taraba

C. Kaduna

D. Kastina

Keys

1. B
2. B
3. D
4. D
5. C
6. C
7. C
8. D
9. D
10. C
11. D
12. B
13. A
14. D
15. C
16. D
17. C
18. B
19. C
20. A
21. C
22. C
23. D
24. C
25. D
26. B
27. B
28. C
29. A
30. B