

# Integrating Sustainability into Physics Education as a Pathway to a Greener Future for Nigeria

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## ABSTRACT

This study emphasizes the importance of incorporating sustainability into Nigerian Physics Education to foster environmental stewardship, innovative problem-solving, and sustainable employment prospects. It also looked at the benefits of sustainable Physics Education and how to apply it in Nigeria, which requires a multifaceted strategy that includes curriculum creation, teacher training, community participation, and partnerships and collaborations. It gives a clear path to how educators, policymakers, and stakeholders may collaborate to promote sustainability and environmental consciousness in Physics Education while also providing students with the information and skills they need to confront Nigeria's environmental concerns. The study suggested that revising the Physics curriculum, offering teacher training, encouraging community engagement, and cultivating partnerships and collaborations are critical for boosting long-term Physics Education policies that will guarantee a greener future for Nigerian students and the nation at large.

**Keywords:** Physics Education, Sustainability, Sustainability in Physics Education, Greener Future for Nigeria

## INTRODUCTION

Nigeria is grappling with several challenges, including environmental degradation, economic instability, and sustainability in education, science and technology. The role of Physics Education in shaping the future of the country cannot be overstated. This suggests that integrating sustainability into Physics education may be crucial for equipping students with the rightful knowledge, skills, and values necessary to drive innovation, promote environmental stewardship, and foster a greener future for Nigeria and its citizens. This, therefore, necessitates a critical examination of the current state of physics education and the development of sustainable pedagogies that can inspire a new generation of physicists, policymakers, and citizens to work towards a more sustainable and equitable future.

The world is facing numerous environmental challenges, including climate change, pollution, and resource depletion (IPCC, 2020). Education seems to be one of the crucial tools in wholeheartedly addressing these challenges by promoting sustainability and environmental awareness (UNESCO, 2019). Physics education, in particular, can significantly shape students' understanding of the natural world and their role in it (Hestness et al., 2011). As such, integrating sustainability into Physics education can help students develop a deeper understanding of the interconnectedness of science, technology, and the environment.

Physics education is a critical component of the Science, Technology, Engineering, and Mathematics (STEM) field, playing a vital role in driving innovation and economic growth (National Research Council, 2012). As the core of STEM, Physics provides the fundamental principles and laws that govern the Behaviour of energy, matter, and the universe, underpinning many areas of science and technology (Serway & Jewett, 2018). Physics education is essential for developing a skilled workforce, fostering critical thinking and problem-solving skills, and promoting innovation and entrepreneurship (Federal Ministry of Education, 2013).

The role of Physics in addressing Nigeria's environmental and economic challenges cannot be overstated, as it is capable of assisting in the mitigation of these challenges by providing students with a deep understanding of

the physical principles underlying environmental phenomena, such as climate change, energy generation, and water management (Jacobson & Delucchi, 2011). By applying physics principles to real-world problems, students can develop innovative solutions to address Nigeria's environmental and economic challenges, promoting sustainable development and a greener future for the country and its citizens (Tilbury, 2011).

Despite the importance of physics education, the subject has been plagued by poor performance and disaffection among students. According to the West African Examinations Council (WAEC), the failure rate in Physics has consistently been high over the years, with an average failure rate of 55% in the 2023/2024 academic year (WAEC, 2024). This may have contributed to the observed low enrollment in Physics classes, perpetuating a cycle of disaffection and underperformance (Akinwumi et al. 2015).

There is a pressing need for a physics education that is capable of ensuring sustainable development in Nigeria. This requires a shift from traditional teaching methods to more innovative and sustainable approaches that emphasize critical thinking, problem-solving, and community engagement (Hmelo-Silver, 2004). By integrating sustainability into physics education, students can develop a deeper understanding of the complex relationships between science, technology, and society and become more informed and engaged citizens (Tilbury, 2011).

A sustainable physics education should be taught with several key features, including an emphasis on environmental awareness, social responsibility, and economic viability (Hopkins & McKeown, 2002). To tilt Nigerian physics education towards achieving sustainable development, educators should incorporate real-world examples and case studies, promote community engagement and service-learning initiatives in their classrooms that emphasise the importance of critical thinking and problem-solving skills (National Research Council, 2012). By adopting these approaches, physics education can play a vital role in promoting sustainable development and a greener future for Nigeria.

## Physics Education

Physics education is a crucial component of science education that focuses on the study of the natural world, encompassing the principles and laws that govern the behaviour of energy, matter, and the universe (Serway & Jewett, 2018). It is an essential field of study that underpins many areas of science, technology, engineering, and mathematics (STEM), and is vital for the development of critical thinking, problem-solving, and analytical skills (National Research Council, 2012).

In Nigeria, physics education faces several challenges, including inadequate infrastructure, lack of qualified teachers, and insufficient resources (Ogunleye, 2015). Additionally, the teaching methods often employed in Nigerian physics classrooms tend to be theoretical and lecture-based, which can make the subject seem abstract and uninteresting to students (Adeyemi, 2019). This can lead to a lack of engagement and motivation among students, ultimately affecting their performance and interest in pursuing physics-related careers.

Different perspectives on the definition of physics education emphasize its importance in promoting scientific literacy, critical thinking, and problem-solving skills. According to the National Science Education Standards, physics education should focus on developing students' understanding of scientific concepts, principles, and processes (National Research Council, 1996). Similarly, the American Association for the Advancement of Science (AAAS) emphasizes the importance of science education in promoting critical thinking, problem-solving, and scientific literacy (AAAS, 2019).

In the context of sustainable development, physics education plays a vital role in equipping students with the knowledge and skills necessary to address the complex challenges facing Nigeria's economy and environment. By incorporating sustainability concepts and principles into physics education, students can develop a deeper understanding of the interconnectedness of science, technology, and society and become more informed and engaged citizens (Tilbury, 2011). This can ultimately contribute to the development of a more sustainable and environmentally conscious economy.

In Nigeria, the functionality of physics education in sustainable development can be seen in its potential to promote innovation, entrepreneurship, and economic growth. By providing students with a strong foundation in

physics and related STEM fields, physics education can enable them to develop solutions to real-world problems, such as energy generation, water management, and environmental conservation (Federal Ministry of Education, 2013). Moreover, physics education can also contribute to the development of a skilled workforce, which is

essential for driving economic growth and development in Nigeria.

Physics education is a critical component of science education that plays a vital role in promoting scientific literacy, critical thinking, and problem-solving skills. In Nigeria, physics education faces several challenges, but its potential to contribute to sustainable development and economic growth cannot be overstated. By incorporating sustainability concepts and principles into physics education, students can develop a deeper understanding of the interconnectedness of science, technology, and society and become more informed and engaged citizens.

### **Sustainability in Physics Education**

Sustainability in Physics education is a multifaceted concept that encompasses various dimensions, including environmental awareness, critical thinking, and responsible citizenship. According to Albareda-Tiana et al. (2019), education for sustainable development (ESD) should be a key component of teacher education programs, enabling future teachers to develop competences for promoting sustainability. This perspective highlights the importance of integrating sustainability into physics education to empower students to become environmentally conscious and responsible citizens.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) also emphasizes the significance of education for sustainable development, highlighting its role in addressing global challenges and promoting a more sustainable future (UNESCO, 2019). By incorporating sustainability into physics education, students can develop a deeper understanding of the interconnectedness of science, technology, and society. For instance, a study on physics education in Angola underscores the need for a global perspective, integrating both local and global considerations when addressing sustainability problems.

Incorporating real-world examples and case studies can help students understand the practical applications of physics in addressing sustainability challenges. Project-based learning can also enable students to explore sustainability issues in-depth and develop innovative solutions (Hmelo-Silver, 2004). Furthermore, interdisciplinary approaches can provide a comprehensive understanding of sustainability issues by integrating insights from multiple disciplines, such as biology, chemistry, and economics (Klein, 2015).

By integrating sustainability into physics education, educators can foster critical thinking, problem-solving, and responsible citizenship among students. This can be achieved by encouraging students to analyze complex sustainability problems, develop innovative solutions, and engage in community-based projects. Ultimately, sustainability in physics education aims to empower students to become active participants in creating a more sustainable future.

### **A Greener Future for Nigeria**

A Greener Future for Nigeria refers to a vision of balanced economic growth, social equity, and environmental protection, rooted in the Sustainable Development Goals (SDGs), particularly Goal 13 (Climate Action) and Goal 15 (Life on Land) (United Nations, 2015). Transitioning to renewable energy sources, such as solar and wind power, is crucial to reduce dependence on fossil fuels and mitigate climate change impacts (Akinbami, 2017). This transition can also create green jobs and stimulate economic growth (IRENA, 2020).

Sustainable agriculture practices, like agroforestry and conservation agriculture, can enhance soil health, conserve water, and reduce chemical use, improving crop yields and food security (FAO, 2017). Effective waste management is also essential, with inadequate disposal and recycling infrastructure posing significant environmental and health challenges (World Bank, 2020). Building climate resilience through climate-smart agriculture, early warning systems, and climate-resilient infrastructure can help protect lives and livelihoods (Nigeria Meteorological Agency, 2020).

Physics education can play a critical role in promoting a greener future for Nigeria by equipping students with the knowledge and skills necessary for sustainable development and environmental protection. Students can learn about renewable energy, sustainable practices, and climate resilience, contributing to Nigeria's efforts to adapt to climate change (IRENA, 2020; FAO, 2019). By understanding environmental physics, students can appreciate the importance of conservation efforts, such as protected areas and sustainable land-use practices (WWF, 2020).

By prioritizing sustainability, conservation, and environmental protection, Nigeria can reduce greenhouse gas emissions, improve public health, enhance economic development, and protect biodiversity. A greener future for Nigeria requires a holistic approach, balancing economic growth, social progress, and environmental protection, to ensure a prosperous, equitable, and environmentally conscious nation for current and future generations (United Nations, 2015).

For the study, a greener future for Nigeria is described as a holistic approach to Nigeria's economic growth, social progress, and environmental protection, prioritizing renewable energy, sustainable resource management, climate resilience, and eco-friendly practices, to ensure a prosperous, equitable, and environmentally conscious nation for current and future generations. This definition captures the essence of balancing economic, social, and environmental aspects for a sustainable and greener future.

### **Why Sustainability in Physics Education?**

Physics education provides a unique opportunity to explore the fundamental laws of nature and the behaviour of energy and matter. By integrating sustainability into physics education, students can gain a deeper understanding of the environmental implications of scientific and technological advancements. This can empower them to develop innovative solutions to environmental challenges and make informed decisions about the impact of their actions on the environment.

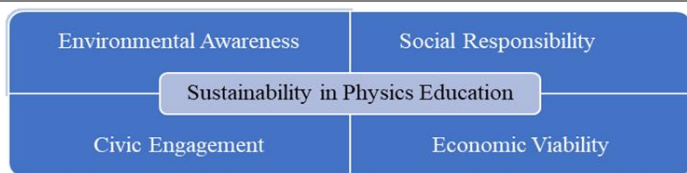
In Nigeria, the need for sustainability in physics education is particularly pressing. The country faces significant environmental challenges, including climate change, deforestation, and pollution (Federal Ministry of Environment, 2020). Physics education in Nigeria often focuses on theoretical concepts without emphasizing their practical applications and sustainability implications (Adeyemi, 2018). By incorporating sustainability into physics education, Nigerian students can develop a deeper understanding of the environmental implications of scientific and technological advancements and contribute to the development of sustainable solutions to environmental challenges.

The benefits of sustainability in physics education are numerous. By emphasizing sustainability, physics education can promote environmental stewardship, sustainable development, and innovation (Krajcik, 2010). Students can develop a deeper understanding of the importance of sustainability and environmental protection and gain the knowledge and skills necessary to contribute to sustainable development (UNESCO, 2017). Furthermore, sustainability in physics education can enhance contextual relevance, making scientific concepts more meaningful and engaging for students (Jegede, 2017).

To achieve these benefits, physics education in Nigeria must be reformed to incorporate sustainability principles and practices. This can involve revising curricula to include sustainability-related topics, providing teachers with training and resources to effectively integrate sustainability into physics education, and promoting hands-on learning and project-based approaches (OECD, 2019). By prioritizing sustainability in physics education, Nigeria can empower the next generation of leaders and citizens to build a more sustainable and environmentally conscious future.

### **Key Aspects of Sustainability in Physics Education**

Sustainability in education encompasses several key aspects that aim to equip students with the knowledge, skills, and values necessary to address complex environmental, social, and economic challenges. These include environmental awareness, social responsibility, and economic viability.



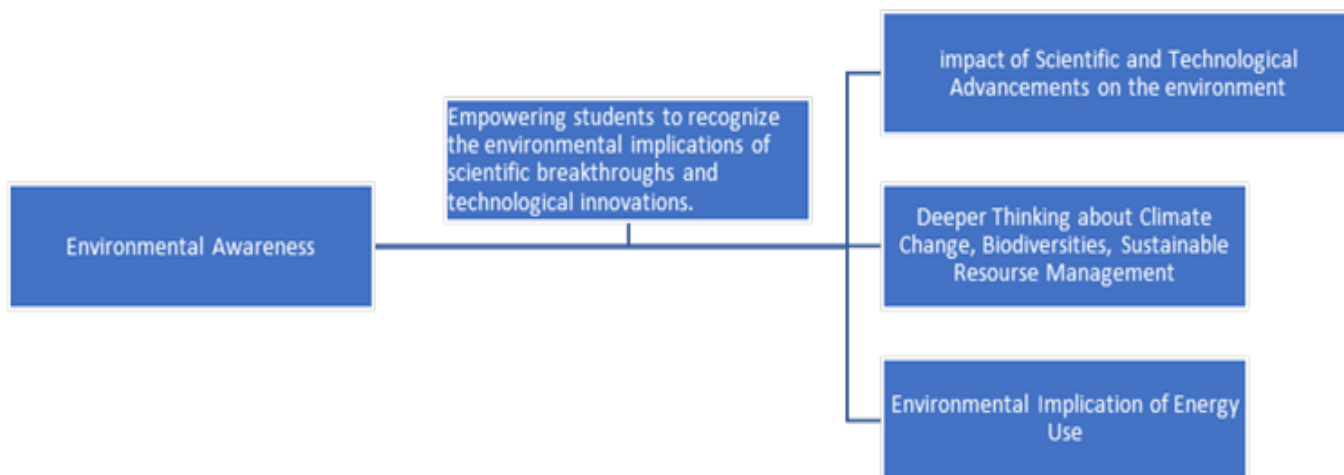
**Fig. 1: Key aspects of Sustainability in Education**

**Environmental Awareness:** Environmental awareness is a vital aspect of sustainability in physics education, enabling students to understand the impact of scientific and technological advancements on the environment (Tilbury, 2011). By incorporating environmental awareness into physics education, students can develop a deeper understanding of the complex relationships between physics, technology, and the environment. This includes learning about climate change, biodiversity, and sustainable resource management, among other topics. Environmental awareness can be promoted in physics education by emphasizing the environmental implications of energy production and consumption, such as the impacts of fossil fuels, nuclear power, and renewable energy (Jacobson & Delucchi, 2011).

Another approach to promoting environmental awareness in physics education is to integrate environmental physics into the curriculum, highlighting the physical principles underlying environmental phenomena. For example, students can learn about the physics of climate change, including the greenhouse effect, global temperature trends, and the impacts of climate change on ecosystems (IPCC, 2013). Hands-on activities and experiments can also be used to promote environmental awareness, allowing students to develop practical skills and a deeper understanding of environmental physics (Hake, 1998). Students can design and conduct experiments to measure the efficiency of solar panels or investigate the thermal insulation properties of different materials.

Real-world examples and case studies can also be used to promote environmental awareness in physics education. By examining real-world examples of environmental issues and challenges, students can develop a deeper understanding of the practical applications of physics in promoting sustainability (Fthenakis & Kim, 2011). For instance, students can learn about the physics of wind energy and its potential to mitigate climate change. Interdisciplinary approaches can also be used, integrating physics with other disciplines like biology, chemistry, and earth science to develop a more comprehensive understanding of environmental issues and challenges (National Research Council, 2012).

By incorporating environmental awareness into physics education, educators can help students develop a deeper understanding of the complex relationships between physics, technology, and the environment, promoting sustainability. This can empower students to contribute to a more sustainable future and pursue careers that align with their values and interests. Environmental awareness is a critical aspect of sustainability in physics education, and its incorporation can have a positive impact on students' understanding of the environmental implications of scientific and technological advancements.



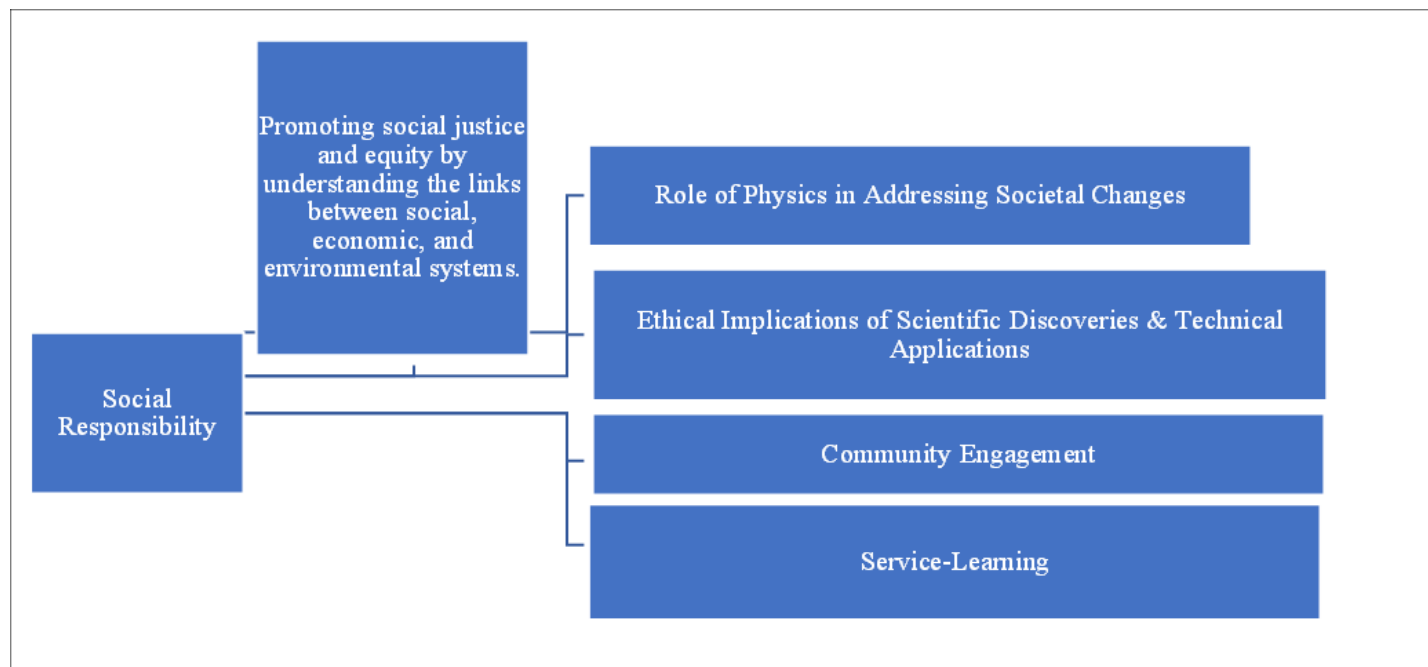
**Fig. 2: Environmental Awareness Approaches**

**Social Responsibility:** Social responsibility is a crucial aspect of sustainability in physics education, recognizing the interconnectedness of social, economic, and environmental systems and promoting social justice and equity (UNESCO, 2019). By incorporating social responsibility into physics education, students can develop a deeper understanding of the role of physics in addressing societal challenges and promoting sustainable development (Tilbury, 2011). This involves learning about issues such as poverty, inequality, and human rights, and developing skills and values that promote social cohesion and community engagement.

One way to promote social responsibility in physics education is to emphasize the ethical implications of scientific discoveries and technological applications. For example, physics students can learn about the ethical considerations surrounding the development of nuclear energy, artificial intelligence, or biotechnology (Shrader-Frechette, 2014). Real-world examples and case studies can also be used to highlight the social and environmental impacts of scientific and technological advancements, such as the physics of renewable energy systems and their potential to mitigate climate change (Jacobson & Delucchi, 2011).

Community engagement and service-learning are also effective ways to promote social responsibility in physics education. By participating in community-based projects or service-learning initiatives, students can apply their knowledge of physics to address real-world problems and promote sustainable development (Hmelo-Silver, 2004). Critical thinking and reflection are essential skills for promoting social responsibility, encouraging students to think critically about the social and environmental implications of scientific and technological advancements (Bailin & Siegel, 2003).

By incorporating social responsibility into physics education, educators can help students develop a deeper understanding of the complex relationships between science, technology, and society and promote sustainable development. This can empower students to become active citizens who contribute to creating a more just and equitable society. By emphasizing social responsibility, physics education can play a critical role in promoting sustainable development and addressing societal challenges.



**Fig. 3: Social Responsibility Approaches**

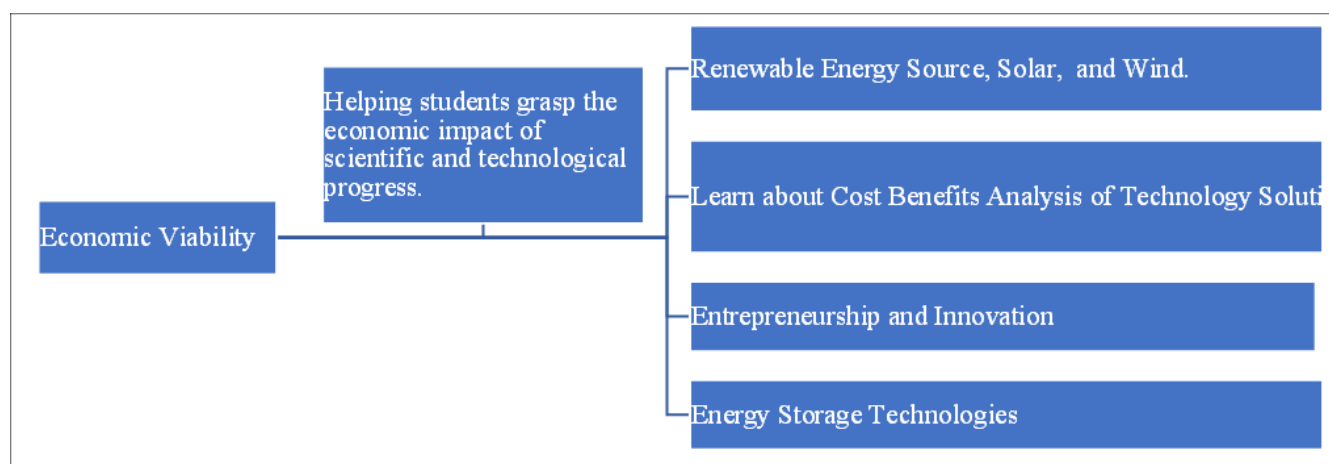
**Economic Viability:** Economic viability is a crucial aspect of sustainability in physics education, enabling students to understand the economic implications of scientific and technological advancements. By incorporating economic viability into physics education, students can develop a deeper understanding of the complex relationships between physics, technology, and the economy (Hopkins & McKeown, 2002). This includes learning about sustainable business practices, the green economy, and the Sustainable Development Goals.

To promote economic viability in physics education, educators can emphasize the economic benefits of

sustainable technologies, such as renewable energy sources like solar and wind power (IRENA, 2019). Students can also learn about the cost-benefit analysis of different technological solutions, such as energy storage technologies (Jenkins & Masters, 2014). Additionally, case studies and real-world examples can be used to illustrate the economic implications of sustainable technologies and promote a deeper understanding of the practical applications of physics in promoting economic viability (Kammen, 2006).

Entrepreneurship and innovation can also be encouraged in physics education to promote economic viability. By teaching students about the process of innovation and entrepreneurship, educators can help students develop the skills and knowledge necessary to turn scientific and technological advancements into economically viable solutions (Sahlman, 1997). Interdisciplinary approaches can also be used to promote economic viability, integrating physics with other disciplines like economics, business, and engineering to develop a more comprehensive understanding of economic issues (National Research Council, 2012).

By incorporating economic viability into physics education, educators can help students develop a deeper understanding of the complex relationships between physics, technology, and the economy, promoting sustainable development. This can empower students to contribute to a more sustainable future and pursue careers that align with their values and interests. Ultimately, economic viability is a critical aspect of sustainability in physics education, and its incorporation can have a positive impact on students' understanding of the economic dimensions of sustainability.



**Fig. 4: Economic Viability Approaches**

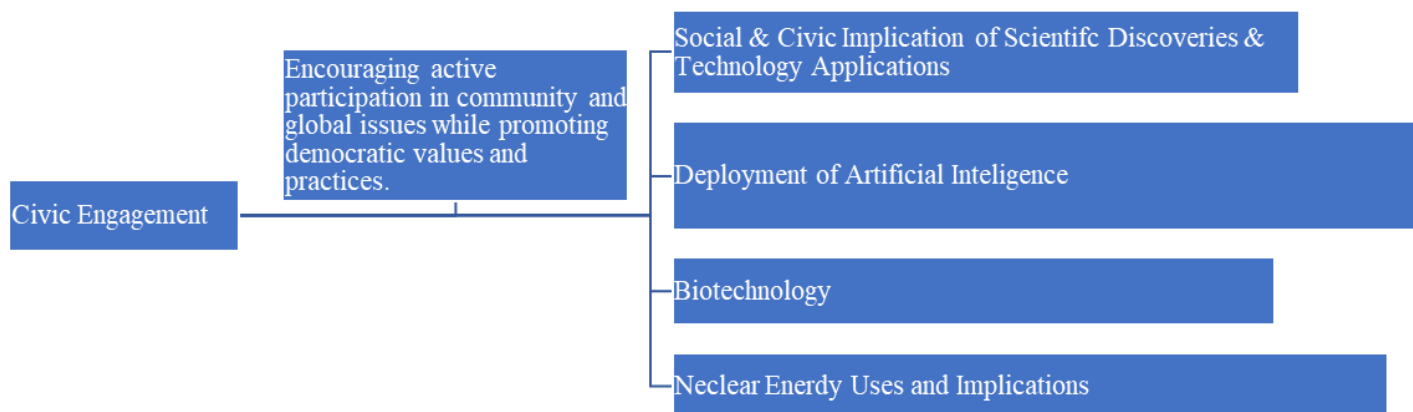
**Civic Engagement:** Civic engagement is a critical aspect of sustainability in physics education, encouraging active participation in community and global issues and promoting democratic values and practices (Holden, 2007). By incorporating civic engagement into physics education, students can develop a deeper understanding of the complex relationships between physics, technology, and society (Tilbury, 2011). This involves learning about participatory democracy, community development, and global citizenship, among other topics. Civic engagement enables students to understand the social and civic implications of scientific and technological advancements.

One way to promote civic engagement in physics education is to emphasize the social and civic implications of scientific discoveries and technological applications. For example, physics students can learn about the social and civic implications of emerging technologies, such as artificial intelligence, biotechnology, and nuclear energy (Shrader-Frechette, 2014). Community-based projects and service-learning initiatives can also be integrated into physics education, highlighting the importance of civic engagement and community involvement. Students can participate in projects that apply physics principles to address community needs, such as designing more efficient water management systems or developing sustainable energy solutions (Hmelo-Silver, 2004).

Critical thinking and reflection are essential skills for promoting civic engagement in physics education. By encouraging students to think critically about the social and civic implications of scientific and technological advancements, educators can help students develop a deeper understanding of the complex relationships between science, technology, and society (Bailin & Siegel, 2003). Collaboration and teamwork are also essential skills,

enabling students to work effectively with community partners and develop the skills and knowledge necessary to become effective civic leaders (National Research Council, 2012). Real-world examples and case studies can also be used to promote civic engagement, illustrating the practical applications of physics in promoting sustainability (Fthenakis & Kim, 2011).

By incorporating civic engagement into physics education, educators can help students develop a deeper understanding of the complex relationships between physics, technology, and society, and promote sustainability. This can empower students to become active contributors to creating a more sustainable and equitable future. Civic engagement is a vital aspect of sustainability in physics education, enabling students to understand the social and civic implications of scientific and technological advancements. By emphasizing civic engagement, physics education can play a critical role in promoting sustainability and community involvement.



**Fig. 5: Civic Engagement Approaches**

## Benefits of Sustainable Physics Education

Integrating sustainability into physics education can have numerous benefits, including:

### Environmental Stewardship

Integrating sustainability into physics education can foster a deeper appreciation for environmental stewardship among students. By learning about the environmental implications of scientific and technological advancements, students can develop a sense of responsibility to protect the natural world (Krajcik, 2010). This can lead to a greater awareness of the importance of sustainable practices and a commitment to reducing their environmental footprint (National Research Council, 2012). Students can learn about the impact of energy production and consumption on the environment and develop strategies for reducing energy waste (IPCC, 2021). By instilling a sense of environmental stewardship in students, physics education can play a critical role in promoting sustainability and protecting the natural world.

### Innovative Problem-Solving

Sustainability in physics education can also promote innovative problem-solving skills among students. By exploring sustainable solutions to environmental challenges, students can develop creative and critical thinking skills (Hmelo-Silver, 2004). Students can design and develop sustainable energy systems, such as solar or wind power systems, which require innovative problem-solving skills (Kelley, 2018). By encouraging students to think creatively about complex environmental issues, physics education can foster a new generation of innovators and problem-solvers who can develop sustainable solutions to real-world problems. Moreover, innovative problem-solving skills can be applied to a wide range of fields, including science, technology, engineering, and mathematics (STEM) (National Academy of Engineering, 2019).

### Career Opportunities

Sustainable physics education can prepare students for careers in fields such as renewable energy, sustainable technologies, and environmental consulting. As the world transitions to a more sustainable future, the demand

for professionals with expertise in sustainability and environmental science is increasing (IRENA, 2020). By incorporating sustainability into physics education, students can gain the knowledge and skills necessary to pursue careers in sustainable energy, green technologies, and environmental management (BLS, 2022). For example, students can learn about solar energy systems, wind power systems, and energy efficiency measures, which can prepare them for careers in the renewable energy sector (SEIA, 2022). By providing students with career opportunities in sustainability, physics education can play a critical role in promoting sustainable development and reducing environmental degradation.

## **Strategies for Implementing Sustainable Physics Education in Nigeria**

Implementing sustainable physics education in Nigeria requires a multi-faceted approach that involves several key steps.

### **Curriculum Development**

Developing curricula that incorporate sustainability principles and environmental awareness into physics education is essential (Krajcik, 2010). This can involve revising existing curricula to include topics such as renewable energy, sustainable technologies, and environmental physics (National Research Council, 2012). By incorporating sustainability into physics education, students can gain a deeper understanding of the environmental implications of scientific and technological advancements and develop innovative solutions to environmental challenges.

### **Teacher Training**

Providing teachers with training and resources to effectively integrate sustainability into physics education is critical (Darling-Hammond, 2006). Teachers play a vital role in shaping students' understanding of sustainability and environmental awareness, and therefore, it is essential to equip them with the necessary knowledge and skills (Hativa, 2013). Teacher training programs can focus on sustainability education, environmental science, and innovative pedagogies to promote sustainable physics education.

### **Community Engagement**

Engaging with local communities and stakeholders to promote sustainability and environmental awareness is also important (Tilbury, 2011). This can involve partnering with local organizations, businesses, and community groups to provide students with opportunities to apply sustainable principles in real-world contexts. By engaging with the community, students can develop a deeper understanding of the social and environmental implications of scientific and technological advancements.

### **Partnerships and Collaborations**

Collaborating with organizations and industries to provide students with opportunities to apply sustainable principles in real-world contexts is essential (National Academy of Engineering, 2019). Partnerships and collaborations can provide students with hands-on experience and exposure to real-world sustainability challenges, which can enhance their learning experience and prepare them for careers in sustainability. By partnering with organizations and industries, educators can also stay up-to-date with the latest sustainability trends and technologies.

Implementing sustainable physics education in Nigeria requires a comprehensive approach that involves curriculum development, teacher training, community engagement, and partnerships and collaborations. By working together, educators, policymakers, and stakeholders can promote sustainability and environmental awareness in physics education and equip students with the knowledge and skills necessary to address the environmental challenges facing Nigeria.

## **CONCLUSION**

In conclusion, integrating sustainability into physics education is crucial for equipping students with the

knowledge, skills, and values necessary to drive innovation, promote environmental stewardship, and foster a greener future for Nigeria. By incorporating sustainability principles and environmental awareness into physics education, students can develop a deeper understanding of the complex relationships between science, technology, and society and become more informed and engaged citizens. The benefits of sustainable physics education are numerous, including promoting environmental stewardship, innovative problem-solving, and career opportunities in sustainability. Implementing sustainable physics education in Nigeria requires a multi-faceted approach that involves curriculum development, teacher training, community engagement, and partnerships and collaborations. By working together, educators, policymakers, and stakeholders can promote sustainability and environmental awareness in physics education and equip students with the knowledge and skills necessary to address the environmental challenges facing Nigeria.

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