REMEDIATING STUDENTS' MISCONCEPTIONS IN BIOLOGY: A REVIEW

BY

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Abstract

Misconceptions in biology are persistent among students and can significantly obstruct their understanding of fundamental concepts in biology, leading to gaps in knowledge that persist throughout their education. This study explores the origins of common misconceptions in biology and examines the effectiveness of various remediation strategies implemented in educational settings. The study highlights approach such as active learning, conceptual change models, peer instruction, formative assessment, and technology-enhanced learning as effective methods for identify and remediating misconceptions. Each strategy is examined for its ability to engage students, promote conceptual understanding, improve engagement and foster long-term retention of accurate biological knowledge. The study also discusses the challenges associated with these remediation efforts, *including the persistence of deeply ingrained misconceptions and the necessity for teachers to be adequately trained in identifying and addressing these issues. The findings underscore the importance of a multifaceted approach to teaching biology, where remediation of misconceptions is integrated into the curriculum to support deeper learning. This study concludes that identifying and remediating biology students' misconceptions is crucial aspect in fostering a deep and accurate understanding of concepts in biology*

Keywords: Remediation, misconceptions, Biology, students, review

Introduction

Biology as one of the fields of science that examines living organisms and their surroundings. It is one of the science courses offered at secondary school level of education in Nigeria. The objectives of biology in the Nigeria includes to enhance understanding of living organisms, their interactions with the environment, and the mechanisms behind life processes which can then be applied to improve human health, agriculture, and environmental sustainability. According to Muraya and Kimano (2011), Biology provides people with the opportunity to learn about the world around them, which can help them become more aware about their surroundings, their health, and the society they live in. Additionally, studying biology gives students the skills, information, and mindset they need to maintain and govern their surroundings. Despite the importance of biology, the student's performance in biology concepts is inconsistency and has been a major concern to stakeholders in the field of science education.

Biology is one of the sciences that is closely related to natural phenomena and has concepts that are abstract, complex and contain numerous difficult terms such as ecology, heredity, evolution, meiosis and mitosis which commonly leads to a difficulty among students in understanding the concept correctly. Difficulties in understanding the concept leads to misconceptions which is not in accordance with the understanding or conception agreed upon by scientists in their field (Suparno, 2013). The difficulties experienced by students can be caused by several factors including the learning strategies brought by the teacher because of their teaching methods, student habits in learning, low learning intensity, students' fear of certain topics, and the lack of learning resources (Etobro & Fabinu, 2017). Students who have difficulty understanding and interpreting concepts will interpret the concepts they are learning on their own, causing misconceptions in themselves (Kamilah & Suwarna, 2019). Misconception as a major factor contributing to student's poor performance in biology (Ogundare et al., 2020) is defined as the difference in thinking between a person's concept and the concept of scientific theory determined by experts (Putri et al., 2021). Misconception refers to a concept that is incompatible with the scientific understanding or understanding accepted by experts in the field (Maryanti et al., 2022). Misconceptions can occur because of the acceptance of wrong information, integration errors, and perceptions that are not the same as scientific principles (Duda et al., 2020). Misconceptions can be formed from a discrepancy between the knowledge possessed by students and the theory being studied or taught (Nandiyanto et al., 2022). Which can cause delays in the transfer of new information related to the concepts to be learned by students (Rukmana, 2017). Misconceptions that emerge regularly can impede the formation of scientific concepts in students and teachers (Chaniarosi, 2014).

Students' misconceptions obstruct further learning, preventing new knowledge from being properly integrated (Costu et al., 2009). Misconceptions can cause students to misunderstand scientific phenomena. Misconceptions will become a hindrance for students in the next learning process if they are not immediately remedied. As a result, it is critical to identify misconceptions so that efforts can be made to improve the learning process and arrange remediation activities to correct misconceptions in learning ecology. The goal of remediation activities is to improve student learning issues (Rasim et al., 2021). Misconceptions must be carefully identified so that teachers can implement the best learning method. To determine whether students have misconceptions, extensive identification is required which is the main purpose of this study

Purpose of the Review

The objective of this review is to examine the various strategies and approaches used to identify and remediate student' misconceptions in biology. It aims to analyze the effectiveness of different interventions, from traditional instructional methods to more innovative techniques such as inquiry-based learning and digital tools. By synthesizing existing research, this review seeks to provide insights into best practices for educators and contribute to the development of more effective biology education. Ultimately, it aims to development of more effective and engaging biology instruction and also to enhance the understanding of how to address and remediate misconceptions to improve students' outcomes in the biology education.

Literature Review

This study thrust on constructivism learning theory of Jean Piaget (1896–1980) which emphasizes the active role of learners in building their own understanding. Rather than passively acquire knowledge through direct instruction. Instead, they construct their understanding through experiences and social interaction, integrating new information with their existing knowledge into their schemas to promote deeper learning and understanding.

A constructivist theory has to do with students' ability or capacity to construct their own knowledge through self-modification of cognitive structures (Iddrisu et al., 2017) which involves a student to accommodate a new information. It is during the accommodation process that the knowledge is refined and reorganized. Also, students can as well develop misconceptions during the accommodation process. As such, students brought with them to class ideas from interacting with the environment, the feature which may either resonate or be inconsistent with the accepted scientific concepts. Such ideas, though inconsistent with some accepted norms by the scientific community, are of interest in this study. Misconceptions are unavoidable stages in knowledge acquisition (Fumador & Agyei, 2018). Therefore, there is a need for further research on and for better understanding and role of misconceptions in teaching and learning scientific concepts.

Common Misconceptions in Biology

Misconceptions in biology are common and span a variety of core topics, often rooted in students' prior experiences or misunderstandings of complex scientific concepts (Wahyono & Susetyarini, 2021). Some of the most prevalent biological concept's misconceptions include:

In ecology, students often misunderstand the nature of ecosystems and the relationships within them. A frequent misconception is the idea that all organisms in an ecosystem are equally affected by environmental changes, failing to recognize the different roles organisms play in food chains and food webs (Bello et al., 2026). Students may also misunderstand the flow of energy in an ecosystem, such as believing that energy cycles like matter, rather than understanding that energy flows in one direction and is eventually lost as heat (Johnson & Cincera, 2019). Most students often confuse the processes of photosynthesis and cellular respiration. A prevalent misconception is the belief that plants only photosynthesize during the day and stop completely at night, rather than understanding that cellular respiration occurs continuously (Svandova, 2014). Additionally, students sometimes fail to grasp that plants produce their own food through photosynthesis, mistakenly thinking that plants obtain food from their surroundings like animals do.

Furthermore, students frequently misunderstand the relationship between dominant and recessive traits. A common misconception is that dominant traits are inherently more prevalent in populations, or that they are stronger than recessive traits, which is not always true. Misconceptions also extend to the nature of inheritance (Makhrus, & Busyairi, 2022), with many of the students confusing genotype and phenotype, or believing the fact that inherited traits are a blend of parental characteristics rather than being dictated by specific genetic combinations. Turkmen and Usta (2007) concluded that a big deal about misconceptions is that, it cannot be easily change if left unaddressed and can obstruct students' understanding of biology and hinder their ability to apply biological concepts to real-world situations. Identifying these misconceptions is crucial for teachers to adapt instruction that effectively challenges and corrects them.

Remediation Strategies

To effectively address and correct misconceptions in biology, teachers should employ a variety of instructional methods and interventions, each designed to challenge students' existing misunderstandings and promote conceptual change. Key strategies include:

Conceptual Change Instruction: This method is rooted in the Conceptual Change Model, which focuses on directly confronting students' misconceptions by creating cognitive conflict (Mufit et al., 2023). It can be done when teachers present situations that challenge incorrect beliefs, encouraging students to recognize inconsistencies in their understanding (Tatag et al., 2017). For instance, in teaching evolution, teachers might use evidence from fossil records and comparative anatomy to counteract the misconception that individuals evolve. By presenting data that contradicts faulty ideas, students are guided toward revising their thinking.

Inquiry-based learning encourages students to actively engage in the scientific process by posing questions, conducting experiments, and drawing conclusions based on evidence (Muktar & Asistar, 2020). This hands-on, exploratory approach helps students confront their misconceptions through direct experience (Kigba et al., 2021). For example, in teaching cellular respiration, students might conduct experiments to measure the respiration rates of different organisms under various conditions. This allows them to see firsthand how respiration occurs continuously, even when photosynthesis does not.

Analogies and models are frequently used to help Students Bridge the gap between their misconceptions and accurate scientific concepts (Coll et al., 2015). Well-chosen analogies can make abstract biological processes more tangible (Mohammed et al., 2022). For example, comparing the process of photosynthesis to a factory assembly line can help students visualize how plants produce food. However, care must be taken to ensure that analogies are clear and do not introduce new misconceptions (Mammino, 2024).

Peer instruction involves students working in groups to discuss and solve problems, allowing them to articulate and challenge each other's ideas (Antwi, et al., 2016). This method has been shown to be effective in addressing misconceptions because students often learn well from peers who can explain concepts in accessible terms.

For instance, during discussions on genetics, students can work together to solve Punnett square problems, helping each other identify and correct misunderstandings about inheritance patterns (Aurah et al., 2014).

Frequent formative assessments, such as quizzes, concept inventories, or clicker questions, is another strategy that can be used to identify and address misconceptions in real time (Enu & Ngcobo, 2020). These assessments provide immediate feedback to both students and instructors, allowing for the correction of misunderstandings before they become entrenched (Carney et al., 2022). For example, after a lesson on evolution, a concept inventory could reveal that students still hold Lamarckian views of inheritance, enabling the teacher to revisit and clarify the concept.

Digital tools and simulations offer students opportunities to visualize and interact with complex biological processes in ways that traditional instruction cannot (Asare et al., 2023). Virtual labs, interactive animations, and simulations can be particularly effective in remediating misconceptions. For instance, a simulation showing the energy flow through an ecosystem can help students understand the one-way flow of energy, challenging the misconception that energy cycles like matter. Teaching students' metacognitive skills such as how to reflect on their own understanding, identify gaps in their knowledge, and apply critical thinking can help them become more aware of their misconceptions and take an active role in correcting them (Tabanli, 2023). For example, students might keep reflective journals where they note moments of confusion and how they resolve these conflicts over time.

Simulations and virtual labs allow students to engage with biological processes and experiments in a controlled, risk-free environment (Byukusenge et al., 2022). These tools provide opportunities to visualize and manipulate systems that are otherwise difficult to observe in real life. For instance, virtual labs on topics like cellular respiration, photosynthesis, or ecosystems let students run experiments and manipulate variables in ways that would be impractical in a classroom setting. Through these simulations, students can visualize abstract processes and see the real-time effects of changes, helping to correct misconceptions. For example, a simulation showing the breakdown of glucose during cellular respiration can help dispel the misconception that plants only respire at night or that respiration stops in the absence of photosynthesis.

Educational software and apps designed for biology education provide students with interactive content that reinforces correct biological concepts (Tavares et al.,

2021). These tools often include gamified learning, quizzes, and real-time feedback that help students identify misconceptions early on. Using game-based learning and immersive experiences to challenge students' misunderstandings. The immediate feedback and corrective scaffolding embedded in these platforms promote the gradual correction of misconceptions.
Each of these instructional methods can be individually or in conjunction, depending on the context and the specific misconceptions being addressed to help students construct a more accurate understanding of biological concepts, fostering deeper learning. Assessment and feedback form a critical foundation for addressing and remediating students' misconceptions in biology (Soeharto et al.., 2019). By providing a clear window into student understanding, these tools equip teachers to adapt instruction effectively, formative assessments, such as quizzes or classroom questioning, offer ongoing insights into student learning, enabling teachers to identify misconceptions early in the learning process (Ozan & Kıncal 2017; Yazidi, 2023). Summative assessments, like final exams or projects, provide a comprehensive overview of student knowledge, revealing persistent misconceptions.

Diagnostic assessments, designed specifically to identify misconceptions, investigate into students' thinking capacity. Concept inventories, focusing on specific concepts, can accurately identify common misconceptions (Eric et al., 2021; Kanwal & Farooq, 2021). Feedback serves as the bridge between assessment and improvement. Descriptive feedback, offering specific details about student performance, guides students towards growth. Actionable feedback provides clear steps for improvement, empowering students to take ownership of their learning (Uloh-Bethels et al., 2024). Timely feedback maximizes its impact, while student-centered feedback fosters self-reflection and independence. By investigating misconceptions through assessment and providing targeted feedback, educators can create a dynamic learning environment (Elmahdi et al., 2018). This approach not only corrects misconceptions but also cultivates metacognition, enabling students to become independent learners. Ultimately, the synergy between assessment and feedback drives instructional improvement, leading to a deeper and more enduring understanding of biological concepts (Zou et al., 2024).

Effectiveness of remediation Approaches

Remediation approaches play a significant role in addressing academic challenges encountered by students (Kilag et al., 2023); these approaches have to do with various arrangement of interventions, including personalized tutoring, adaptive learning technologies, targeted skill-building exercises and collaborative learning environments (Ogundare et al., 2024). The effectiveness of these remediation approach profoundly influences students' academic performance, provide enablement to overcome obstacles and achieve their full potential in sciences concepts (Zhao et al., 2022)

Refutational texts can be openly use to refute common misconceptions while presenting correct information has been shown to improve students' understanding of complex biological concepts, such as natural selection and ecological dynamics (Mason et al., 2022). The application of Posner's conceptual change model is also an effective approach in addressing misconceptions. It has been shows that by providing alternative conceptions and engaging students in reflective thinking, misconceptions about genetics and evolution can be successfully corrected (Ryu & Sandoval, 2020). The integration of digital tools such as virtual labs and gamified learning platforms has been shown to engage students and improve their understanding of biological concepts. These tools can enhance conceptual clarity and retention (Jiang et al., 2023). The use of online platforms for collaborative learning and interactive content has demonstrated effectiveness in remediation efforts, particularly in providing diverse and flexible learning opportunities (Bowers et al., 2024).

Crouch & Mazur (2018) found that peer instruction, where students teach each other, can effectively address misconceptions by allowing students to articulate their understanding and receive immediate feedback. Likewise, collaborative group work fosters discussion and deeper understanding of biological concepts. Johnson et al. (2021) found that students working in groups can correct misconceptions more effectively than those working individually. Interactive simulations and visualizations significantly enhance students' understanding of complex biological processes by providing dynamic and interactive representations. For instance, studies shown that students using interactive simulations exhibit a better grasp of photosynthesis and cellular respiration concepts compared to traditional methods (Liao et al., 2021). Studies have discussed the effectiveness of formative assessments in diagnosing and addressing misconceptions. Emphasis is on tools such as concept maps and clicker questions are effective in identifying and correcting misconceptions in real-time (Black & Wiliam, 2018) another remediation approach is timely and targeted feedback from formative assessments helps students revise their understanding and overcome misconceptions (Hattie & Timperley, 2017).

Despite the effectiveness of these strategies, challenges remain. Misconceptions are often deeply ingrained and can persist even after targeted instruction. Additionally, students may resist changing their beliefs, especially when misconceptions align with intuitive reasoning or cultural beliefs. Overcoming these barriers requires patience, persistence, and a multifaceted approach that combines different remediation strategies. Another challenge is the need for teachers to be aware of common misconceptions and to have the skills and resources to address them effectively. Professional development and ongoing support for educators are crucial to ensure that they can implement these strategies successfully.

Discussion

To effectively remediate misconceptions, biology educators must be proactive in identifying and addressing these incorrect ideas. This involves not only teaching correct concepts but also explicitly confronting and refuting misconceptions. Curriculum design should incorporate opportunities for students to explore and correct their misunderstandings through inquiry-based learning, real-world applications, and continuous formative assessment. Moreover, educators should be encouraged to create a classroom environment that supports critical thinking and open discussion, where students feel comfortable expressing their ideas and misconceptions without fear of judgment. This can foster a deeper understanding and appreciation of scientific concepts, ultimately leading to more scientifically literate students.

Conclusion

Identifying and remediating biology students' misconceptions is crucial aspect in fostering a deep and accurate understanding of concepts in biology. These misconceptions, often rooted in intuitive but incorrect ideas, prior experiences, or instructional oversimplifications, can significantly hinder student' learning and retention of scientific knowledge. Finally, the ongoing research and innovation in remediation strategies hold promise for improving biology education. By effectively addressing misconceptions, teachers can help students build a solid foundation in biology, better preparing them for advanced scientific learning and enabling them to apply their knowledge in real-world contexts. Continued focus on this area is essential for enhancing science literacy and ensuring that students are equipped to understand and engage with the complexities of the biological world.

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