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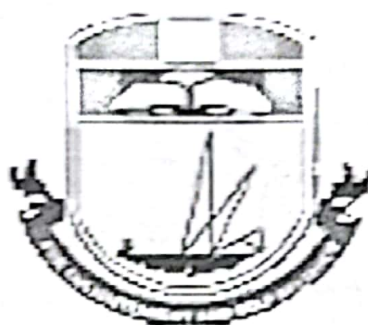
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ACQUISITION OF ENTREPRENEURIAL SKILLS IN CHEMISTRY EDUCATION TOWARDS SUSTAINABLE DEVELOPMENT: THE ROLE OF SCIENCE-TECHNOLOGY-SOCIETY APPROACH

By

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Abstract

Nigeria in recent times has been faced with persistent unemployment and economic down turn that has plunged the nation into recession. Hence, the quest for resourceful, adaptable and enterprising students who can rescue the nation cannot be overlooked. Therefore, the need to produce students that are equipped with entrepreneurial skills which can enable them to function appropriately after school becomes a necessity. Entrepreneurial skill is a crucial agent of innovation which enhances sustainable development in a country. Hence, the acquisition of entrepreneurial skills by students transform them from job seekers to job creators which in turn increases capacity building, employment opportunities and enhances employability. This may rescue the nation from the persistent unemployment and economic crises it is facing in recent times, which is a concern to science educators. This is apparently due to the fact that science is the bedrock for socio-economic advancements of all nations. Hence, the themes of the science curriculum and its implementation should be accorded maximum attention. This paper therefore, provide insights into the role of Science-Technology- Society (STS) approach to the teaching and learning of chemistry to enhance the acquisition of entrepreneurial skills which will enable students to function effectively in the society towards achieving sustainable development. Also, the role of STS in the acquisition of the 21st century skills and factors that affect the adoption of the STS approach by chemistry teachers were discussed. It also provides justification for the need to incorporate entrepreneurial skills in chemistry curriculum. Finally, some entrepreneurial skills that chemistry students can undertake for self-reliance were highlighted. It was recommended among others that chemistry teachers should adopt the STS approach in teaching, to indicate the relevance curriculum contents to the society.

Keywords: Entrepreneurial skills, Science, Technology, Society, Sustainable development

Introduction

The goal of chemistry education is to imbibe the right skills in students that will enable them to develop and function effectively in the society. However, students have been graduating from school without possessing these skills. This situation leads the nation into the challenges of unemployment and economic downturn that has plunged it into recession. Therefore, the need to seek for avenue for self employment for students by creating avenue where they can acquire entrepreneurial skills for self reliance and fulfillment is now compelling (Jack & Blessed, 2015). This will lead the drive towards sustainable development. Realizing the urgent need to imbibe in students the right skills to function in the society after school, and the role of science in the technological development of a nation, it is imperative that entrepreneurial skills should be integrated into the chemistry education to help students relate the concept of chemistry as it links with technology and society. This interrelated link is the focus of STS which is a reform that is adopted in developed countries across the world.

The STS approach of teaching arouse from the necessity of teaching and learning in the context of human experience (STAN, 2001). It was stipulated in the National Policy of Education (2014) that teachers should make instruction concept-centered, activity based and work related. An overview of this statement indicates emphasis on equipping students with entrepreneurial skills during instruction is crucial for them to function effectively in the society.

Concept and Nature of the Science-Technology-Society Approach

In the world where science and application of science plays important role in the society as they do today, it is essential that individuals possess some basic understanding of science in order to make informed decision in their daily lives and function effectively as a citizen. Science, technology and society are interrelated that they cannot be completely treated in isolation. Science is defined as an organized body of knowledge that investigates the natural phenomenon through observation, identification, description, experimental investigation and theoretical explanation of phenomena (Harper, 2010). Technology is the application of the knowledge of science to solve problems relating to man and his environment. It involves the utilization of practical knowledge of science to solve real life problems, while society is a group of people living together in a geographical area that shares laws and traditions within their confinement. It represents the totality of individuals with common interest sharing some cultural beliefs.

Science- Technology- Society (STS) involves the application of the knowledge of science through technology to improve and solve problems relating to the society. This approach, utilizes the interrelationships between the concepts of science, technology and society in teaching and learning of chemistry. It is a reform that is adopted across the globe and a means that is used to put the knowledge of science to application towards improving human life. Therefore, to acquire the objectives of teaching and learning of chemistry it is important to give an insight to the role of STS approach which arouse from the necessity of teaching and learning of science in the context of human experience (STAN, 2001). The introduction of STS curriculum into science curriculum aims at equipping students to understand and situate scientific and technological development in their cultural, environmental, economic, political and social context.

Due to changes in the trend of events globally, there is the need for all nations to be equipped with relevant grounding in science that involves technology which surrounds them taking cognizance of issues and conflicts that are related to the use of the technology to attain sustainable development. This changes lead to advocating for change in science teaching that involves considering the relevance of scientific knowledge from the societal point of view. Mansour (2009) noted that STS is an interdisciplinary field of study which explores and understand the ways modern science and technology influences culture, values and institutions on one hand and how modern values also shapes science and technology. The STS approach involves the integration of science, technology and social issues in stating specific aims of teaching science and strengthening the awareness of learners to a range of knowledge, skills and values relating to social issues and technological processes (Kok & Schoor, 2014). Its process involve teaching by starting with students and their questions, utilizing all available resources to resolve problems and taking crucial actions individually or collaboratively to resolve issues. STS is a more positive approach in terms of improving students' attitude to science which differs from other typical approaches to science teaching.

Table 1: Differences between STS Approach and Non- STS Approach

STS Approach	Non -STS Approach
Student centered	Teacher centered
Individualized and personalized; recognizing students diversity	Group instruction geared for the average student
Use of variety sources	Directed by curriculum and chapters in a book

Cooperative work on problems and issues	Some group work, primarily in laboratories with directions to be followed
Teachers build on students experiences assuming that students learn best from their own experiences	Teachers do not build on individual students experiences. It is assumed that students learn more efficiently by being presented with organized, easy to grasp information
Teachers and students plan instruction around problems and current issues	Teachers plan their instruction using prescribed curriculum guides and textbooks
Teachers and students are involved with structuring goals and associated assessment strategies	Goals are not discussed nor used to assess learning

Source: Yager (2009), as defined by National Science Teachers Association (2006).

The Role of STS Approach to the Teaching and Learning of Chemistry to Enhance the Acquisition of Entrepreneurial Skills

Nigeria in recent times has encountered challenges of unemployment and economic downturn over the last few years. This situation has plunged the nation into economic recession in recent times. The federal government reforms on the Millennium Development Goals MDGs and the target of NEEDS saw value in poverty eradication, job creation, value orientation, wealth generation and using education to empower people (NERDC, 2009). Realizing the urgent need to imbibe in students the right skills to function in the society after school and relating it to the role of chemistry in the technological development of a nation, it is imperative that entrepreneurial skills be integrated into chemistry education. One of the goals of chemistry education as stated in the senior secondary school chemistry curriculum is to imbibe in students the right skills and values that will enable them to develop and function effectively in the society (NERDC, 2009). Therefore, the teaching of chemistry needs to direct its focus to accord students the opportunity to be equipped with skills that will make them self reliance. Hence, the acquisition of entrepreneurial skills for self employment and self fulfillment is now compelling (Jack & Blessed, 2015). The federal government of Nigeria in the National Policy of Education, stipulated that teachers should make instruction concept-centered, activity based and work related (FRN, 2014). An overview of this statement indicates emphasis on the need to equip learners with knowledge and skills that will make them function effectively in the society after school.

Entrepreneurship is concerned with utilizing one's innate capacities developed overtime through training and experience to stimulate economic progress thereby providing business opportunities that will bring progressive change in the individual (entrepreneur) and the society. It can be regarded as the process of creating new business concepts or recreate an already existing organization with new ideas. Omiko, (n.d) referred entrepreneurship as the ability to overcome structural obstacle that prevents one from excelling. However, the main component of entrepreneurship is not starting a business but stimulating economic progress through innovation and action (Pinta & Benue, n.d). It plays a major role in fostering economic growth which requires individuals' ability to turn ideas into action by exploring the spirit of creativity, innovation, risk taking, planning and managing projects in order to achieve objectives (European Commission, 2010)

Entrepreneurial skills are innate capacities that students need to be equipped with to succeed in business which are developed through training, practice and experience (Adeyemo, 2009). It is the ability to utilize ideas and create business opportunities for personal, social and developmental gains (Olagunju, 2004). It is regarded as individual's innovative ability by devoting time and efforts, putting into consideration the financial, psychic and social risks thereby obtaining independence, monetary and personal satisfaction in turn (Hisrich & Peters, 2002). However, teaching and learning has not been focusing on imbibing entrepreneurial skills in students rather there have been focus on understanding contents of instruction. The implication of this is that graduates are not provided with opportunities to be self reliance which has the capacity of

and themes that frame 21st century learning include traditional core subject while emphasizing civic literacy, global awareness, financial literacy, health literacy and environmental literacy. It is important to note that students generate new ideas and concepts through mental and social processes. The new association between existing ideas and concepts leads to new ways of doing things that can change thinking, processes and products. To increase students skills in the 21st century, Zemelman, Harvey and Arthur (2005) noted that teachers should do more of problem based learning, real world applications, provide challenging opportunities for learning, involve students in inquiry and problem solving about significant human issues relating to the society.

Several frameworks have been identified for the 21st century skills. The North Central Regional Education Laboratory (NCREL) and Metiri Group (2003) identified four categories in the 21st century skills. These includes; digital age literacy, inventive thinking, effective communication and high productivity. The Academy School District aligned with Colorado Department of Education to define the 21st century skills in six categories which include invention, technology literacy, collaboration, critical thinking and reasoning, self direction and information literacy. These skills can be developed in students by teaching with STS approach in the following ways:

Invention: This skill requires students to construct their own knowledge by asking questions, planning solutions, manipulating all available resources, analyzing and disseminating findings. This skill laid emphasis on applying new ways to solve problems. For students to cope with the changing world, the STS approach can improve invention skills in students when utilized by teachers. The adoption of STS approach requires students to identify and strategize ways of solving problems in their immediate environment. Therefore, the quest for seeking various approaches to problem solving creates new ways of solving problems.

Technological Literacy: This skill arouse from the need to be proficient in utilizing appropriate technologies in various contexts in all areas to acquire lifelong knowledge and skills in the 21st century. On this note, the advent of versatile technologies required that students apply technology, develop awareness of technology related careers and factors critical to success in those careers as well as becoming sensitive and understanding societal issues related to using technology (e.g. social networks). The role of STS cannot be undermined in this context because identification of societal problem and search for solutions to solving them can be mediated through the use of digital technologies. Teachers who adopt the STS approach can engage their learners in problem solving activities that will require the use of technologies by looking beyond the curriculum. This will enable students to possess skills related to technology literacy that will assist them in the changing world.

Collaboration: this deals with the ability of students to interact with others utilizing various mediums in order to work, learn and provide solutions to problems in their environment. Collaboration involves three basic things which are;

- i. Demonstrate ability to work effectively and respectfully with diverse teams.
- ii. Exercise flexibility and willingness to be helpful in making compromises to accomplish common goal.
- iii. Assume shared responsibility for collaborative work and attach values to individual contributions (Trilling & Fadel, 2009).

This skill can be acquired through STS approach by grouping students to work on projects that are relevant to the need of the society. In this manner students learn by doing and put together diverse opinions from members to collectively solve problems.

Information Literacy: This skill is a basis for lifelong learning. It involves skills that require students to identify their information need and find out reliable sources to find this information and at the end disseminate the resulting knowledge from the synthesis of such information. Information literacy includes

efficiency in accessing information, making critical evaluation of information and utilizing it accurately and creatively. Information literate should be able to;

- i. Determine the type and extent of information he/she needed
- ii. Access the needed information effectively and efficiently
- iii. Evaluate information and its sources critically
- iv. Incorporate selected information in his/ her knowledge base
- v. Utilize selected information effectively to accomplish specific purpose
- vi. Have adequate understanding of ethical and legal issues related to use of information (PPRC, 2010)

Self Direction: This skill is related to students independently making informed decisions utilizing their metacognitive skills. This skill includes students' awareness of their ability to direct their cognitive processes to become lifelong learners. It requires the use of fundamental skills that are necessary for learning to occur. Students that possess this skill apply what they learn to varieties of real life situations thereby becoming problem solvers. They also exhibit productivity and accountability on timely completion of projects to express learning. They also show respect for different opinions, interest and experiences thereby reflecting their own learning and refocusing their efforts accordingly.

Critical Thinking and Reasoning: In response to observation, experience and communication, students engage in decision making that result to inferences. Students should be versatile with the skills of identifying problems, formulating hypothesis and manipulating variables to obtain findings that will lead to logical conclusions. Critical thinking and reasoning occurs when students utilize their knowledge and experience gathered through active involvement in community services to solve problems relating to the society. The role of STS approach in acquiring this skill is related to one of its attribute as an inquisitive approach that relates usefulness of knowledge to the society.

Factors Affecting the Adoption of Science-Technology-Society Approach by Chemistry Teachers

The importance of STS approach to chemistry education cannot be over emphasized. Various challenges can be attributed to its implementation by teachers, such as follows;

1. The activities of the classroom when STS approach is used depends on how much tradition and application that the teacher and the learners can control.
2. The African world view or belief of teachers and students of some science concepts may be a barrier to implementing this approach in different societies.
3. The absence of some experiences and resources around the community may hinder the utilization of the STS approach by teachers in some indigenous areas.
4. Emphasis on content assessment and time constraint in schools can be an inhibiting factor to utilizing the STS approach by teachers.
5. Aggravation of teacher control and learners dependency can be persistent when most ideas to be utilized are provided by the teacher. This discourages teachers to adopt this approach.
6. Poor background knowledge of the teacher on the STS carrier subjects may hinder its implementation.
7. Lack of exposure and awareness to the use of STS approach during teacher training programme affects its adoption by teachers.
8. Strict adherence of teachers to the curriculum contents and assessment of learning outcomes in external examinations based on the contents of the curriculum discourage teachers to dive into using this approach to teach. (STAN, 2001)

Based on the assertions stated above, it is apparent that teachers still face challenges in the adoption of STS approach in their classrooms.

The Need to Incorporate Entrepreneurial Skills in Chemistry Curriculum for Sustainable Development

Chemistry is the scientific discipline that deals with components and composition of matter. It emphasizes about the constituents of matter and the amount at which they are present. Due to the relationship of chemistry with other branches of science it is being described as central science (Jimoh, 2005; Wiki, 2013). The knowledge of chemistry is applicable in other branches of science such as biology, physics, agricultural science etc. Chemistry can be described as the scientific knowledge that sustain the technological field mostly because it is the science that cut across all aspect of human life especially the basic needs of human such as food, shelter, clothing, among others (Lenin, 2017). This provides entrepreneurial opportunity to students in the discipline. For any nation to be developed, these basic needs have to be readily available and anything that will promote provision of all these needs have to be taken care of such as acquisition of the knowledge of chemistry. Chemistry is being recognized as the backbone of development owing to different importance attach to it; placing emphasis on the teaching and learning of chemistry is background of developing the nation. Due to series of importance derived from the application of the knowledge of chemistry which can be employed to promote national development. It is required that entrepreneurial skills are incorporated into the chemistry curriculum. DeBoer (2000) enumerated different areas of applications of chemistry that can enhance sustainable national development, as:

- i. Application of chemistry in everyday activities: with the aid of chemistry knowledge, one can easily determine the type of soap that is effective for cleaning based on the type of water available whether soft or hard. It is through the knowledge of chemistry that scientists discovered that there are some ions eg. Ca^{2+} and Mg^{2+} present in water which are responsible for the hardness in water which needs to be removed due to their disadvantages such as formation of scum while washing with hard water and as a result required more soap than necessary; also furring of kettles and water boilers giving the surfaces of these materials different colours. The removal of the ions present in the hard water can be carried out through application of chemistry knowledge such as ion exchange method. The act of removing these ions present in the hard water is one of the means in which chemistry knowledge has been able to cater for sustainability of human beings.
- ii. Chemistry as a cultural force in the modern world: with the aid of chemistry knowledge successful explanation of medicine in curing different types of ailment has been given, the chemical composition of drugs can be better explained in order to understand its effectiveness.
- iii. Chemistry is used to produce an informed citizen: those who acquired chemistry knowledge have been able to contribute meaningfully to those things happening around the world and get other citizens better informed such as, global warming, climate change, renewable energy etc.
- iv. Chemistry helps in understanding chemistry related issues in media, for example, how some chemicals can be used to produce explosive materials.
- v. Application of chemistry knowledge in the world of work, for example in building some materials which are believed to be harmful to human health have been replaced with better ones through the knowledge of chemistry for example plaster of paris is now being used for ceiling instead of abestors which is seen as cooler material suitable for use in country with a harsh weather like Nigeria.

All the applications of chemistry knowledge identified by Gilbert and Treagust (2009) can be seen to be required by every human being to live peacefully and successfully in order to promote human sustainability that result to the global development at large. Hence, students that choose careers in chemistry are acquainted with recent reforms in chemistry to produce goods and services that will meet the immediate needs of the society they belong. In the same vein, Suresh (2013) while discussing the application of green chemistry, which is described as chemistry that has to do with reduction and proper disposing of waste that can prevent damaging of the environment. This assertion will make one give insight into whatever that make the environment save for human beings to live can be regarded as utmost importance when discussing

promotion of national development. It was further stated that green chemistry has 12 principles, some of which are;

- i. Prevention: it is the act of preventing waste rather than producing it and later finding means of clearing it
- ii. Atom economy: employing a synthetic method which encourages use of maximum amount of raw materials so as to prevent much remnant in form of waste.
- iii. Less hazardous chemical synthesis: the synthetic methods employed in producing materials should make use of less or non-toxic materials that can affect human health. Application of green chemistry and its principles in producing materials needed for day-to-day activities will go a long way in curbing the environmental hazards that can influence human health negatively.

Lenin (2017) also observed that principles of chemistry have so much influence on the life of human to the extent that they do not know that they come in contact with chemicals from time to time. The applications of chemistry knowledge in three key areas have been observed which are as follows:

- i. Drug: it is being described as chemical substances which interact with macromolecular targets such as carbohydrate, protein, lipids etc and as a result produces biological response which is therapeutic and responsible for diagnosing, preventing and treating of diseases. There are different types of drugs for different ailments. For example, we have neurologically active drugs such as tranquilizers e.g. equanil, chlordiazepoxide etc used for treatment of stress and analgesics eg. Paracetamol, aspirin used as pain reliever. Another class of drugs is antimicrobials which consist of (i) antibiotics which is used in treating infections eg. Salvarsan (ii) antiseptics e.g. Dettol, iodine etc. these are being applied to living tissues such as wound, cut as well as diseased skin surface.
- ii. Food: chemistry also has different roles to play when it comes to food consumptions such as preservative, food colouring, flavor, antioxidants, sweeteners and nutritional supplement for example sucrose, saccharine as sweeteners and table salt, sugar, vegetable oils as preservatives.
- iii. Cleaning agent that is, detergent which helps in removal of foreign bodies on fabrics and skin, there are two major types which are: (i) soaps these are produced from sodium and potassium salts of long chain fatty acids e.g. Stearic, oleic and palmitic acids. (ii) Synthetic detergents which have properties of soap but do not contain soap, it can be used in both soft and hard water.

The three major areas of application of chemistry knowledge described by Lenin (2017) can be seen as the basic needs of human beings that every individual required to contribute meaningfully to the development of the nation which should be the priority of everybody that needs to take part in the provision of human sustenance. The availability of all these materials at high quantity and quality requires that students with skills of producing them. This thereby pave way for incorporating entrepreneurial skills that is crucial in determining the development of a nation among learners. Therefore, the knowledge and skills that backs the production of goods and services for sustainable development should not be handled with levity. Apart from production of all these materials, it can serve as career opportunity for students which in turn boost the economy of the nation. Also possessing knowledge about the hazardous nature of materials will educate students on the effects of abusing the materials.

The various entrepreneurial opportunities that chemistry students can undertake are not limited to the production of the following:

- i. Cleansing agents examples includes; synthetic detergent and soap detergent, bleaching solutions.
- ii. Cosmetics examples include; hair and body cream, perfume, facial cleansers.
- iii. Toiletries examples are; germicides, tissue papers, e.t.c.
- iv. Paint making
- v. Fertilizers
- vi. Ceramics used in production of flower vase, cups, plate, e.t.c.
- vii. Plastics

- viii. Ethanol
- ix. Shoe polish
- x. Chalk production
- xi. Food additives examples include; food preservatives, sweeteners, food colours.
- xii. Explosives
- xiii. Distilled water

Conclusion

In attempt to alleviate the problems of unemployment in Nigeria to attain sustainable development, there is need to improve on the quality of school leavers. School leavers should be equipped with skills that will make them self reliance thereby becoming job creators through entrepreneurship. The role of STS approach in acquiring entrepreneurial skills in chemistry cannot be overemphasized. Teachers should approach instruction by relating its contents to its usefulness in the society. Also, for students to cope with the rapidly changing world, the need for them to be equipped with the 21st century skills becomes apparent. The adoption of the STS approach by teachers can help to develop these skills in students. Taking a close look at chemistry as a discipline that is relevant to all areas of human endeavor, it is important to link its contents to several entrepreneurial opportunities that students can undertake after studying it. Some of these opportunities includes; production of fertilizers, explosives among others.

Recommendations

Considering the role of STS in teaching and learning of chemistry to equip students with entrepreneurial skill that will make them self reliance after leaving school, it is recommended that;

- i. Chemistry teachers should approach teaching curriculum contents by relating it to its application in the society by adopting the STS approach.
- ii. Teachers should be equipped with knowledge of utilizing the STS approach to enable their students acquire entrepreneurial skills. This can be achieved by introducing STS in teacher education programmes.
- iii. Seminars and workshops should be organized for in service teachers to create awareness and educate them in overcoming challenges of utilizing the STS approach in a typical classroom settings
- iv. The 21st century skill is apparent to help students function in the changing world. Therefore, teachers should adopt the STS approach to foster these skills in their students to enable them cope with the rapidly changing world and compete with their peers across the globe.

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