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The Role of Inquiry Based Learning in Promoting Scientific Literacy in Biology Education

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Abstract **Original Research Article**

Scientific literacy remains a central concern in Biology education due to persistent reports of weak conceptual understanding, limited reasoning ability, and poor application of biological knowledge among secondary school students in Nigeria. Instructional practices in many classrooms continue to rely on teacher directed approaches that provide limited opportunities for learners to actively construct knowledge. This paper examines the role of inquiry-based learning in promoting scientific literacy in Biology education. The discussion is anchored on constructivist learning theory and inquiry learning theory, which explain learning as an active process shaped through questioning, investigation, and reflective thinking. Relevant empirical studies conducted within and outside Nigeria between 2018 and 2025 are examined to show how inquiry oriented instructional practices influence students' understanding of biological concepts, process skills, and scientific reasoning. The paper also considers the implications of inquiry based learning for Biology teachers and curriculum implementation within the Nigerian education system. Suggestions are provided to guide effective classroom practice and teacher preparation with the aim of improving scientific literacy outcomes in secondary school Biology.

Keywords: Inquiry Based Learning, Scientific Literacy, Biology Education, Secondary School Students, Constructivist Learning, Instructional Practices.

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Introduction

Science education today is expected to do more than prepare students for examinations. It should help learners understand science in a way that shapes how they think, reason, and respond to issues in society. When students truly understand science, they can examine evidence carefully, explain ideas clearly, and make sound judgments about matters that affect their lives. This broader capacity is what scholars describe as scientific literacy (Bybee, 2021; Organization for Economic Cooperation and Development, 2023).

Within this broader expectation of science education, Biology becomes especially significant because it is one of the main subjects through which scientific literacy is developed at the secondary school level.

Biology occupies a vital position within the Nigerian secondary school curriculum because of its relevance to health, agriculture, environmental sustainability, and technological advancement. As a core science

subject, Biology equips learners with scientific knowledge, inquiry skills, and reasoning abilities necessary for informed decision-making in personal and societal contexts (Bybee, 2021; Lederman et al., 2023). Despite these expectations, reports from public examinations and classroom observations consistently reveal that many students complete secondary school with superficial understanding of biological concepts and limited capacity to apply knowledge to real-life situations. The way Biology is taught therefore influences how students interpret real life problems. If learning remains limited to memorizing notes and reproducing information, students may succeed in examinations but struggle to apply knowledge meaningfully outside the classroom. This trend raises serious concerns about the level of scientific literacy being achieved through Biology instruction in Nigerian schools.

Scientific literacy refers to the ability of individuals to use scientific knowledge, identify questions, interpret evidence, and draw reasoned conclusions that inform decisions related to science and society (Organization for Economic Cooperation and Development, 2023). In the context of Biology education, scientific literacy extends beyond rote memorization of facts to include understanding biological processes, applying scientific skills, interpreting data, and engaging meaningfully with socio-scientific issues such as health, environment, and biotechnology (Fives et al., 2020). Achieving this level of literacy requires instructional approaches that actively involve learners in scientific thinking and practice.

However, classroom practices in many Nigerian secondary schools remain predominantly teacher-centred, with instruction often characterized by lecture, note copying, and examination-driven teaching (Okeke & Ezenwosu, 2021; Yusuf & Afolabi, 2022). These practices limit opportunities for learners to ask questions, investigate biological phenomena, and develop higher-order thinking skills. Consequently, students may struggle with tasks that require explanation, interpretation, or application of biological knowledge beyond textbook contexts.

Inquiry-based learning has been widely advocated as an instructional approach capable of addressing these challenges. Inquiry-based learning positions learners as active participants in the learning process by engaging them in questioning, investigation, data analysis, and evidence-based reasoning (National Research Council, 2020). Through inquiry, students experience Biology as a dynamic process of knowledge construction rather than a static body of facts.

True understanding in science involves more than knowing facts. It requires insight into how knowledge in science develops through observation, investigation, reasoning, and continuous revision. Students should be able to ask thoughtful questions, interpret findings, and justify their conclusions using evidence. Lederman, Lederman, and Antink Meyer (2023) emphasize that understanding how science works is essential for meaningful engagement with scientific ideas. Similarly, the Organization for Economic Cooperation and Development (2023) explains that learners should be able to use scientific knowledge responsibly when addressing social and environmental issues.

Despite these expectations, concerns remain about classroom practices. In many secondary schools, teaching is still largely centered on explanation by the teacher, while students listen, copy notes, and prepare for examinations. Although this approach may cover the syllabus, but it does not always encourage deep thinking. Lazonder and Harmsen (2020) observed that students develop stronger understanding when they are actively involved in exploring ideas rather than passively receiving information. Within the Nigerian system, studies have reported that students often perform better in recall-based tasks than in questions requiring explanation and reasoning (Okeke & Ezenwosu, 2021; Yusuf & Afolabi, 2022). These observations raise important questions about whether classroom experiences are adequately nurturing thoughtful engagement with Biology.

When students are allowed to observe phenomena, discuss ideas, examine evidence, and explain their reasoning, learning becomes more meaningful. The

National Research Council of the United States of America (2020) notes that active participation in the learning process strengthens both conceptual understanding and reasoning ability. Such experiences help students see Biology not merely as a subject to pass, but as a discipline that explains real life situations.

While many scholars agree that classroom experiences should promote deeper understanding, there is still a need to reflect carefully on how Biology education can more effectively cultivate thoughtful reasoning and responsible application of knowledge. In our educational setting, this reflection becomes even more important, as the demands placed on learners continue to increase in a rapidly changing scientific world.

This paper therefore examines how Biology education can better promote scientific literacy through classroom practices that encourage active thinking, evidence based reasoning, and meaningful understanding, among secondary school Biology students in Nigeria, to reflect critically on how teaching can move closer to the true purpose of science education, with emphasis on theoretical foundations, empirical evidence, and classroom implications.

LITERATURE REVIEW

Concept of Inquiry Based Learning in Biology Education

Inquiry based learning is widely recognized in science education as an instructional approach that organizes teaching and learning around questions, investigation, and evidence-based reasoning (National Research Council, 2000; Lazonder & Harmsen, 2016). In Biology education, inquiry-based learning allows students to study living systems through observation, experimentation, and analysis rather than passive reception of information. Learners are encouraged to generate questions, propose explanations, test ideas, and reflect on findings within guided or structured classroom settings. Lederman, Lederman, and Antink Meyer (2023) note that engaging learners in the processes through which scientific knowledge is developed helps them understand both content and the nature of science itself.

Inquiry based learning may take different forms depending on the level of teacher guidance. Bell, Smetana, and Binns (2005) explain that structured inquiry involves teacher provided questions and procedures, guided inquiry allows learners to design parts of the investigation, while open inquiry gives learners greater responsibility in defining problems and methods. In secondary school Biology, structured and guided inquiry are commonly recommended due to curriculum demands and learner readiness, particularly where students are still developing investigative skills.

Studies conducted in Nigerian secondary schools indicate that inquiry-based learning supports active engagement and improves students' interest in Biology lessons. Okeke and Ezenwosu (2021) reported that students exposed to inquiry-oriented instruction demonstrated better conceptual understanding than those taught through conventional lecture methods. When learners participate in investigations related to plant growth, genetics, ecology, or human biology, they develop stronger connections between theory and practice. This approach also encourages collaborative learning and discussion, which support meaning making within the classroom.

Scientific Literacy in Biology Education Scientific literacy in Biology education involves understanding biological concepts, applying scientific processes, and making informed decisions related to biological issues. The Organization for Economic Cooperation and Development (2023) describe scientific literacy as the ability to use scientific knowledge, identify questions, interpret evidence, and draw reasoned conclusions that inform decisions related to science and society. In the context of Biology education, this includes not only knowledge of biological principles but also skills such as observation, interpretation of data, and evaluation of evidence (Fives et al., 2014). It also involves attitudes such as curiosity and openness to new evidence.

In Nigeria, concerns about scientific literacy have been linked to examination performance, classroom practices, and curriculum implementation. Yusuf and Afolabi (2022) observed that many students demonstrate difficulty explaining biological phenomena beyond memorized definitions. Such findings suggest that instruction may not sufficiently support higher level thinking and reasoning, particularly in areas requiring interpretation and application of knowledge.

Scientific literacy also has clear social relevance. Issues such as public health, environmental management, genetic modification, and food security require citizens who can interpret biological information and participate in informed discussions. Bybee (2013) argues that science education must prepare learners to engage responsibly with scientific issues that affect everyday life. Biology education therefore carries responsibility for developing learners who can engage with such issues thoughtfully and confidently.

Inquiry Based Learning and Scientific Literacy

Inquiry based learning promotes scientific literacy because it engages students in the actual processes of science. Rather than receiving information passively, learners observe, ask questions, gather data, interpret findings, and explain their conclusions. These activities mirror how scientific knowledge is developed. As students repeatedly participate in such processes, they gradually develop the ability to think critically and reason with evidence.

Scientific literacy involves the ability to use scientific knowledge, interpret evidence, and make informed decisions about issues that affect society (Organisation for Economic Cooperation and Development, 2023). Inquiry based learning supports this development by giving students practical opportunities to apply knowledge in meaningful situations. For instance, when students investigate biological concepts such as ecology, genetics, or human physiology, they must rely on observation and evidence before drawing conclusions. This strengthens their understanding and improves their capacity to apply ideas beyond examination contexts.

In Nigerian secondary schools, where classroom instruction often emphasizes note taking and examination preparation, inquiry-based learning provides a more engaging alternative. Studies conducted in Nigeria indicate that students exposed to inquiry-oriented instruction demonstrate better conceptual understanding and stronger reasoning skills than those taught primarily through lecture methods (Okeke & Ezenwosu, 2021). This suggests that active involvement in learning helps students move beyond memorization toward deeper comprehension. Inquiry based learning also builds confidence. When students discuss results, defend explanations, and participate in investigations, they begin to see themselves as capable of engaging with scientific ideas. This confidence encourages sustained interest and thoughtful participation in Biology. Over time, such experiences contribute to the development of scientifically literate learners who can interpret biological information and respond responsibly to issues in their environment.

Theoretical Foundations of Inquiry Based Learning

Constructivist Learning Theory

Constructivist learning theory was advanced by Jean Piaget, a Swiss psychologist, in 1950 and later expanded by Lev Vygotsky, a Russian psychologist, in 1978. The theory explains that learning is not a passive process in which students receive information from the teacher. Instead, learners actively construct knowledge by interacting with their environment and relating new information to what they already know.

Piaget emphasized individual cognitive development. He explained that learners build understanding through processes such as exploration, reflection, and adaptation of ideas. Vygotsky, on the other hand, stressed the importance of social interaction in learning. He argued that

discussion, collaboration, and guidance from a more knowledgeable person help learners develop deeper understanding.

In Biology education, this theory suggests that students learn better when they are actively involved in investigating concepts rather than memorizing notes. When learners observe specimens, carry out experiments, discuss findings, and reflect on results, they construct their own understanding of biological processes.

The implication of constructivist learning theory for this study is clear. If scientific literacy requires students to interpret evidence, explain ideas, and apply knowledge, then teaching methods must allow them to actively build that understanding. Inquiry based learning aligns with constructivist principles because it provides opportunities for exploration, questioning, discussion, and reasoning. Therefore, constructivism supports the view that inquiry-based learning can promote scientific literacy among secondary school students.

Discovery Learning Theory

Discovery learning theory was proposed by Jerome Bruner, an American psychologist, in 1961. Bruner argued that learners understand concepts more deeply when they discover relationships and principles by themselves, especially when guided by the teacher. He believed that learning becomes more meaningful when students are actively involved in solving problems rather than receiving ready-made answers.

According to Bruner, the role of the teacher is not simply to transmit information but to structure learning experiences in ways that encourage exploration and critical thinking. When learners investigate problems, test ideas, and draw conclusions, they develop stronger intellectual abilities.

In the Biology classroom, this perspective supports instructional practices that involve experimentation, questioning, and explanation. For example, when students investigate ecological relationships or genetic inheritance patterns, they are not only learning content but also developing reasoning skills.

The implication of discovery learning theory for this study is that inquiry based learning provides the conditions necessary for meaningful understanding. Since scientific literacy involves reasoning with evidence and applying knowledge to real life situations, teaching approaches that encourage guided discovery are more likely to promote scientific literacy than methods based mainly on memorization.

Conclusion

The discussion presented in this paper shows that inquiry-based learning plays an important role in promoting scientific literacy in Biology education. By engaging learners in questioning, investigation, and reasoning, inquiry-oriented instruction strengthens understanding of biological concepts and supports the development of essential scientific skills.

Evidence from Nigerian studies indicates that students exposed to inquiry-based learning demonstrate improved comprehension, stronger reasoning ability, and greater engagement in Biology lessons. These outcomes reflect meaningful progress toward the development of scientific literacy among secondary school students.

Inquiry based learning also aligns with curriculum goals that emphasize learner participation and practical activities. When effectively implemented, it offers a practical approach to improving Biology instruction and enhancing scientific literacy in Nigerian secondary schools.

Suggestion

To enhance the effectiveness of inquiry-based learning in promoting scientific literacy, Biology teachers should receive continuous professional support on planning and implementing inquiry-

oriented lessons, particularly within the practical constraints of classrooms. Teacher education programs should place greater emphasis on inquiry pedagogy during pre-service training, ensuring that new teachers are well equipped to guide students through active investigation and reasoning.

Schools and education authorities should provide adequate instructional materials and resources that facilitate hands-on learning and classroom investigation. Curriculum planners should review Biology syllabi to allow sufficient time for inquiry activities, rather than overemphasizing content coverage. Additionally, regular classroom supervision should prioritize the observation and support of teaching practices that encourage student participation, critical thinking, and the development of scientific reasoning.

By implementing these measures, secondary school Biology instruction can better engage learners, strengthen their understanding of biological concepts, and promote the development of scientific literacy in meaningful and sustainable ways.

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