

Chapter 12

Fostering Sustainability through Nature - Inspired Innovations in Science Education

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Abstract

The study reviewed on Teaching Science Education Students Nature-inspired innovations as panacea for our ailing and distressed planet earth. The study also emphasized the significance of teaching nature-inspired innovations in science education, highlighting their relevance in fostering creativity and problem-solving skills among students who would play key role in protecting the ailing planet. Innovative practices in science education, such as incorporating biomimicry, not only enhance academic achievement but also encourage students to draw insights from nature to address contemporary issues. Nature-inspired innovations have made substantial strides in fields such as medicine, leading to breakthroughs in treatments that mimic biological processes. Additionally, advancements in materials science are continuously influenced by natural phenomena, resulting in sustainable and efficient material designs. Furthermore, product design increasingly leverages nature-inspired concepts to create more functional and environmentally friendly solutions. The study concluded that teaching science education students about nature-inspired innovations, such as biomimicry, is crucial for promoting creative problem-solving, enhancing academic achievement as well as fostering skills that can be harnessed to save the planet from global warming effect. It was recommended amongst others, that Science education teachers should implement outdoor mini-courses that allow students to engage directly with nature as such experiences would help them understand nature-based health techniques and the principles of biomimicry, fostering a deeper appreciation for how natural processes can inspire medical innovations. Comprehensive approach not only broadens students' perspectives but also prepares them for future challenges by blending scientific inquiry with practical applications.

Key words: Nature-inspired Innovations, Science Education, Medicine, Natural materials, Product designs

Introduction

Education remains the bedrock for human development and it is known to be one of the essential instruments which a nation uses to facilitate total enlightenment of its citizens and enhance all its socioeconomic and political parameters for sustainable development. Education is the totality of life's experiences which enables people to be relevant, responsible, productive and useful to the society. No wonder Awodun and Oyeniyi, (2018) asserts that a good educational system is a strong base for science and technological development which equips people with sound knowledge and skills for designing methods and processes that will enable them to make maximum use of their natural resources for the advancement of the society.

The growth and development of a nation depends largely on the type and quality of science and technology education individuals acquire. Science and Technology therefore forms an integral part of the human society and its impact is expected to be felt in every sphere of life. Developed nations of the world, by applying science and technology education principles have been able to maintain sovereignty which has provided them with functional and meaningful roles in wealth creation, improvement of the quality of life, real economic growth and educational advancement. (Shodeinde,

Education and Human Development: Interdisciplinary Perspective

2018). The National Policy on Education, Federal Republic of Nigeria (FRN, 2020) prescribed the following for science, technical and vocational education: provision of knowledge and skills necessary for economic development; providing people who can apply scientific knowledge to the improvement and solution of environmental problems for the use and convenience of man among others. One of the ways in which the above objectives can be fully achieved is through Science Education.

Science education is a veritable tool for national development. It is regarded as the bedrock of the nation and plays it an indispensable role in national integration. Adesoji and Olatunbosun, (2018) pointed that Science education is universally acknowledged as a crucial determinant of individual and societal development. It plays a pivotal role in shaping individuals' skills, knowledge, and competencies, thereby contributing to economic growth and social progress. In Nigeria, like many other countries, educational institutions are entrusted with the responsibility of imparting knowledge and equipping students with the necessary tools for success in their academic pursuits and future careers. Therefore, it can be said that the teaching of Science education shapes and molds the character of modern societies through innovations.

Teaching science education students about nature-inspired innovations can significantly address the environmental challenges faced by Nigeria. By integrating innovative practices in science education, educators can foster a deep understanding of sustainability and ecological systems, thus empowering students to develop solutions to combat issues such as climate change, biodiversity loss, and pollution (Adesoji & Olatunbosun, 2018). Nature-inspired innovations, often referred to as biomimicry, can serve as models for sustainable practices that mimic natural processes. This approach not only enhances students' learning and retention of scientific knowledge but also encourages them to apply this knowledge in real-world contexts, ultimately contributing to the healing of our distressed planet.

The world we have made, as a result of the level of thinking we have done thus far, creates problems we cannot solve at the same level of thinking at which we created them." – *Albert Einstein*. "Nature is the source of all true knowledge. She has her own logic, her own laws, she has no effect without cause nor invention without necessity."

Nature, the physical world around the earth, is made up of the biotic (plants, animals, humans) and the abiotic (the environment around us: air, water, and land). The biotic components of planet earth have survived by breathing air, drinking water, and eating food obtained from the land. Man had a good relationship with nature, but as time progressed, there was a change in relationship, man started to exploit and manipulate nature. A number of revolutions have caused a change in man's relationship with nature: the agricultural revolution, the scientific revolution and the industrial revolution (Emmott, 2013). Man, gradually transited from the hunter/gatherer to the mechanized farmer, and with the industrial revolution came the use of pesticides, fertilizers, crossbreeding and genetic engineering into agriculture. Some researchers are of the opinion that man tampering with animals, in the name of genetic engineering, brought about the coronavirus, which is responsible for COVID-19 (Cyranoski, 2020). In the scientific revolution, man discovered nature and could explain the workings of nature by using the principles of science (mathematics, chemistry, physics, and biology) and came up with a wide variety of scientific development, most of which exploited nature. With the industrial revolution, handmade items were now mass produced in industries, and industries were now as varied as they were as diverse. The transportation industry transited from horses, canoes to steam engines, and now there exist a wide variety of transportation. In our advancement of transportation, we have also created a highly efficient network for the global spread of diseases such as COVID-19, that started in Wuhan, a city in Eastern China. There is indeed no limit to man's ingenuity. As man enters the next revolution, the robotic revolution, only time will tell the consequences of this next move. Science, indeed, has helped man to explore, exploit and manipulate nature, but it has also failed man; man impacted nature negatively and nature is now distressed and affecting man negatively.

Science has indeed helped in discovering how things work and engineering has used this to provide innovative solutions to the problems man faced as he learnt to live on earth. But as time progressed man's inventions were no longer in tandem with nature and man started to destroy the

Education and Human Development: Interdisciplinary Perspective

same earth that sustains him. Industries exist to provide services and make products that man needs/wants in order to make planet earth a comfortable place to dwell in. These industries extract raw materials from the environment, at a rate faster than it can be replenished, and often pollute the environment during exploitation and processing of these raw materials. During processing a lot of 'unwanted substances' called waste, which tends to be inimical to the environment, are discharged into air, water and land. When products are of no use or have become obsolete, they are also disposed of to the land. All these discharges are harming our environment: increase in CO₂ from transportation and industry is giving rise to global warming with its attendant problems of floods, heatwaves, fires, sea-level rise, change in agricultural pattern; air pollution is affecting human health with diseases such as cancer, respiratory, cardiovascular, and neurological diseases, and destroying the ozone layer that keeps the harmful ultraviolet rays of the sun from reaching earth. Plants and animals are not left out of the effect of environmental pollution. The activities of man on planet earth seem to be opposed to how the natural world works. Like water flowing down a path, nature chooses the path of least resistance. But not so with man's activities, most of which are an uphill task with associated environmental.

The activities man undertakes for his survival on planet earth is also being undertaken by the plants and animals that he shares the earth with. The natural world, undisturbed by man, is orderly and full of patterns that can be adopted/adapted in the design of products and processes that man needs to live on earth. Nature has this unusually simple technologies and innovations of solving some of the world's complex challenges (Aziz and El Sherif, 2016). Nature has had 3.8 billion years of experience (Benyus, 2002), and as experience is the best teacher, man can study how nature works and be inspired by her for innovation, this is the paradigm shift needed by man to save planet earth.

Conceptual Clarifications

Nature-inspired innovations

Innovation, according to the United Nations Education Science and Cultural Organization (UNESCO) in Okoye (2012), is a general change that is deliberate and must never be regarded as simple adjustment. The idea of copying from nature is not new as before the industrial revolution, man's inventions mimicked nature: the Indian rock-cut architecture mimicked the caves the early man dwelt in, the Chinese learnt to make silk by observing the silkworm, the Egyptians were inspired by mountains to build pyramids, the umbrella was inspired by children using lotus leaves for rain shelter, and Leonardo Da Vinci studied bird flight and designed the flying machine, from which the Wright brothers constructed the first aircraft, which flew in 1903. Therefore, Janine Benyus (Benyus, 2002) coined the word "biomimicry" for nature inspired innovation; it is the study of nature's forms and functions in order to draw inspiration to use in designing innovative engineering solutions in solving man's challenging problems. The term biomimicry, coined from two Greek words *bios* (life), and *mimesis* (to imitate) literally means "to imitate life"

Leveraging on Nature's Design Principles

No doubt, nature has been around for such a long time, there are however principles that have guided it all these years. It is therefore, pertinent to note that the only way forward for our distressed and ailing planet is to learn these principles and inculcate them in science education student in order to forestall further damage on planet earth. Science education students should be taught that:

- i. Nature runs on sunlight; it is the source of power/energy is 'freely' available, found locally and renewable
- ii. Nature uses only what is needed; this means it does not take from the environment as much as is wanted, but only what is needed, it seeks to optimize rather than maximize
- iii. Nature fits form to function; the purpose and activity determines shape, that is function determines form or form follows function;
- iv. Nature recycles everything; it finds a use for everything, so waste does not exist, it closes the cycle within the whole ecosystem.

Education and Human Development: Interdisciplinary Perspective

- v. Nature rewards cooperation – does not exist in isolation, takes from and gives to another organism present, communal and beneficial relationship
- vi. Nature banks on diversity, that means it has a wide variety of plants and animals, the multidisciplinary nature of its function and activities to meet a need gives nature its resilient characteristic.
- vii. Nature demands local expertise; it works in tandem with what is available in the local environment and does not import
- viii. Nature curbs excess from within; it does not create unnecessary materials
- ix. Nature taps the power of limits; it identifies limits and sets boundary for a feasible solution based on life-friendliness (using safe materials and processes with safe operating conditions conducive to life, such as, ambient temperature and pressure)
- x. Nature runs on information; in order to adapt to their environment, organisms send, and receive information from one another and from the environment and respond appropriately in a negative (to slow down a process) or positive (to speed up a process) feedback loop manner.

Innovative Practices in Science Education Teaching

Science education is concerned with finding answers to problems in a bid to understand and interpret natural phenomena. Science Education has been recognized, the world over, as a prerequisite for scientific and technological development (Ejidike & Oyelana, 2015). It provides opportunities for students to acquire relevant functional knowledge and skills that are associated with scientific processes needed for advancement in science and technology. In science education, students are encouraged to acquire and practice the scientific skills.

For students to understand the concept of nature-inspired innovations and become agents for forestalling health, environmental hazards as well as saving our ailing planet, the Science education teachers must approach the teaching of strategize how best to educate students about nature-inspired innovations. Science teachers have to convert science teaching into sport and learning process that generate interest in the students and motivate them to stay back in the science discipline than to run away from it. Science education should become fun and thrilling to the students rather than burden and boredom. Science education is an engine for the growth and progress of any society.

Nature Inspired Innovations in Practice

A lot of applications of the principles discussed above that point to the fact that drawing inspiration from nature is people-profit-planet (3P) friendly, and therefore can be used to ensure a safer planet earth. The Science education teacher can teach students on the following nature-inspired innovations as panacea for saving our planet:

Nature-inspired innovations in medicine

Science education students can be taught how medicine has a lot of nature-inspired innovations. Rattan is a plant similar to bamboo and has been found to have similar load bearing capacity and internal 3-Dimensional (3D) structure to human bone, and is been used as a scaffold for bone regeneration (Mitha, 2019). Rattan is biocompatible and absorbable, and its structure mimics natural bone. It is used to create scaffolds that support damaged bones and induce bone regeneration. Therefore, in this 21st century, the medical field leverages on the importance Rattan tree plant provides in aiding bone regeneration. In the same vein, the jellyfish has the ability to expand its tentacles to grab food and inspired by this, Zhao (2012) came up with microchips that attach to cancer cells and can be used to observe them as they drift in the blood stream. Microchips can indeed attach to cancer cells, allowing researchers to monitor these cells as they move through the bloodstream. By utilizing techniques such as microfluidic chips, scientists capture and analyze rare tumor cells from blood samples, enhancing cancer diagnostics and possibly improving treatment outcomes. Furthermore, Geckel, the waterproof glue has been used by surgeons to seal holes in organs and other tissue in large animals (Niiler, 2021), and is being proposed on humans (Yu &

Education and Human Development: Interdisciplinary Perspective

Cheng, 2018). This was inspired by the natural adhesive properties of gecko lizards' feet. Bencherif (2012) inspired by the cellular structure of seaweeds, designed an implantable scaffold that is injectable and sponge like and can be used to fill the empty spaces created by surgery when a tissue is removed. Nacre, the inner shell layer of molluscs, has inspired the design of implants, porous scaffolds for bone repair, and also coatings for scaffolds to activate desired biological behaviour (Perera and Coppens, 2019). Medicinal plants have also been discovered by watching animals self-medicate (Shurkin, 2014). There is significant nature-inspired innovation in medicine that students need to be taught about as these have led to the development of various technologies and methods as can be seen in microfluidics for drug delivery and blood collection which have been inspired by natural processes. Additionally, specific medical technologies have been developed based on biological models, such as surgical glue inspired by geckos and tissue attachment systems inspired by octopus' suckers.

Nature-inspired innovations in materials

Nature-inspired innovations in materials is also known as biomimicry which involve designing materials and systems that emulate natural processes and structures. Science education students can be taught that nature has a vast diversity of materials that have helped various organisms adapt in their natural environment (Aziz & Sherif, 2016). Researchers are being inspired by these natural occurring materials, studying them for their form and function, and then using them as models for artificially created ones with similar or completely new functions. The spiny flexible skin of the porcupine fish inspired the manufacture of a durable and flexible superhydrophobic material according to Yamauchi et al., (2019). The multilayered brick-and-mortar structure of the abalone seashell and that of the reindeer antlers have been mimicked to make metals that are tough, lightweight, and thin without being brittle (Zhang et al., 2019). A lightweight plastic that is stiff, strong (14 times stronger than metal), tough and can absorb the impact of bullets and projectiles has been invented by mimicking the outer coating of pearls (Zhang & Ren, 2019). Chameleons have also inspired flexible smart skin that changes color in response to heat and sunlight (Dong et al., 2019). The spider web silk, which is known to be five times stronger than steel and tougher than Kevlar, the toughest man-made polymer used to make bulletproof vests (Vepari & Kaplan, 2007) has inspired the artificial spider silk. Kevlar is made under high pressure using concentrated sulphuric acid, while spiders produce silk using water as a solvent in the open air, at ambient temperatures and pressure. The artificial spider silk is also made at room temperature from common, easily accessible materials, – mainly water, silica and cellulose, it can be stretched several times its length before breaking, and is also completely biodegradable (Wu et al., 2017). Potential uses of the artificial spider silk are: bullet-proof clothing; wear resistant lightweight clothing; ropes, nets, seat belts, parachutes; rust-free panels on motor vehicles or boats; biodegradable bottles; bandages, surgical thread and artificial tendons or ligaments, supports for weak blood vessels and much more (Babu, 2019). In order to make poor quality wood stronger, Leary (1993) studied teak wood and petrified wood, known for their strength, durability and resistance to wood eating insects, and found that the walls of their cells contain silica and other minerals, which must have been absorbed from the soil through the roots. This was mimicked to make poor quality wood stronger by injecting it with a mixture of silica and alcohol in a pressurized container, thus forcing silica into the cells of the wood.

Nature inspired innovations in product designs

Nature-inspired innovation, also known as biomimicry, has led to many products and technologies that are more efficient, cost-effective, and environmentally friendly. Products are part of our everyday life, some of which have been inspired by nature:

- **LEDs:** Inspired by the light-enhancing microsystems of fireflies
- **Velcro:** an adhesive was inspired by plants with burs sticking to clothing and dog's fur.
- **Shinkansen bullet train:** The front of the train was modeled after the beak of a kingfisher to reduce sonic booms when exiting tunnels
- **Octopus-inspired soft robots:** Inspired by the properties of octopuses

Education and Human Development: Interdisciplinary Perspective

- **Lotus Effect:** Lotus leaves are known for their self-cleaning properties due to their unique microstructure, which inspires coatings for buildings and vehicles that repel dirt and water, keeping surfaces clean.
- **Geckel** was inspired by the gecko lizard's reversible sticking ability in any position, and the mussel (snail)'s slimy secretion, which is sticky and effective even when wet (Cho et al., 2019). Both technologies have significantly helped in science and medical innovations.

CONCLUSION

In conclusion, teaching science education students about nature-inspired innovations, such as biomimicry, is crucial for promoting creative problem-solving, enhancing academic achievement as well as skills that can be harnessed to save the planet from global warming effect. By drawing lessons from natural models and processes, students can develop innovative solutions to human challenges, fostering a deeper understanding of both science and sustainability. This approach not only prepares them for modern societal needs but also encourages a mindset geared towards sustainability and adaptability in their future careers.

RECOMMENDATIONS

Based on the study reviewed, the following recommendations were made:

- i. Science Education Teachers should implement outdoor mini-courses that allow students to engage directly with nature. Such experiences can help them understand nature-based health techniques and the principles of biomimicry, fostering a deeper appreciation for how natural processes can inspire medical innovations.
- ii. Science Educators can encourage students to work on interdisciplinary projects that connect biology, design, and technology. By exploring real-world examples of how nature has inspired innovations, for example night vision goggles based on animal vision), students can be helped to develop creative solutions to human challenges, emulating successful adaptations found in nature.
- iii. Educational stakeholders and Science educators should incorporate case studies of successful biomimicry innovations, such as camouflage technology or night vision goggles, into the curriculum. Discussions around these examples can stimulate interest in interdisciplinary approaches and demonstrate the relevance of nature-inspired designs in various fields like engineering, sustainability and materials science.
- iv. Science Educators should integrate hands-on projects that encourage students to design products inspired by natural organisms or processes, such as creating waterproof materials based on lotus leaves or energy-efficient structures mimicking termite mounds. This practical application of biomimicry fosters creativity and problem-solving skills while engaging students with real-world challenges.

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Education and Human Development: Interdisciplinary Perspective

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