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FOSTERING ENVIRONMENTAL STEWARDSHIP VIA ECOLOGY IN BIOLOGY EDUCATION

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Abstract

In the contemporary world, environmental degradation, climate change, depletion of natural resources, and loss of biodiversity have emerged as serious global concerns. Education plays a vital role in addressing these challenges by creating awareness and promoting sustainable practices among young learners. Biology, being a life science, offers immense opportunities to integrate environmental education within its curriculum. Teaching biology through environmental and sustainability education enables learners to understand the intricate relationship between living organisms and their environment and recognize the consequences of human actions on ecological balance. This paper examines the pedagogic relevance of integrating environmental education into biology teaching. It highlights the concept, importance, curriculum integration, teaching strategies, role of the biology teacher, and educational outcomes of this approach. Emphasis is given to learner-centered, pedagogic strategies that promote scientific temper, environmental awareness, ethical values, and responsible behavior. Integrating environmental education into biology pedagogy contributes significantly to the development of environmentally conscious and socially responsible citizens committed to sustainable development. However, challenges such as limited resources and insufficient teacher training hinder effective implementation. Strengthening teacher capacity, improving curriculum design, and fostering collaboration among schools, government, and environmental organizations are essential to enhancing environmental education. This paper underscores the potential of biology learning as a transformative tool in shaping a generation that is not only academically proficient but also environmentally conscious and proactive in sustainability efforts. The paper concludes that effective stewardship education requires moving students from awareness to action through personally relevant, interdisciplinary, and application-focused learning experiences.

KEYWORDS: Biology Education, Environmental Education, Environmental Stewardship, Sustainability

Introduction

Biology is a fundamental branch of science that deals with the study of living organisms and their interaction with the environment. Since life is inseparably connected with nature, biology provides a strong foundation for environmental education. In the present era, humanity faces serious environmental problems such as global warming, pollution, deforestation, water scarcity, and extinction of species. These challenges threaten ecological balance and human survival, making environmental education an essential component of school curriculum. The environment is the main foundation for the sustainability of life on earth. However, in recent decades, human activities have caused massive environmental damage, threatening the balance of global ecosystems. Nigeria, as one of the most biodiverse countries in the world, faces serious environmental challenges. Deforestation, plastic pollution, forest fires, and biodiversity loss are some of the environmental issues that dominate national and international environmental reports (Okorondu et al., 2022). Forest and peatland fires, have caused haze that is detrimental to public health and the country's economy. The loss of natural habitat also threatens the existence of endemic species which are now on the brink of extinction.

This environmental crisis not only affects ecosystems, but also human life. Climate change triggered by environmental degradation has led to natural disasters such as floods, droughts and rising sea levels. In addition, air pollution from forest fires and motor vehicle emissions has increased cases of respiratory illnesses in major cities. If not addressed immediately, this environmental damage will worsen and impact future generations (Sukumaran, 2022; Kaur & Pandey, 2021).In this context, education plays a crucial role in shaping people's awareness and behavior towards the environment. Environmental education, especially through biology learning, can be an effective means to increase students' understanding of the importance of environmental conservation (Dillon & Herman, 2023; Yadav et al., 2022). Biology as a science that studies life and the interaction of organisms with their environment has great potential to integrate environmental issues into the learning curriculum. Through the right approach, students will not only understand biological concepts theoretically, but can also apply the knowledge in real contexts, such as environmental conservation and management efforts (Tariq, 2024).

Teaching biology through environmental and sustainability education helps students connect biological concepts with real-life environmental issues. It encourages learners to understand the importance of conservation, sustainable use of natural resources, and responsible human behaviour. This approach not only enhances conceptual understanding but also promotes environmental values, attitudes, and life skills essential for sustainable living. Thus, integrating environmental education in biology teaching is pedagogically significant and socially relevant. However, the main challenge faced is how to integrate complex and multidimensional environmental issues into biology learning which is often limited to textbook materials. The education curriculum in Nigeria still tends to focus on academic achievement, while aspects of character education and environmental awareness are often neglected. In fact, effective environmental education requires a holistic approach that involves not only the transfer of knowledge, but also the formation of attitudes and practical skills (Uralovich et al., 2023). Therefore, innovation is needed in biology learning methods that can link the subject matter with current environmental issues, so that students can understand the relevance of biological science in everyday life.

Based on the above background, some research questions that can be raised include how environmental issues such as deforestation, plastic pollution, and biodiversity loss, can be

integrated into biology learning, what is the impact of biology learning based on environmental conservation on students' awareness towards environmental issues, and what strategies are effective to increase the role of teachers in teaching environmental conservation through biology learning. This article aims to enlighten us on fostering environmental stewardship via ecology in Biology education, present effective strategies for integrating environmental conservation issues into the biology curriculum, and provide suggestions for teachers, schools, and education policy makers in developing biology learning based on environmental conservation. By examining current environmental issues and linking them to biology learning, this article is expected to make a real contribution to efforts to increase the environmental awareness of Nigeria's younger generation. Through the right educational approach, students will not only become academically intelligent individuals, but also citizens who care and are responsible for the environment.

This study is justified by the urgent need to address the growing environmental crisis through education, particularly within the Nigerian context where environmental challenge continues to escalate. Despite the inclusion of ecology concepts in the Biology curriculum, there is still a significant gap between students' theoretical knowledge and their actual environmental behavior. The existing teaching practices often emphasize rote learning and examination performance, with limited attention given to practical, value-based, and action-oriented environmental education. As a result, many students lack the awareness, skills, and motivation required to engage in sustainable environmental practices.

This research is therefore necessary to explore effective ways of integrating environmental stewardship into Biology education through ecology. It seeks to provide practical pedagogical strategies that can transform biology classrooms into platforms for developing environmentally responsible citizens. Additionally, the study will contribute to improving curriculum implementation, enhancing teacher effectiveness, and supporting policy reforms aimed at promoting sustainability education. Ultimately, fostering environmental stewardship among students is essential for ensuring long-term ecological balance, national development, and the well-being of future generations.

Concept of Environmental Education in Biology

Environmental education aims at developing awareness, knowledge, skills, attitudes, and values necessary to understand and protect the environment. It helps learners identify environmental problems and encourages active participation in environmental conservation. In biology education, these concepts are closely related to topics such as ecosystems, biodiversity, food chains, natural resources, pollution, climate change, and human health. Integrating environmental education enables students to understand ecological relationships and the long-term impact of human activities on nature.

Environmental education plays an important role in shaping people's awareness and behavior towards the environment. Constructivist learning theory emphasizes that knowledge is built through experience and interaction with the environment (Saleem et al., 2021). In the context of environmental education, students are invited to be actively involved in understanding environmental issues through observation, experimentation, and real projects. This approach not only improves students' understanding of biology concepts, but also develops critical and solution skills in dealing with environmental problems (Chusni et al., 2021).

Biology as a science that studies life and the interaction of organisms with their environment has great potential to integrate environmental issues into learning. Biology materials such as ecosystems, biodiversity, and climate change can be linked to current environmental issues,

such as deforestation, plastic pollution, and biodiversity loss. For example, in studying forest ecosystems, students can be invited to analyze the impact of deforestation on biodiversity and climate change (Wigand et al., 2022). Thus, learning biology is not only theoretical, but also contextual and relevant to everyday life.

Some Schools have implemented innovative environmental education programs that will encourage schools to create an environmentally friendly learning environment through activities such as tree planting, waste management and energy saving (Heleri & Ismanto, 2021; Zaliyanti & Azani, 2024). In addition, some schools also integrate environmental education into the biology curriculum through practical projects such as biopore making, organic plant cultivation and water quality monitoring. These programs not only increase students' environmental awareness, but also teach them to be responsible for the environment.

Many biology teachers are still focused on academic achievement and pay less attention to character and environmental education aspects. Therefore, training and workshops are needed for teachers to improve their understanding and skills in integrating environmental conservation into biology learning. In addition, collaboration between schools, government, and environmental NGOs is also needed to create a learning environment that supports conservation efforts. By integrating environmental issues into biology learning, it is expected that students will not only become academically intelligent individuals, but also caring and responsible citizens of the environment. Effective environmental education can be a long-term solution to overcome the environmental crisis in Nigeria, while forming a young generation that is ready to face environmental challenges in the future.

Integrating Environmental Issues in Biology Learning

Integrating environmental issues in biology learning is a strategic step to form a generation that cares about nature conservation. In the context of biology education, materials such as ecosystems, biodiversity, and climate change are not only taught as theoretical concepts, but also linked to actual environmental issues that occur around students. Ardoin & Heimlich (2021) posited that the use of local examples in learning not only increases the relevance of the material, but also encourages students' emotional and cognitive engagement. This is in line with the research of Herman et al. (2021) who found that contextualizing material through local environmental issues is effective in increasing students' understanding of the complexity of environmental problems.

In addition, integrating environmental issues in biology learning can also be done through an interdisciplinary approach. For example, the concept of biodiversity is not only discussed from a biological point of view, but also related to economic, social and cultural aspects. For example, the loss of biodiversity in tropical forests not only affects the ecosystem, but also local communities who depend on the forest for their livelihoods.

Teaching Strategies for Integrating Environmental Biology in Education

Teaching biology through environmental and sustainability education makes learning meaningful, contextual, and learner-centered. Abstract biological concepts become easier to understand when connected to real-world environmental situations. This approach promotes inquiry-based learning, critical thinking, problem-solving skills, and scientific reasoning.It also contributes to the development of scientific temper and environmental ethics among learners. Students learn not only biological facts but also values such as responsibility, cooperation, respect for nature, and concern for future generations. Thus, biology teaching becomes value-oriented, action-based, and socially relevant.

Biology teachers can adopt various pedagogic strategies to integrate environmental and sustainability education effectively:

1. Field visits and nature walks to observe local ecosystems, plants, animals, and environmental conditions.

2. Project-based learning on waste management, water conservation, biodiversity conservation, and climate change.

3. Laboratory activities such as compost preparation, soil testing, water quality analysis, and plant growth experiments.

4. Group discussions, seminars, and debates on environmental issues and sustainable development.

5. Use of ICT tools like documentaries, animations, presentations, and online resources

These strategies promote experiential learning, collaboration, creativity, and active participation among students.

Teaching Ecology for Environmental Stewardship

To effectively foster environmental stewardship, ecology teaching must go beyond theoretical instruction and actively engage students in practices that promote care for the environment. Research in environmental and science education strongly supports the use of experiential, inquiry-driven, and context-based pedagogies (Ardoin & Heimlich, 2021; Dillon & Herman, 2023).

1. Place-Based Ecology Learning: Teachers should use the local environment as a living laboratory where students investigate real ecological systems. Place-based education enhances students' connection to their environment and promotes stewardship behaviors. For example, learners can study local biodiversity or assess pollution levels in nearby water bodies.

2. Inquiry-Based and Problem-Solving Approach: Inquiry-based learning encourages students to ask questions, investigate ecological problems, and develop solutions. This approach has been shown to improve critical thinking and environmental literacy. Students can explore issues such as species loss or flooding within their locality.

3. Action-Oriented Learning (Learning by Doing): Environmental stewardship is strengthened when students participate in real-life environmental actions such as tree planting, recycling, and conservation projects. Action-oriented learning promotes long-term pro-environmental behavior.

4. Integration of Indigenous and Local Knowledge: Incorporating indigenous knowledge systems into ecology teaching helps students understand sustainable environmental practices rooted in local culture. This approach supports holistic environmental understanding and sustainability.

5. Use of Socio-Scientific Issues (SSI): Teaching controversial environmental issues such as climate change and deforestation through discussion and debate enhances students' ethical reasoning and decision-making skills.

6. Technology-Enhanced Ecology Learning: The integration of ICT tools such as simulations, documentaries, and environmental monitoring applications enhances student engagement and understanding of complex ecological systems.

7. Reflective and Value-Based Learning: Reflection through journaling and discussion helps students internalize environmental values and develop responsible attitudes toward nature.

Project-based and contextual learning strategies

One of the effective learning strategies to integrate environmental issues in biology is project-based learning (PBL). In PBL, students not only learn theory, but are also directly involved in real projects related to environmental conservation. For example, students can do tree planting projects, environmental cleanup, or river water quality monitoring. Mergendoller and Thomas as cited in Zebua (2025), PBL is effective in improving students' critical thinking skills, collaboration, and social responsibility. Research by Ardiansyah et al. (2024) also showed that PBL in the context of environmental education can increase students' awareness of the importance of preserving nature.

In addition to PBL, contextual learning is also an effective strategy to connect biology material with everyday environmental issues (Ardoin & Heimlich, 2021). For example, when studying the concept of pollution, students can be invited to analyze the impact of plastic waste on marine ecosystems. This approach not only makes learning more interesting, but also helps students understand the relevance of biological science in real life. Budiman et al. (2021) averred that contextual learning is effective in increasing students' learning motivation and their ability to apply knowledge in real situations.

Impact on Students' Awareness and Behaviour

The integration of environmental issues in biology learning has been proven to have a positive impact on student awareness and behavior. Suárez-Perales et al., (2021) asserted that effective environmental education can change students' attitudes and behaviors in a sustainable manner. For example, after knowing the impact of plastic waste on marine ecosystems, students tend to be more aware of reducing the use of plastic in their daily lives. This is in line with the results of research by Zhang (2024) showing that environmental education can influence students' pro-environmental behavior, such as reducing energy consumption, recycling waste, and using environmentally friendly transportation.

Furthermore, environmental learning can also improve students' critical thinking and problem-solving skills. For example, when students are invited to analyze the causes and solutions to air pollution problems, they learn to identify problems, collect data, and propose realistic solutions. According to Bibi et al (2025), these skills are not only important for environmental awareness, but also for students' success in various aspects of life.

Role of the Biology Teacher in Promoting Environmental Education

The biology teacher plays a crucial role in promoting environmental education. The teacher acts as a facilitator, guide, and role model by encouraging eco-friendly practices such as reducing plastic use, conserving water and energy, protecting biodiversity, and adopting sustainable lifestyles. Through effective teaching and value integration, the teacher helps students develop positive environmental attitudes and responsible behaviour. Teaching biology through environmental and sustainability education helps students to:

1. Develop environmental awareness and sensitivity

2. Understand the importance of biodiversity and ecological balance

3. Acquire scientific skills such as observation, analysis, and problem-solving

4. Develop values like responsibility, cooperation, and respect for nature

5. Apply biological knowledge to solve real-life environmental problems

6. Practice sustainable living in daily life

Challenges in Using Ecology Education to Promote Stewardship

Although the integration of environmental issues in biology learning has many benefits, there are some challenges that need to be overcome which hinder the effective use of ecology education for fostering environmental stewardship:

1. *Overloaded Curriculum:* Emphasis on content coverage limits experiential learning. Biology syllabi often prioritize breadth of content (e.g., memorizing taxonomic names, biochemical pathways) over deep ecological inquiry. This leaves little room for field studies, long-term observations, or community-based projects—key experiences that help students develop emotional connections to local ecosystems and a sense of responsibility toward them.

2. *Examination-Oriented Teaching:* Focus on rote memorization undermines value and behavior formation. High-stakes assessments typically reward factual recall rather than environmental attitudes or pro-environmental behaviors. Consequently, teachers emphasize rote learning of ecological concepts (e.g., nutrient cycles, food webs) instead of fostering critical reflection on human impacts or ethical reasoning. This undermines the value-belief-norm chain essential for stewardship.

3. *Limited Resources:* Inadequate laboratory, field, and outdoor learning facilities constrain practical ecology instruction. The lack of resources and facilities in some schools may hinder the implementation of learning strategies such as Problem Based Learning (PBL) or the use of technology. Effective ecology education requires outdoor learning spaces (school gardens, nature reserves), basic equipment (quadrats, water test kits, binoculars), and digital tools (GIS, data loggers). Schools lacking these resources cannot implement inquiry-based or place-based learning, making it difficult for students to experience ecological principles firsthand and develop stewardship behaviors.

4. *Teacher Preparedness:* Some Biology teachers lack training in innovative and environmental education pedagogies. The lack of teacher training on environmental education is also an obstacle. Many teachers feel unprepared to integrate environmental issues in learning due to lack of knowledge and skills. These teachers have strong subject knowledge but little training in environmental education pedagogies—such as issue-based learning, action research, or participatory decision-making. Without professional development, they feel unqualified to facilitate discussions on controversial environmental issues or guide students toward stewardship actions, limiting the transformative potential of ecology lessons.

Conclusion

Ecology in Biology education offers a unique and powerful avenue for fostering environmental stewardship. By moving beyond content transmission to embrace experiential, inquiry-based, and value-driven approaches, ecology education can cultivate environmentally responsible citizens capable of addressing contemporary environmental challenges. The integration of environmental issues in biology learning is an important step to form a generation that cares about the preservation of nature. Through strategies such as project-based learning, contextual learning and other innovative pedagogies students not only understand biology concepts, but also develop pro-environmental awareness and behavior. Although there are challenges in its implementation, collaborative efforts between various

parties can help overcome these obstacles and ensure that environmental education becomes an integral part of the biology curriculum. Thus, biology education not only serves as a means of knowledge transfer, but also as a tool to shape a generation that is responsible for the future of the earth.

Suggestions

To strengthen the role of ecology in fostering environmental stewardship, the following suggestions are proposed:

1. *Curriculum Reform:* Ecology curricula should explicitly include stewardship-oriented objectives and local environmental issues. More interpretive educational materials and activities should be develop and integrate to enrich learning experiences.

2. *Teacher Professional Development:* Continuous training should emphasize inquiry, outdoor learning, and sustainability education. Biology teachers should effectively integrate environmental education into classroom practice by adopting learner-centred, experiential, and inquiry-based teaching strategies,

3. *School–Community - Government Partnerships:* Collaboration with environmental agencies and local communities can enhance authentic learning experiences. collaborative efforts between the government, schools and communities are also needed. For example, the government can provide training to teachers on environmental education and provide the necessary facilities.

4. *Assessment Reform:* Evaluation should include projects, portfolios, and community-based activities, not just written examinations.

5. *NGO's Partnership: C*ollaboration with non-governmental organizations (NGOs) or universities can also assist schools in developing effective environmental education programs. This collaborative approach can improve the quality of environmental education and ensure that students have meaningful learning experiences.

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