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Science and Technology Teachers are Foundations of a Developing Nation using Cross River State of Nigeria as a Case Study

Awafung Emmanuel Adie[1], Francis Agim[2], Awafung Veronica Iye[3] and Olive Ezinwa Stan-Ukaoma[4]

[1]Department of Biomedical Engineering Kampala International University Uganda awafungadie@gmail.com; awafungadie@kiu.ac.ug
[2, 3]. Department of health Education, University of Calabar, Nigeria.
[4.] Global Mercyships

ABSTRACT

The role of science and technology in the development of a nation is a critical area of study, particularly when examining the case of Cross River State in Nigeria. This paper provides a comprehensive review of how advancements in various scientific and technological domains can serve as the foundation for the progress and growth of a developing region. The paper begins by highlighting the importance of scientific innovations for Crops River State, a region heavily reliant on engineering chemistry etc. The paper also underscores the critical need for infrastructure development supported by engineering and construction innovations. The creation of robust transportation networks, power grids, and other essential infrastructure is a cornerstone of sustainable development, and the paper explores how such technological advancements can transform Cross River State. Furthermore, the review discusses the potential of medical research, pharmaceutical breakthroughs, and telehealth solutions to enhance healthcare access and outcomes for the local population in Cross River State. It also highlights the transformative impact of teachers in digital technologies, such as e-government services and digital education platforms, in driving economic growth and societal progress. The paper emphasizes that for Cross River State to fully capitalize on the benefits of science and technology teachers, and they should include building local STEM capabilities, encouraging technology transfer, and establishing an enabling policy environment that fosters innovation and collaboration. **In conclusion**, this comprehensive review underscores the central role of science and technology as the foundation for the development of a nation, as exemplified by the case study of Cross River State in Nigeria. The insights provided in this paper offer valuable guidance for policymakers, researchers, and stakeholders committed to driving sustainable progress in similar developing regions.

Keywords: Science, Technology, Teachers, Nation, Developing, Cross river state, Nigeria

INTRODUCTION

Science and technology have proved to be significantly useful in man's daily struggle to control his environment and build a comfortable world. Globally, countries have continually sought to improve the quality of science and technology education particularly developing countries. The role of science and technology in the sustainable development of every nation can hardly be overemphasized. Pursuit of science education leads to national reconstruction and development for self-reliance [1-3]. Thus, the economic and social development of both developed and the developing nations such as Nigeria are to a large extent dependent on the level of scientific and technological literacy of her citizens. All branches of science have important contribution to make in a nation's technological advancement. The subjects that make up sciences include physics, chemistry and biology. Among the branches of science, chemistry occupies the central role which link other branches of sciences as a prerequisite for the future study of professional courses such as medicine, nursing, and so on [4]. [5], pointed out that chemistry is

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presumed to be the fulcrum which all science and technology disciplines and careers hinged for national development. This is due to ability of chemistry to explain matter from the elementary particles, and thus deal effectively with science concepts and principles regarding natural phenomena in the environment. The world is a chemistry world because everything in the world consists of one chemical substance or the other. Therefore, there is no gainsaying that the role of chemistry in science and technology for industrial and overall development of any nation cannot easily be under estimated. As a result, [6] stressed that chemistry occupies a central position among the sciences due to its remarkable contribution in medicine, pharmacy, textile industry, engineering, petroleum and agriculture to mention but a few. In medicine, chemistry is useful in the development and testing of new medical treatments and medicines [7]. This is because the drugs used for treating or preventing diseases are made of chemicals and the development of such drugs involves chemical analysis and synthesis of new compounds. [8], stated that the contribution of chemistry is not confined just to discovery stage of drugs but also to the entire spectrum of clinical development, leveraging on the knowledge of synthetic chemistry and biochemistry. The author further stated that chemistry remains the backbone of drug discovery which continue to boost the growth of the pharmaceutical industry.

Infrastructure Development

Engineering and construction technologies are key for building roads, bridges, power grids, and other critical infrastructure in the region. In engineering, engineers apply the concepts, principles and theories of physical chemistry, inorganic chemistry, organic chemistry, electrochemistry, biochemistry, analytical chemistry, surface chemistry, geochemistry, material chemistry, and asphalt chemistry to carry out their operations [9]. The more an engineer understands chemistry the more beneficial it is to him or her. Chemistry explains that the current passing through transistors, resistors, capacitors, inductors and semiconductors are due to the movement of electrons. Therefore, an electrical engineer must have this knowledge to make an electrical circuit. In the same way, a civil engineer needs to have adequate knowledge of the chemistry of cement to be able to handle cement and other components used in construction. In other areas like Water Resource Management, the rivers and waterways in Crops River State are vital resources. Scientific advances can help in efficient irrigation systems to maximize water use Water purification and sanitation technologies.

Flood Monitoring and Control Systems.

Healthcare Improvements for Medical research, pharmaceuticals, and telehealth technologies can enhance healthcare access and outcomes for the local population. Digital Transformation will help in the Investigation, information and communication technologies can digitize government services, improve education, and foster entrepreneurship and economic growth.

Chemistry Also Has a Wide Application in Agriculture

The application of chemistry ranges from the manufacturing of materials for the production of improved variety of crops and animals for consumption or commercial purposes to the safe storage and processing of agricultural products. Through the knowledge and application of chemistry, a variety of fertilizers have been produced to increase crop yield, a number of pesticides and insecticides to control pests and insects, plastic pipes for improved irrigation, and sulphur dioxide to keep grains fresh for a longer period of time. Also, the knowledge of chemistry enables farmers to understand the importance of photosynthesis and the need to grow crops in an open space to receive maximum sunlight [10]. In education, chemistry as a branch of science and as a subject of study plays a vital role in the educational system of a country [11]. This is why chemistry occupies a unique position in the school curriculum. As a central subject to many sciences related courses, chemistry combines with other subjects such as mathematics, English language, biology, and physics to gain admission into the university to study science related courses such as medicine, pharmacy, agricultural science, nursing, biochemistry, dentistry, microbiology, laboratory technology, geology, geochemistry, pure and applied chemistry, chemistry education and engineering. It therefore becomes imperative for anyone wishing to study any of the courses listed or related to such, to offer chemistry as one of the prerequisite subjects in secondary school to gain admission into the university. Inspite of chemistry as a prerequisite to these courses and an invaluable tool for a nation's development, the unpleasant poor trend of achievement of students in the subject is alarming according to reports from researchers such as [12-15]. In particular, [15] reported that out of 1,209 students that sat for the SSCE examination in 2005 in Cross River State, only 19.86% of the candidates passed at credit level. Also, out of 4,976, 5,476, 5,460, 5,630, 5,138 and 6,105 candidates that sat for the subject examination in 2006, 2007 2008, 2009 and 2010, only 17.40%, 24.42%, 21.69%, 15.75% and 23.34% respectively passed at credit level. This result indicated that students are not doing well in the subject in cross river state. However, the situation of poor trend of achievement of students in chemistry is not peculiar to Cross River State alone but also applicable to other states of the country. For instance, [12] reported that out of the 105,453 candidates who sat for chemistry in Abia State from 2010 to 2014, only 26,680 had credit pass in the subject. This means that only about one in four students can use chemistry as one of the subjects that would qualify them for university admission. Looking at the distribution of students' achievement in chemistry who sat for the SSCE

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examination in 2014, 2015, 2016, 2017 and 2018 in Cross River State as presented in Table 1 also indicated a poor trend of students' achievement in the subject. The result showed that out of 34,855 candidates who sat for the examination, only 15,955 representing 45.8% of the population passed the subject at credit level, a mark which indicated that greater percentage of the students obtained grades below credit pass (that is, D7-F9) in chemistry. All the reports point to the direction that all is not well with our educational system and this calls for concern from parents, teachers, school administration and other stakeholders. If urgent and responsive steps are not taken to critically examine the possible causes of this poor trend of achievement and solutions advanced to arrest the situation, students' achievement in the subjects may not improve and the goal of science education would be defeated.

Table 1: Percentage distribution of science students' achievement in May/June Senior Secondary Certificate Examination (SSCE) in Cross River State from 2014 – 2018

Year	Number of candidates	Total credits (A_1-c_6)	Percentage pass (A_1-c_6)	Total failure	Percentage failure
2014	6,586	2,479	37.64	4,107	62.36
2015	6,221	3,029	48.69	3,192	51.31
2016	6,468	2,767	42.78	3,701	57.22
2017	7,727	3,867	50.05	3,860	49.95
2018	7,853	3,813	48.55	4,040	51.45

Source: Statistics Section, West African Examination Council (WAEC)Branch Office, Uyo, Nigeria (2021)

Some factors have been implicated for why there exist a poor trend of achievement of students in chemistry. For instance, [16] posited that the mass underachievement of students in chemistry is due to poor study habits of students. The overloaded chemistry curriculum has also been cited as being responsible for students' poor achievement in chemistry [6]. [17], reported that students' poor achievement in chemistry because of lack of teaching materials and resources to teach the subject. Some other reports revolved around poor and inappropriate teaching methods [18-20]. Chemistry, physics and most science subject consists of complex and difficult abstract concepts; thus, students engage in rote learning or memorization [21, 22]. [15], reported that poor retention of chemistry concepts was responsible for students' poor achievement in the subject.

Among the various factors enumerated to be responsible for the poor achievement of students in chemistry, poor teaching methods seems to be a major contributory factor which has been described as being predominantly teacher-centered methods of instruction. Such methods practically neglect students' active participation in the classroom. Thus, making them passive recipients of knowledge. [23], stated that to make chemistry learning more meaningful and student-centered, there is need to explore and adopt more effective delivery techniques. Concept Mapping is reportedly one of such strategies that may be used to enable students to think about connections on what is being learned, organize their thoughts, visualize relationships between key concepts in a systematic way and be able to reflect on their understanding. Concept mapping according to [24] is a graphical tool for organizing and representing knowledge. It is represented in hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically. Concept maps are developed to enhance conceptual understanding as well as active and meaningful learning in sciences.

According to [25], there are three features used in creating concept maps:

a. A list of concepts
b. Lines that represent the rational links between these concepts
c. Labels for these linking relationships.

Concepts maps are frequently employed in the classroom because they offer a complementary alternative to natural language as a means to communicating knowledge. This visual approach may be of great benefits to students' academic achievements. Concept mapping also helps student to improve on their achievement and retention of learned materials. Apart from instructional strategies there are many other factors which may influence students' achievement in chemistry, among which are gender and school location. Gender according to [26], is the social or culturally constructed characteristics and roles which are ascribed to males and females in the society. According to the Swiss Agency for development and cooperation, gender refers to a socially constructed definition of women and men, and it is not the same as sex (biological characteristics of women and men) Gender is determined by the conception of tasks, functions and roles attributed to women and men in society and in public and private life [26]. In our society today, it is often believed that women are underachievers in science related areas and technology. The issue of bridging the gap between men and women in technical subjects and science remain very elusive. [27], defined school location as a place where a school is sited, be it rural or urban setting. Urban schools are those in the urban centers or municipalities or towns while rural schools are those in villages or semi-urban areas. [28], stated

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that the location of school may affect students' achievement in biology. A school located in rural area they argued, will have all the characteristics of a rural environment. Similarly, an urban school will have an environment and features that are unique and different from rural location. As the environment differs, the level of academic achievement may also differ. Academic achievement according to [29], is a measure of knowledge gained through formal education usually indicated by test scores, grade point average and degree. Academic achievement is the extent to which a student, teacher or institution has achieved their short- or long-term educational goals. According to Wikipedia the free encyclopedia, academic achievement refers to cumulative grade point average CGPA and completion of educational benchmark and bachelor degree. Academic achievement is commonly measured through examinations, continuous assessments, but there is no general agreement on how it is best evaluated or which aspects are most important procedural knowledge such as skills or declarative knowledge such as facts. The concern of this study therefore is to investigate effects of concept mapping on senior secondary school students' achievement in chemistry in Ogoja Education Zone of Cross River State, Nigeria.

Theory Framework

Many theories have been on for the review which includes Piaget's theory of constructivism propounded in (1987) argues that people produce knowledge and form meaning upon their experiences. Two of the key components which create the construction of an individual's new knowledge are accommodation and assimilation [30]. Assimilation causes an individual to incorporate new experiences into the old experiences, ultimately altering their perceptions. Accommodation, on the other hand, is reframing the world and new experiences into the mental capacity already present. The constructivist holds the view that learners actively construct knowledge (cognitive restructuring) and that meaningful learning occurs when concept are organized in an individual concept structure. Concept mapping makes learners' current knowledge explicit which allows them to identify gaps in understanding and incorporating new information or ideas. Piaget theory of constructivism also addresses how learning occurs, not focusing on what influences learning [31]. Teachers following Piaget's theory of constructivism must challenge the students by making them effective and critical thinkers and not being merely a teacher" but also a mentor, a consultant and a coach. The implication of Piaget theory of constructivism to students is that it challenges them by making them effective and critical thinkers and helping them to work together in the class to solve problems or complete tasks [32]. The implication of the theory to this study is that concept mapping instructional strategy encourages active engagement or participation of students in learning science concepts in a self-regulated learning environment [33]. As a constructivist approach to learning, concept mapping encourages active participation of learners in knowledge construction, autonomy in learning, creativity, and development of problem-based attitude to learning and active retention of concepts. David Ausubels theory of meaningful learning (1968) [34]. David Ausubel theory of meaningful learning states that learners learn through a meaningful process of relating new ideas, events and concepts to already existing concepts. Ausubel said that meaning is not an implicit response but an expressed and distinguished conscious experience that takes place when meaningful signs, symbols, concepts or propositions are related to a given individual cognitive structure or schema. Ausubel stated that if he had to reduce all educational psychology in just one principle, he would say that, the most important single factor influencing learning is what the learner already knows, establish this and teach them. David Ausubel says that meaningful learning is a crucial type of learning for classroom instruction. This knowledge involves new knowledge that is related to what the learner already knows, and it can easily be retained and applied. Ausubel's theory emphasized the need of prior knowledge of the students in order to have a meaningful learning. Also, teachers should be aware of the students' prior knowledge in order to make the best use of it in the teaching process [35]. David Ausubel also suggested the use of an advanced organizer as a way to help students make connection to the ideas with the new concepts [26]. The advanced organizers may be a device or a mental learning aid to help students get a grip of the new information. According to the theory, the students have to be active, and teachers have to reinforce new learning through performing the role of a facilitator. The theory completely condemns the idea of role learning in classrooms. According to the theory, three basic requirements are to be meet for meaningful learning to take place, these are;

i. Students must construct mental pictures of the language which help them to relate with new information.
ii. Students must construct significant concepts and propositions, which must be relevant to the knowledge to be obtained.
iii. The learners must consciously and deliberately choose to relate new knowledge to what he already knows in some nontrivial way.

Ausubel theory of meaningful learning is relevant to this study because, the principle guiding the concept mapping strategy is hinged on the theory [37]. During the process of concept map constructions, learners consciously relate what they already know to the new concept [38]. The construction of concept map follows a hierarchy, beginning with the most generic concepts and ideas which the learner knows to the specific and more complex concepts which the learner is to acquire. Also, the tenets of the theory, to the concept mapping teaching strategy afford the students

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the opportunity to be active in the learning process rather than being passive listeners, students acquire meaningful learning rather than rote learning and promote retention of concepts in the permanent schema rather than mere memorization which occurs at the temporary memory. The place of the teacher here is not to act as an instructor but to play the role of a facilitator of knowledge [39].

Summary of the Review Paper

From the different reviews we can conclude with a summary that the introduction of science education

- **Drives Economic Development:** Science education equips students with critical thinking, problem-solving, and technological skills needed to drive innovation and economic growth.
- Producing a skilled STEM workforce is crucial for developing new industries, improving agricultural productivity, and enabling Africa to compete in the global knowledge economy [28].
- **Improves Health and Wellbeing:** Science education provides the foundation for understanding and addressing public health challenges, from developing vaccines to improving sanitation and hygiene [26]. It enables the design and deployment of appropriate medical technologies and treatments to combat infectious diseases, malnutrition, and other health issues prevalent in Africa.
- **Addresses Environmental Challenges:** Science-based knowledge and skills are essential for tackling climate change, biodiversity loss, desertification, and other pressing environmental threats facing the continent. Science education fosters the development of sustainable energy solutions, water management systems, and agricultural practices to enhance climate resilience.
- **Promotes Scientific Literacy**: Strengthening science education helps cultivate a scientifically literate population that can make informed decisions, engage in evidence-based discussions, and become active participants in the development of their communities.
- **Inspires Innovation and Entrepreneurship:** Hands-on science education sparks curiosity, creativity, and a spirit of innovation among students, encouraging them to devise novel solutions to local and global challenges. This can spur the growth of science-based startups and small businesses, diversifying economic opportunities in Africa.
- **Reduces Gender Disparities:** Inclusive science education programs can help break down barriers and encourage more girls and women to pursue STEM fields, addressing the persistent gender gap in these disciplines. Investing in quality science education at all levels is crucial for unlocking Africa's and Nigeria's full potential. By equipping the next generation with scientific knowledge and skills, countries can accelerate sustainable development and improve the lives of their citizens.

CONCLUSION

The key is for Cross River State and the rest part of the world to strategically identify its development priorities and then leverage relevant scientific and technological teachers and innovations to address them. This requires a concerted effort to build the teacher's capacity, build local STEM capabilities, encourage technology transfer, and create an enabling policy environment. With the right focus on science and technology, Crops River State can accelerate its path toward a more prosperous and sustainable future.

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