

**Integrating Engineering into Teaching and Learning Science:  
Phases, Challenges and the Way Forward**

**Gogwim M. N<sup>1</sup>., Yaki A. A<sup>2</sup>., Bello R. M<sup>3</sup>.**

Department of Science Education  
School of Science and Technology Education,  
Federal University of Technology, Minna

**Corresponding Email:** [nicodemusgogwim@gmail.com](mailto:nicodemusgogwim@gmail.com)

**Abstract**

*This paper is prompted by the current educational reform efforts that call for the integration of engineering into science education. Therefore, it examines the integration of engineering into the teaching and learning of science. It also pointed out how it is possible and beneficial to integrate engineering into teaching and learning of science. Emphasis is made on how engineering helps to make abstract science concepts concrete and develop better skills in students to fit into the current demands of the workforce. Factors militating against the integration of engineering into formal teaching and learning of science were clearly explained with how they can be quickly and rightly overcome. Due to the current educational reforms going on worldwide, there is an urgent need to integrate engineering into biology instruction for better development of creative skills among students, which are mostly and currently needed in the workforce. It was recommended that engineering be integrated into the science curriculum and that science teachers should be trained, supported, encouraged, and motivated to implement it to teach science.*

**Keywords:** Engineering, STEM, Science, Education

**Introduction**

As technology keeps advancing in our nation, so does our dependency on it as a people. For a country to grow for human benefit, it needs to embrace technology in all ramifications. Teaching and learning science require appropriate methodologies or strategies for effective and positive outcomes. The teaching and learning of science in the past has depended almost entirely on traditional teaching methods such as lecture, demonstration, questioning, field-trip, discussion, etc.

This has made the learning of science and science-related subjects difficult and has encouraged cramming among science students. It is so sad that most science students taught with the methods mentioned above can not compete in skills application. For example, there are shortages of professional workers in the workforce market with proficient Science, Technology, Engineering and Mathematics (STEM) knowledge and skills required in the 21st century (Sazman, 2019). The growing concerns that there are insufficient numbers of professionals majoring in STEM disciplines have prompted nations like the United States of America, United Kingdom, etc. to launch the American Society for Engineering Education (ASEE) in 2006 as an initiative with the overall intent of transforming educational engineering through an academic scholarship to better prepare graduates for the 21st-century workforce. Engineering education helps integrate engineering research into teaching and learning of science which in turn accelerates technological and educational innovations and improve the quality and diversity of graduates who would enter the labour market ceremoniously. Advancing STEM education requires going beyond an extracurricular science and mathematics outreach initiative. It requires that engineering and

technology applications be incorporated into the science curriculum for better teaching and learning of science. According to Ghalia, *et al.* (2016), implementing engineering curriculum into science education will increase the educational outcomes of the students. It will go a long way in helping to motivate students to learn science content and increase students level of understanding of science. It will also boost students interest in pursuing a STEM or STEM-related careers. The advancement accompanies the increased emphasis on integrating engineering into science teaching and learning in developing and introducing initiatives to expose students to engineering applications like STEM. Despite the influential role of these initiatives in exposing students to engineering, they cannot bypass teachers as the cardinal source of influence for students achievement (Ghalia, 2016).

Engineering is a significant focus in STEM education because it has encompassed applications that advance students learning in an open-ended problem within real-world contexts. It is found to help develop students' problem-solving skills and communication and teamwork skills, mainly since collaboration is often used as an instructional strategy for engaging students in solving open-ended problems (Park, 2012). The introduction of NGSS (NGSS Lead States, 2013) has made engineering a core part of the science curriculum, emphasizing that science curricula that "stimulate and build interest" in STEM can increase the numbers of students pursuing STEM fields.

#### **Need to Integrate Engineering into Science Teaching and Learning.**

The integration of engineering into the teaching and learning of science is crucial for the following reasons:

To promotes creativity: - integrating engineering into science teaching and learning helps to promote new ideas and innovations. For example, there will be no meaningful development in artificial intelligence or digital learning if there is no ingenuity and creativity. These are products of science, technology and engineering.

To encourage tech use: Integrating engineering into science teaching and learning empowers students with good knowledge of technology and innovation. When they encounter new technologies, they should be prepared to embrace them instead of being hesitant or fearful. It will also guarantee the upper hand in the global landscape as the world becomes technologically based every day.

To encourage Teamwork: Integrating engineering into teaching and learning science helps teach students of all ability levels. Students of varying ability levels can work together to find solutions to problems, record data, write reports, give presentations, etc. The result is students will understand how to collaborate and thrive in a team-oriented environment.

To encourage knowledge application: - using engineering as a strategy for teaching and learning science will teach students skills that they can use in the practical world. This motivates the students to learn as they know that the skills they acquire can be utilized immediately and in such a way that can positively impact them and their loved ones. In addition, the ability to apply their knowledge to new and novel tasks will bode well for them when they enter the workforce.

To teach problem-solving skills: - STEM education teaches students how to solve problems using critical thinking skills. By engaging in STEM learning experiences, students learn to examine the issues and create a workable plan to solve them.

To build resilience: - When engineering is used to teach or learn science, students can fail and try again. It stresses the value of failure as a learning process, enabling students to embrace mistakes as part of the learning process. This allows students to build confidence and resilience, allowing them to keep going even when the going gets rough. After all, failure is part of the process that ultimately leads to success.

To encourage experimentation: - without engineering, many technological advancements that have occurred in a couple of decades would not be possible. Unfortunately, many of these innovations were created by people who were told that their ideas wouldn't work and their response was, "Let's try and see". This type of attitude can be encouraged with STEM learning.

To increase the number of students pursuing STEM fields, the number of those with STEM knowledge and skills will undoubtedly increase by integrating engineering into science teaching and learning.

It enables students to realize the importance of science and engineering: integrating engineering into science teaching and learning will help foster the understanding of how science and engineering are mutually related and the critical role they play in innovation and problem-solving.

### **Integrating Engineering into the Teaching and Learning of Science**

To integrate engineering into science teaching and learning, an engineering design process must be strictly followed. The use of Bio-inspired design, Biometrics and Biomimicry can encourage the process through which innovative, responsible and impactful solutions to mankind problems can be achieved. (Bilici, 2021). According to Householder and Hailey (2012), the following phases are used to integrate engineering into the teaching and learning of science:

Phase 1: Problem identification

Phase 2: Background research investigation

Phase 3: Idea generation through brainstorming

Phase 4: Selection of the best solution.

Phase 5: Prototype construction.

Phase 6: Prototype testing and assessment.

Phase 7: Communication and reflection

Phase 8: Redesigning and finalizing the design.

According to Park (2012), the following engineering design process can be used to integrate engineering into teaching and learning of science:

Phase 1: Identify the problem/need

Phase 2: Research and Rank Objectives and constraints

Phase 3: Develop possible solutions

Phase 4: Select the best solution within constraints

Phase 5: Model solution

Phase 6 : Test/Evaluate the solution

Phase 7: Present/communicate the results

Phase 8: Redesign and Revise

English and King (2015) implemented Engineering as engineering design process in alimentary school. The pases include:

1. Problem solving
2. Idea generation
3. Design construct
4. Evaluation and
5. Redesign

The phases of; Ask, Imagine, Plan, Create and improve (Shahali *et al* 2017).

Given the proceeding, the implementation of Engineering as a teaching approach will depend on the instructional content and the final outcome.

From the above engineering design processes, it's clear that engineering can be integrated into teaching and learning of science.

### **Factors Militating the Integration of Engineering into Sscience Teaching and Learning.**

Teaching and learning science using engineering has not come without challenges. These challenges are:

Inadequately trained teachers in engineering: - integration of engineering into teaching and learning of science is always problematic. This is because most teachers of science have little or no knowledge of engineering.

Therefore, when asked to implement the curriculum that incorporates the use of engineering to teach science, they always find it not only difficult but somehow impossible: because of the following factors

Lack of conceptual understanding of how to integrate engineering into their curriculum: - According to Ziaefard, *et al.* (2017), science teachers lack the conceptual understanding on how to integrate engineering into school curriculum from which they can implement. This is because only few of them might have been exposed to instruction that integrates curriculum design, engineering, and technology, so it is not surprising that they lack the knowledge on how to use engineering effectively to teach.

Lack of practical knowledge: - most science teachers are not practically oriented and this stands as a serious barrier in the integration of engineering into science teaching and learning. Engineering as a field of study requires more of practical applications than theoretical presentations. For science teachers who base in teaching theory for example, may find it extremely difficult to bring in engineering into the curriculum of science.

Poor funding of education: - one of the major problems that hinders the the integration of engineering into science curriculum is the fact that education as a sector is usually being poorly funded. Using engineering to teach science will demand a lot of funds for the purchase of materials and also for training and retraining of teachers.

Lack of administrative support for the programme: - Ross, *et al.* (2018) states that professional development opportunities, as well as curriculum integrating engineering applications are not prevalent, which means that the support that teachers need for transforming their practices is quite limited.

Education policy makers: - education policies made by policy makers do not usually provide room for the integration of engineering into science teaching and learning. This is one of the reasons why the integration of engineering into science curriculum may be difficult.

Corruption: - this is a cancer that eats deep into the education sector. Some of those who are entrusted to manage education sectors are highly corrupt. Apart from looting the money allocated for education upkeep, they make bad policies that do not provide conducive learning environment for the students. This is already a problem to the implementation of engineering as a strategy of teaching and learning of science particularly in secondary schools.

Teachers attitudes: if teachers consider the integration of engineering into the science curriculum as an additional workload for them, they may have negative attitudes towards its implementation.

Time constraint: Time is one of the significant challenges in implementing engineering into the teaching and learning of science. This is because students need a lot of time to perform the activities that are enshrined in the design procedures

### **Way Forward**

Despite the problems stated above, as a nation, we must work sleeplessly towards addressing them. The following ways will go a long way in addressing those problems:

Establishment of engineering training centres for science teachers: - to teach in science teachers the skills of engineering to enable them to acquire and apply same in the integration of engineering into science teaching and learning, training centres must be established to give them training inform of seminars, workshops, conferences, etc. This will provide the enabling environment for them to develop the needed skills.

The school administrators should support teachers to develop engineering skills: - For science teachers to be motivated to take the bull by the horn in ensuring that they acquire the needed skills for the teaching of science using engineering, such teachers must be encouraged and supported by the school proprietors/proprietress both in kind and in the form of incentives.

Identification of curriculum that is infused appropriately with engineering: - Ross et al. (2018) recognized that while it is valuable to learn how to identify a curriculum that is appropriately infused with engineering, there is much to learn about transforming already developed classroom lessons into "engaging and educationally appropriate design challenges with open-ended solutions"

Proper funding of the education sector: When the education sector is properly funded, the environment for better teaching and learning of science shall stay. This will also create avenues

for proper sponsorship of science teachers to acquire more knowledge and skills to implement engineering as a method of teaching and learning science. It will also make it possible for teachers and school administrators to acquire the materials needed for this purpose.

Better education policies should be made: - when good policies are made regarding education, particularly science education, it becomes easier for contemporary ideas to be incorporated into the system. For example, for a contemporary method such as engineering to teach science to be integrated into science education, policies favouring its inclusion must be made first. Without such guidelines, it becomes difficult for the new method of teaching and learning to see the light of the day.

Tackling corruption in the education sector with corrupt managers will always remain without any technological progress. This is because, when funds are released to the education sector for research, infrastructure, and staff training, such money may end up in the broader pockets of the looters. But when the corrupt persons are arrested, prosecuted and sanctioned, the system will pave the way for the right people who may eventually come in with better ideas or opinions for the growth of education.

### **Conclusion**

This paper illustrates several considerations that may inform the future to integrate engineering into teaching and learning science meaningfully. The need for the integration of engineering into the teaching and learning of science is also stressed. Challenges facing the implementation of engineering as a method of teaching science were also highlighted, and ways to overcome them were clearly stated.

### **Recommendations:**

Based on the above research study, the following recommendations were made:

1. Curriculum planners should ensure that they make provision for the integration of engineering into science curricular.
2. Government and other non-governmental organizations whose interest is in science education should support the program by providing the enabling environment (fund) to schools to establish the program.
3. School administrators should ensure that science teacher receive suitable training on using engineering to teach science. This could be through organizing seminars, workshops, conferences, etc.
4. Science related engineering courses should be introduced in the departments of science and technology education across the universities in the country for the upcoming teachers to learn.
5. Science teachers should be prepared and willing to implement any policy regarding engineering to teach science.
6. Durations for teaching science should be increased in the school timetables to enable science teachers to accommodate engineering to teach science.

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