Journal of Educational Sciences
Journal homepage: https://jes.ejournal.unri.ac.id/index.php/JES

P-ISSN 2581-1657
E-ISSN 2581-2203

Decoding Difficulty: A Quantitative Analysis of Difficult Concept in the Biology Curriculum

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ARTICLE INFO

Article history:

Received: 04 June 2024
Revised: 27 July 2024
Accepted: 02 Oct 2024
Published online: 26 Oct 2024

Keywords:

Concept Difficulty;
Biology;
Gender

A B S T R A C T

The study sought to establish the concepts that students perceive to be difficult in the biology curriculum in Nigerian schools and key factors that contribute to the difficulties of the concepts. The study adopted a quantitative survey research design. The participants in this study were 340 students from senior secondary schools in Nigeria. Difficult Concept in Computer Studies Questionnaire (DCCSQ) (r=.80) was used to collect data for the study. It was revealed that nervous coordination, mitosis and meiosis, variation and evolution, regulation and Internal Environment were perceived to be very difficult. The study found that the most significant factors that students find to be enhancers of learning difficulty of biology concepts includes lack of instructional materials, the absence of well-equipped laboratories for practical teaching, large class sizes, complexity of topics and the broad biology curriculum. It was revealed that there was no statistically significant difference between male and female students in their perception of the difficulty of biology concepts. It was concluded that improving access to instructional materials, enhancing laboratory facilities, and addressing the complexity of the biology curriculum are critical steps needed to improve students' understanding of difficult biology concepts. It was recommended that teachers should also adopt more interactive teaching methods to engage students and enhance understanding.

1. Introduction

One of the core objectives of education in Nigeria is to foster a comprehensive understanding and application of knowledge across diverse aspects of life. However, improving the quality of education worldwide remains a significant challenge in the 21st century, with capacity building identified as a critical factor

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Doi: https://doi.org/10.31258/jes.8.4.p.570-581

in addressing this issue (Ike, 2017). Capacity building is widely recognized as essential to research and developmental activities, encompassing a broad range of academic fields. Many African nations are striving to cultivate a scientifically literate society, stressing the importance of basic scientific knowledge for individuals to understand and explain natural phenomena in their surroundings (Chapman, 2017).

The study of science, particularly biology, is crucial for advancing technological development in any nation. Recognizing the importance of biology in Africa's development, the 23rd Ordinary Session of the African Union Heads of State and Government in June 2014 adopted a 10-year Science, Technology, and Innovation Strategy for Africa (STISA-2024). This strategy, aligned with the AU Agenda 2063, aims to leverage science, technology, transformation, and innovation to achieve the continent's development goals. Biology-related disciplines are seen as critical in enabling Africa to improve living standards, transform economies, enhance regional and continental integration, uphold democratic values and principles of good governance, and preserve its cultural identity.

The primary objectives of the secondary school biology curriculum are to equip students with sufficient laboratory and field skills in biology, assess their understanding of the structure and functions of living organisms, and cultivate an appreciation for nature. These objectives include developing students' ability to conduct and evaluate biological experiments and projects, acquiring scientific skills such as observation, classification, and data interpretation, and gaining foundational knowledge necessary for advanced studies in biological sciences. Additionally, the curriculum aims to instill scientific attitudes for problem-solving, the ability to apply biological principles to personal, social, environmental, and economic issues, and to foster an understanding of the interrelationships between biology and other scientific disciplines (Adam, 2019).

The senior secondary school biology curriculum emphasizes the relationship between living and non-living entities, highlighting biology's relevance to agriculture, the structure and physiology of organisms, ecological principles, and the role of evolution and heredity in agriculture and medicine. Concepts are presented in a spiral format, progressing in complexity as students advance through the course (Kir, 2023). Field studies, guided discovery, and laboratory techniques are prioritized in the curriculum. The major themes covered include the organization of life, biological functioning, environmental interactions, and continuity of life. In Vocational High Schools in the field of tourism expertise, chemistry subjects are not studied directly as subjects, but are integrated into applied science subjects (Afinda, 2023).

In Nigeria's secondary biology curriculum, "topics" commonly refer to the subjects students are expected to learn. However, in academic literature, these topics are often referred to as "concepts" (Chan & Hume, 2019). Understanding the difficulty level of studying a concept or topic is essential for contextualizing this study. Gascoigne and Kelliher (2018) define difficulty as the excessive effort required to achieve a goal, and in education, this refers to the complexity students

face in understanding particular concepts. The perceived difficulty of a subject or concept is linked to the average student's ability to grasp it (Gbeleyi et al., 2022). Complexity, curricular overload, and a lack of practical instruction are significant factors contributing to the difficulty of certain topics (Ndayambaje et al., 2021). Additionally, fear, disinterest, and misconceptions further exacerbate the challenge of learning these topics.

Language is an important tool to express and communicate with the others (Sari, 2023). Since the mid-1950s, two dominant research strands have shaped the science education literature. The first focuses on how to attract students to science (Reis et al., 2012; Eam et al., 2019), while the second explores strategies to enhance students' achievement in science once they are engaged (Adam et al., 2024; Sung & Hwang, 2013; Akintoye et al., 2023). A central theme in these research directions has been the identification of science concepts that students perceive as difficult to learn. These challenging concepts often discourage students from pursuing science and hinder their academic performance. To advance the global effort to attract more students to science and improve their success, there is an urgent need to focus research at this intersection of difficulty and achievement. This study aims to address this gap in the literature.

Previous studies at this intersection have primarily focused on cataloging and listing difficult topics or concepts. In biology, lists of perceived challenging topics continue to be published (Cimer, 2012; Chukwuemeka & Dorgu, 2019; Ndayambaje et al., 2021; Anidu & Udoh, 2021). However, there are three notable shortcomings in this body of literature. First, few studies have examined how variables such as gender influence students' perception of difficulty in science topics, despite evidence that gender affects science achievement (Akintoye et al., 2024; Banerjee, 2016; Adam et al., 2023; Onowugbeda et al. 2024). Second, limited attention has been given to understanding the factors that exacerbate the difficulty of these topics. Third, there is a scarcity of research on topic difficulty in science within Africa, especially compared to studies conducted in other regions. Given Africa's consistent underperformance in science relative to other parts of the world, this lack of research into the specific science concepts that African students find challenging represents a significant gap in the literature. This gap hampers the ability of educators and policymakers to implement effective strategies to improve students' understanding of biology concepts. Consequently, this study seeks to investigate the biology topics in the secondary school curriculum that students perceive as difficult and identify factors that exacerbate the difficulty of these topics.

Research questions

The research questions to which answers were sought were:

1. What topics in the new biology curriculum do students find difficult to learn?
2. What are the factors that students find to be enhancers of learning difficulty of biology concepts?
3. Is there a statistically significant difference between male and female students in their perception of the difficulty of biology concepts?

2. Methodology

A quantitative research design was employed to collect data for this study. The *Difficult Concept in Biology Questionnaire* (DCBQ) was specifically designed and administered for this purpose. The study participants consisted of 340 secondary school students in Nigeria, drawn from an initial distribution of 380 questionnaires. These secondary schools were selected based on the criterion that they had taught biology for at least seven years, and all schools met this requirement. The *Difficult Concept in Biology Questionnaire* (DCBQ) was the primary tool for collecting quantitative data and was divided into five sections.

Section A gathered demographic information about the respondents, consisting of nine items, excluding their names to ensure anonymity. Section B presented 18 selected biology topics from the WAEC syllabus used across all Nigerian secondary schools. In this section, students rated each topic using a three-point scale: *very difficult*, *moderately difficult*, and *not difficult*. Section C explored the factors that influenced students' perceptions of difficulty for each topic. This section provided a list of reasons derived from a pilot study and employed a four-point Likert scale: *strongly agree (SA), agree (A), disagree (D),* and *strongly disagree (SD).* Section E asked students for suggestions on improving their study of biology, using the same four-point scale to avoid bias in responses. The four-point scale was considered appropriate and has been used in similar research (Awaah et al., 2021).

The DCBQ was validated by three experts in biology education. After validation, the instrument's test-retest reliability was measured two weeks after its initial administration to senior high school students, yielding a reliability coefficient of 0.80, indicating satisfactory reliability. To ensure anonymity, students were informed that their responses would not affect their annual appraisals, and the study's primary objective was explained as a way to improve the school's assessment methods, ultimately enhancing the quality of teaching and learning. Permission to conduct the study was obtained from school administrators, and the research team created a relaxed and friendly environment with the assistance of principals and teachers, encouraging students to participate willingly. In the final phase of data collection, all participants signed a consent form attached to the questionnaire, affirming their voluntary participation under the school's authority. IBM-SPSS Version 23 was used for the analysis. In the coding process, a score of 1 was assigned for *not difficult*, 2 for *moderately difficult*, and 3 for *very difficult*. Each respondent received an overall difficulty score ranging from 1 to 3 based on their responses.

3. Results and Discussion

Research question one examined the topics in the new biology curriculum do students find difficult to learn. This was answered using percentage of difficulty of the topics in the biology curriculum as seen in Table 1.

Table 1.Level of Topic Difficulty in Biology Among Secondary School Students

S/N	Topics	Not Difficult	Moderately Difficult	Very Difficult
1.	Energy Flow in Ecosystem	42.6%	39.6%	17.8%
2.	Micro-Organisms	88.2%	8.8%	2.9%
3.	Cellular Respiration	48.5%	30.7%	20.8%
4.	Respiratory System	60.8%	23.5%	15.7%
5.	Digestive System	70.6%	15.7%	13.7%
6.	Excretion	57.8%	14.7%	27.5%
7.	Nutrition	72.3%	26.7%	1.0%
8.	Nutrient Cycle	44.1%	32.4%	23.5%
9.	Ecological Management	35.3%	30.4%	34.3%
10.	Nervous Coordination	11.8%	34.3%	53.9%
11.	Reproduction In Mammals	50.0%	28.4%	21.6%
12.	Adaptation For Survival	40.2%	31.4%	28.4%
13.	Genetics	37.3%	28.4%	34.3%
14.	Tissues And Supportive System	45.5%	23.8%	30.7%
15.	Transport System	56.4%	23.8%	19.8%
16.	Regulation of Internal Environment	23.8%	34.7%	41.6%
17.	Variation And Evolution	16.7%	38.2%	45.1%
18.	Conservation Of Natural Resources	41.2%	34.3%	24.5%
19.	Adaptation For Survival	53.9%	24.5%	21.6%
20.	Sense Organs	79.4%	13.7%	6.9%
21.	Classification Of Plants	86.3%	10.8%	2.9%
22.	Classification Of Animals	84.3%	11.8%	3.9%
23.	Mitosis And Meiosis	23.5%	29.4%	47.1%
24.	Habitats	79.4%	19.6%	1.0%
25.	Fruits	75.2%	13.9%	10.9%
26.	Ecology Of Population and Ecological Succession	46.5%	25.7%	27.7%

Table 1 presents students' perceptions of the difficulty levels associated with 26 topics in the Nigerian biology curriculum. The topics identified as the most challenging, indicated by the highest percentages for "Very Difficult," are as follows: Nervous Coordination (53.9%), Mitosis and Meiosis (47.1%), Variation and Evolution (45.1%), and Regulation of Internal Environment (41.6%). Conversely, the topics perceived as least difficult, characterized by high percentages for "Not Difficult," include Micro-Organisms (88.2%), Classification of Plants (86.3%), Classification of Animals (84.3%), Sense Organs (79.4%), and Habitats (79.4%). Figure 1 illustrates that Nervous Coordination is regarded as the most difficult concept, while Habitats is viewed as the least difficult within the biology curriculum.

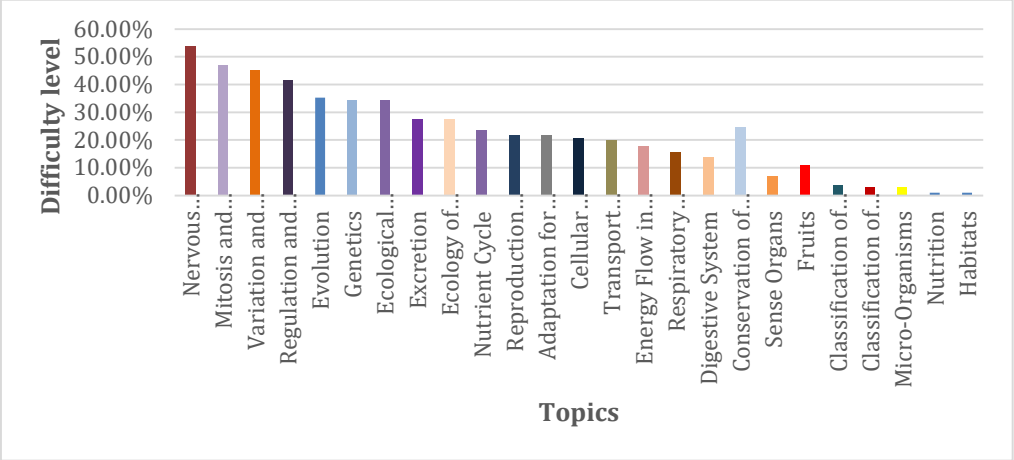

Figure 1. Ranking of Difficult Concepts in the Biology Curriculum

Research question two examined the factors that students find to be enhancers of learning difficulty of biology concepts. This was answered using percentage as seen in Table 2.

Table 2. Factors Contributing to Learning Difficulties in Biology as Perceived by Students

S/N	Factors	Strongly Disagree	Disagree	Agree	Strongly Agree
1.	Poor Students Study Habits	16.8%	31.7%	35.6%	15.8%
2.	Poor Attitude of Teachers Towards Teaching	23.0%	47.0%	16.0%	14.0%
3.	Unavailable Instructional Materials	9.9%	13.9%	41.6%	34.7%
4.	Complexity Of Topics	11.9%	33.7%	29.7%	24.8%
5.	Ineffective Teaching Methods	15.8%	27.7%	38.6%	17.8%
6.	Lack Of Practical Classes	13.9%	28.7%	22.8%	34.7%
7.	No Equipped Laboratory for Practical Teaching	9.0%	21.0%	25.0%	45.0%
8.	Abstractness Of Topic	19.8%	34.7%	32.7%	12.9%
9.	Low Commitment to Work by Teachers	22.8%	46.5%	20.8%	9.9%
10.	Wrong Assignment of Teachers	47.5%	35.6%	11.9%	5.0%
11.	Poor Knowledge of The Topic by The Teacher	34.7%	40.6%	16.8%	7.9%
12.	Biology Curriculum Is Too Wide	16.8%	20.8%	37.6%	24.8%
13.	Misconception Of Some Topics	14.1%	36.4%	31.3%	18.2%
14.	Insufficient Time Allocation	15.2%	37.4%	27.3%	20.2%
15.	Large Numbers of Students In A Class	15.8%	24.8%	22.8%	36.6%
16.	The Topic/Subject is not related to my Career	30.7%	17.8%	23.8%	27.7%
17.	Too Many Difficult Terms	19.0%	37.0%	29.0%	15.0%

The table highlights key factors that contribute to students' learning difficulties in biology. The most significant factors include the lack of instructional materials (76.3% agreement), the absence of well-equipped laboratories for practical

teaching (70%), and large class sizes (59.4%). Complexity of topics (54.5%) and the wide biology curriculum (62.4%) are also perceived as major challenges. Other important factors include the lack of practical classes (57.5%), ineffective teaching methods (56.4%), and the use of too many difficult terms (44%). Poor study habits, misconceptions, and insufficient time allocation also impact learning, while issues like the wrong assignment of teachers and poor teacher knowledge were less influential. Overall, practical resource limitations and teaching methods are the primary enhancers of learning difficulty in biology.
Research question three addresses the statistically significant difference between male and female students in their perception of the difficulty of biology concepts. This was analysed using t-test as shown in Table 3.

Table 3. T-Test Showing The Difference Between Male and Female Students in Their Perception of The Difficulty of Biology Concepts

Group	N	Mean	SD	T	P(Sig)Level
Male	150	3.77	0.33	1.83	.07(ns)
Female	190	3.65	0.32		

It was revealed from table 3 that there was no statistically significant difference between male and female students in their perception of the difficulty of biology concepts [t (339) = .07; p>.05]. Therefore, the null hypothesis which states that there is no statistically significant difference between male and female students in their perception of the difficulty of biology concepts is not rejected.

Disccussion of Findings

Research question one investigated the concepts that students perceive as difficult within the Nigerian biology curriculum. The findings indicated that Nervous Coordination, Mitosis and Meiosis, Variation and Evolution, and Regulation of Internal Environment were considered very difficult. This aligns with the findings of Obiageli and Nwankwo (2024), which identified that secondary school biology topics perceived as most challenging by students include Genetics, Mitosis and Meiosis, Nervous Coordination, Regulation of Internal Environment, and Supporting Tissues in Plants and Animals, among others.

These perceived difficulties may result from the These topics require a deep understanding of abstract processes, many of which occur at microscopic or cellular levels, making them less tangible and harder to visualise. For instance, Nervous Coordination involves complex physiological mechanisms that are difficult to grasp without advanced knowledge of the nervous system, while Mitosis and Meiosis are often confused due to their similar phases and terminology. Furthermore, Variation and Evolution introduce concepts that demand an understanding of genetics, adaptation, and time scales, which can seem overwhelming. Similarly, Regulation and Internal Environment deals with homeostatic processes, requiring students to link various biological systems, making it conceptually demanding. These difficulties may also stem from the abstract nature of the topics, the reliance on memorisation, and the lack of

interactive or visual teaching aids that could make these processes more comprehensible. Additionally, the overlap between different biological concepts, along with the integration of mathematical and statistical reasoning in topics like evolution and variation, often presents further challenges for students. To address these challenges, educators should consider curriculum adjustments that incorporate interactive tools like simulations and visual aids, and focus on conceptual clarity rather than memorisation. Enhanced teacher training and tailored learning resources could also make these topics more accessible. The findings suggest that biology students would benefit from more engaging and hands-on teaching methods, helping to reduce cognitive barriers and improve student comprehension of these essential concepts.

Research question two examined the factors that students find to be enhancers of learning difficulty of biology concepts. It was revealed that the most significant factors include the lack of instructional materials, the absence of well-equipped laboratories for practical teaching, large class sizes, complexity of topics and the broad biology curriculum. This finding agrees with that of Ndayambaje et al. (2021) who revealed that the root causes of the students' poor performance in Biology are insufficient laboratory equipment, insufficient teaching and learning materials and inappropriate teaching methodology and english language as medium of instruction. One of the most critical factors is the lack of instructional materials. Biology, as a subject, requires visual aids, models, diagrams, and multimedia tools to simplify complex concepts such as cellular processes, anatomical structures, and ecosystems. Without access to appropriate materials, students are left to rely on rote memorisation, which hinders their ability to engage deeply with the content. For example, trying to learn about *mitosis* and *meiosis* without the aid of visual animations or microscope slides makes it difficult for students to differentiate between phases and processes that are otherwise abstract and invisible to the naked eye. This limitation restricts students' ability to grasp concepts holistically, leading to a superficial understanding that increases frustration and anxiety.

The absence of well-equipped laboratories further exacerbates this problem. Practical teaching is essential in biology, as hands-on experiments and investigations foster active learning, reinforcing theoretical knowledge. Well-equipped laboratories allow students to engage in dissections, observe microorganisms, and conduct experiments that are integral to understanding the nature of biological processes. Without these practical opportunities, students are deprived of experiential learning, which not only makes biology more relatable and engaging but also aids in the retention of knowledge. A lack of laboratory experiences leaves students disconnected from the real-world applications of biological principles, increasing the perceived difficulty of mastering the subject.
Large class sizes present another significant challenge, particularly in resource-constrained environments. In large classrooms, teachers are unable to provide personalised attention, and students find it difficult to ask questions, engage in discussions, or seek clarification. The interactive nature of biology, which benefits from inquiry-based learning and collaborative discussions, becomes compromised in overcrowded classrooms. This results in disengagement and reduced

participation, as students may feel lost or overlooked. Additionally, managing practical lessons with large groups becomes nearly impossible, further limiting the opportunities for hands-on learning and experimentation.

Research question three addresses the statistically significant difference between male and female students in their perception of the difficulty of biology concepts. It was revealed that there was no statistically significant difference between male and female students in their perception of the difficulty of biology concepts. This finding aligns with that of Anidu & Udoh, (2021) which revealed that gender had no influence on the final year Biology education students' perception of difficult topics from the Secondary School Biology Curriculum. The finding suggests that both genders face similar challenges when engaging with the subject matter. This result points to a more generalised experience of learning biology, one that is not influenced by gender but rather by the inherent nature of the subject and the learning environment.

One possible reason for this lack of gender-based difference could be that the difficulties associated with learning biology stem primarily from external factors, such as the complexity of the content, teaching methods, and available resources, rather than from differences in cognitive or emotional responses between male and female students. As biology involves intricate processes such as *mitosis* and *meiosis*, complex theories like *evolution* and *nervous coordination*, and abstract concepts like *variation*, the struggle to comprehend these topics is likely uniform across genders. Male and female students are equally affected by these intellectual challenges, especially when instruction does not sufficiently break down complex ideas into more understandable units.

Additionally, in modern educational settings, the push for gender equity and inclusivity may contribute to an environment where both male and female students receive similar learning experiences and opportunities, leading to comparable perceptions of difficulty. Teaching strategies that foster inclusivity, combined with efforts to treat all students equally regardless of gender, may minimise any variations in how male and female students' approach or perceive the difficulty of biological concepts. The result is that both genders feel equally supported (or unsupported) in their learning processes, with no significant divergence in their perceptions of difficulty.

Another factor contributing to this finding could be that biology, unlike certain other STEM subjects, does not carry the same level of gender stereotypes regarding performance. In disciplines like mathematics or physics, long-standing cultural biases often suggest that one gender may be more naturally inclined towards the subject than the other. However, biology is often viewed as a life science with more diverse applications, ranging from medicine to environmental studies, which appeals to a broad spectrum of students. This lack of stereotyping might result in a more neutral learning environment where male and female students feel equally capable, thus leading to no significant difference in their perception of the difficulty of biology concepts.

4. Conclusion

This quantitative survey involving 340 secondary school students in Nigeria investigated the topics within the biology curriculum that students perceive as difficult, the factors that contribute to the perceived difficulty of biology concepts, and differences in perceptions between male and female students. The study revealed that students identified Nervous Coordination, Mitosis and Meiosis, Variation and Evolution, and Regulation of Internal Environment as challenging concepts. The findings indicated that several factors, including a lack of instructional materials, the absence of well-equipped laboratories for practical teaching, large class sizes, the complexity of topics, and the broad nature of the biology curriculum, significantly contributed to the difficulty of these concepts. Furthermore, no statistically significant difference was found between male and female students regarding their perceptions of the difficulty of biology concepts.

Based on these findings, the study suggests that schools and policymakers should prioritize providing adequate instructional materials and well-equipped laboratories to enhance practical teaching. Additionally, reducing class sizes would foster more personalized instruction and improve the quality of interaction between teachers and students. Simplifying or segmenting the broad biology curriculum to concentrate on key topics more thoroughly would also benefit students' understanding. It is recommended that teachers employ more interactive and student-centered teaching strategies to break down complex topics and make them more relatable. Future research should explore specific teaching strategies that effectively simplify and clarify difficult biology concepts. Investigating how digital tools and technologies could enhance student comprehension of these complex concepts would also be valuable. Lastly, conducting a longitudinal study could assess how changes in instructional materials, class size, and curriculum structure impact students' understanding of biology over time.

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How to cite this article:

Adam, U. A., Owolabi, T., Lameed, S., Ubaka, C., & Joy, A. T. (2024). Decoding Difficulty: A Quantitative Analysis of Difficult Concept in the Biology Curriculum. *Journal of Educational Sciences, 8(4)*, 570-581.