Promoting Entrepreneurship Opportunities through Chemistry Education: A Path to the Empowerment of Nigerian Youths for Sustainable Development in the 21st Century

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Abstract

The goal of Chemistry education is the acquisition of science process skills/entrepreneurial skills and development of mental, physical and social abilities and competencies to promote entrepreneurship opportunities for sustainable development in the 21st century. That is, the production of an individual who is self-employed, self-reliant, self-sufficient and an employer of labour. Chemistry involves process skills which are mental tools used in the discovering and acquiring of scientific knowledge. Entrepreneurship plays a significant part in employment generation in any country. The student-activity centred approach to learning should innovate ways of teaching and in classroom situations for entrepreneurial skills development, using well developed lesson contents that stimulate, orientate and motivate students’ interest towards entrepreneurial skills acquisition, individual sustainability and national development. This paper therefore, focuses on promoting entrepreneurship opportunities in our Nigerian youths through chemistry education. Recommendations were made on the role of the government and the teacher in developing entrepreneurial skills through chemistry education which will be best achieved through an active learning of the process skills.

Keywords: Chemistry education, Chemistry Entrepreneurship, Entrepreneurial skills, Youth empowerment, Sustainable development.

Introduction

In the face of the serious and growing threat of unemployment in Nigeria today; the need for Nigerian youths to seek avenues for self-employment and self-fulfilment is now compelling. In other words, Nigerian youths can no longer rely on the Nigerian labour market to provide hitherto job. They have to invent an alternative source of employment which is self-employment; that is, they have to be an entrepreneur. Entrepreneurship is very important to the future of Nigeria economy. Entrepreneurial skills are skills needed to have to succeed in business, most especially in teaching. Entrepreneurial skills are the basic skills necessary to start, develop, finance and succeed in your home enterprise. The Federal Republic of Nigeria (2004) in her national policy on education; enjoin teachers to make instruction concept-centred, activity based and work related. This fact underlines the needs to focus on acquisition of entrepreneurial skills in school instruction for the benefit of school and society.

Entrepreneurial skills are the basic skills necessary to start, develop, finance and succeed in your home enterprise. The national policy on education (FME, 2004) enjoin teachers to make instruction concept-centred, activity based and work related. This fact underlines the needs to focus on acquisition of entrepreneurial skills in school instruction for the benefit of school and society. In the last few years, more than 70% of senior secondary school leavers find it difficult to gain admission into higher institutions, while over 60% of graduates are not able to get employment immediately because they are
relatively unskilled (MDG 2005). This has led many of them venture into entrepreneurial, but unfortunately they have not been adequately prepared to face the challenges of venturing. Part of the problem is the nature of our educational system, which tends to produce “job seekers” instead of “job creators”.

To be able to produce job creators, there is the need to infuse the spirit of entrepreneurship into the mode of instruction of science teachers which will facilitate the emergence of entrepreneurial chemistry students. Ogunleye (2007) clearly stated that the introduction of entrepreneurship education into our science curriculum could lead to a continuous and sustainable technological growth of the country. In view of this fact, development of a science-based entrepreneurship education should receive serious attention among our policy makers and curriculum planners. With chemistry curriculum in the senior secondary school, it is possible for the chemistry teachers to teach their students effectively in a way that the students will see the usefulness of and how they can utilize the knowledge and skills acquired for gainful employment in the society which can be achieved through chemistry education/entrepreneurship which is the main focus of this paper.

**The Concept of Entrepreneurship**

Entrepreneurship is defined by Nickel in Uzoka (2005) as a clear manifestation of effective manipulation of human intelligence as demonstrated in creative resources in a new way in the course of creating a new business concept or opportunity within an existing firm. According to Aminu (2008), entrepreneurship is the process of creating something new with value, by devoting quality the necessary time and effort, assuming the accompanying financial, psychic and social risks, and receiving the resulting rewards of monetary and personal satisfaction and independence.

**Who is an Entrepreneur?**

An entrepreneur is a person who organizes and manages a business, and undertakes and assumes risks for the sake of profit. He or she tends to start ventures that build on specific skills already acquired either through formal education or in a certain occupation or industry. An entrepreneur is the chief executive or leader of one-man business (Ugiagbe, 2007). In other words, an entrepreneur is one that creates, founds or originates. He is an architect, author, creator, inventor, maker or an originator (Roget 2003), of a business idea or venture. Aminu (2008) defined an entrepreneur as a person who have the ability to see and evaluate business opportunities, gather the necessary resources to take advantage of them and initiate appropriate action to ensure success. He argued that, a typical entrepreneur is a risk taker, a man who braves uncertainty, strikes out on his own, and through nature with devotion to duty and singleness of purpose, somehow creates a business and industry activity where none existed before.

**Entrepreneurship education**

Entrepreneurship education is defined by Bolarinwa in Ezeudu (2008) as education that provides training, experience and skills that are suitable for entrepreneurship endeavours. Entrepreneurship education should therefore prepare graduates with entrepreneurial knowledge, competence and skills needed to be self-reliant. Also, Ojukwu in Ezeudu (2008) describe entrepreneurship development as a programme of human capital development inputs aimed at increasing the supply of adequate entrepreneurs who are motivated to make a success out of business. Thus, entrepreneurship education is education for and about business strategies.
The advantages of entrepreneurship education according to Bolarinwa in Ezeudu (2008) are:

- **Skills acquisition:** It will help the students in secondary and tertiary institutions to form a knowledge-base about the function and operation of a business strategy and develop some level of familiarity and comfort with business environment in science and technology through skills acquisition.
- **Work experience:** It will serve as a complementary role in developing the occupation knowledge, job skills and work experience among teachers and students.
- **Creation of employment:** It offers opportunities to students for job experience and for earning, saving and investing money at an earlier stage of life than their peers, contributing to their belief in their abilities and to a sense of self-worth.
- **Reduction of unemployment:** There will be great reduction in the high rate of unemployment (particularly graduate unemployment) in our society; self-employment and business ownership will be viable and appealing goals for today’s students.

Other advantages by Jongur, Kabutu and Zubainatu (2009) include:

- **Effective utilization of local resources;**
- **Decentralization and diversification of business;**
- **Promotion of science and technology;**
- **Capital formation;** and
- **Promotion of entrepreneurship culture.**

**The Place of Chemistry Education in Entrepreneurship**

Science is a branch of study especially concerned with facts, principles and methods; it is the knowledge acquired by careful observation and deduction of the laws which govern changes and conditions by testing those deductions by experiments. Chemistry Education has a crucial role to play in helping to find answers to various human and socio-economic problems as well as making the society more scientifically literate. Chemistry is that aspect of science that deals with the nature of matter, its properties and its change in condition. Chemistry as a physical science is the study of the material substances that occur on earth and elsewhere in the universe. Chemistry involves process skills which are mental tools used in the discovering and acquiring of scientific knowledge. It includes conversion, making process, production, rebirth, transfiguration, etc (Roget, 2003 and Jack, 2013).

Skills are natural or acquired capabilities in a specific activity. It is the ability to do something well. Entrepreneurial skills are occupational survival skills. These skills are equivalent to what is called process skills in science (Chemistry). The chemistry skills involves process skills in chemistry that are paths (or ways) and strategies followed by the chemist in order to arrive at the product of science. They include: Observation, Classification, Measurement, Counting numbers, Recording, Communication, Predicting, Hypothesis, Inference, Experimentation, Research, Interpretation of data, Controlling variable and Generalization, etc. (Valentino, 2000). The use of these process skills over a period of time lead to an accumulation of scientific knowledge in forms of scientific laws, principles and theories, all of which put together constitute the products of science (National Teachers' Institute (NTI), 2006).

The first step, according to Valentino (2000), in implementing a skills-based approach to science instruction begins by carefully defining what you would like the students to be able to do. Discovery Works according to Valentino (2000) organizes science skills into three separate groups: Process Skills,
Reasoning Skills, and Critical Thinking Skills. These groups correspond to three distinct types of cognitive skills. Process skills are used to gather information about the world. Reasoning skills help children make sense of the information they gather by fostering an open mind, curiosity, logic, and a data-based approach to understanding the world. Critical thinking skills require students to apply information in new situations and in solving problems.

Development of science process skills could lead to the acquisition of the skills that successful entrepreneurs use to start their ventures. Some of the entrepreneurial skills are: Creative thinking, Financial management, Organization, Communication, Team building, Decision making, Marketing, Record keeping, Goal setting, Planning and research, Business management (small, medium or large scale enterprise). All these entrepreneurial skills are encompassed in the science process skills.

Entrepreneurship skills occurs when an individual develops a new venture, a new approach to an old business or an idea or a unique way of giving the market a product or service by using resources in a new way under conditions of risk (Umar, 2006). Entrepreneurship skills help to create wealth, self-direction, and satisfying career and; also adds value to society's well-being. Chemistry, on the other hand, is concerned with the utilization of natural substances and the creation of artificial ones. It is an artistic enterprise which offers a lot of occupational opportunities in areas like: Manufacturing of goods (such as pharmaceuticals, foodstuffs, packaging, detergents, soap, flavours, fragrances, pulp and paper, paints, candles, metals, textiles, agricultural products, oxygen, chlorine, ammonia, sulphuric acid, etc.); Sales of goods; Researching; Laboratory services; Consumer education; Analytical and Consultancy services.

The acquisition of professional qualification in chemistry, equip an individual with skills to be self-employed because of having acquired entrepreneurial and/or process skills. Functional chemistry education emphasizes applicability or transferability of the acquired knowledge to the immediate environment. This is the purpose of Chemistry education as stated in the National Policy on Education (FRN, 2004) which includes the "Acquisition of appropriate skills and development of mental, physical and social abilities and competencies to contribute to the development of his society"(p. 67). Consequently, Chemistry, like entrepreneurship, aims to equip an individual to be self-reliant. The entrepreneurial skills will help chemistry graduates (at both secondary and tertiary school level) to become self-employed if they fail to read further or get a job. Teachers are therefore expected to expose their students to entrepreneurial skills through chemistry education in order to promote chemistry entrepreneurship.

Chemistry entrepreneurship according to Oyeku, et al. (2015) involves the process of converting innovations on Chemistry into marketable products for commercial gain. With increasing awareness in Chemistry entrepreneurship, there is a paradigm shift from conducting basic research whose results end up only in academic journals to patenting and commercializing them for economic gains. According to Lockledge (a chemistry entrepreneur) in Oyeku, et al. (2015), holds a PhD in Inorganic Chemistry, and a Chief Executive Officer and Cofounder of Tiptek, a company that manufactures ultra hard and ultra sharp probes for atomic force microscopy applications noted that: “Founding a company gives you the opportunity to create an enterprise, be it large or small, in which you know you are personally making a difference” and that “working in a large company can feel like being a small gear in a large machine”. He explained further that he was motivated to become an entrepreneur by the desire to control his own destiny. He noted that “when you work for someone else, your boss’s priorities dictate your work-life
and lifestyle,” whereas as an entrepreneur, you can decide when and where you work and also added that “Inventing and innovating is fun, and the opportunity to do so in a large company setting is increasingly rare.

Therefore, achieving transformation of chemist and scientist in general into successful business ventures is a sure key to the long term profitability of the world's chemical and related industries. But, this goal requires scientists who possess a critical combination of both technical and entrepreneurial skills. This is because activities of commercialization are quite different almost in direct opposite to activities in the laboratories. Increasingly, such individuals are playing a pivotal role in today's knowledge-driven economy by enhancing existing businesses and by setting up new ventures themselves.

The Universities, in Brazil and all over the world are currently going through a "second revolution" in which the socio-economical development is incorporated as part of their mission and science and knowledge play a key role for the development of the society. In promoting chemistry entrepreneurship, the School of Chemistry in conjunction with the Nottingham University Business School, USA is running a programme on M.Sc. Chemistry and Entrepreneurship. The course aims to provide students with an appreciation of the interrelationships between fundamental research and its commercial exploitation while the students will also be able to take advantage of the course’s flexible structure to develop an understanding of specific areas of modern Chemistry and to become fluent in the financial, marketing and managerial aspects of modern business. Another objective of the course is to make students to acquire the technological and business background to enable them to make a significant contribution to today’s chemistry-based, technology-driven economy.

Also, the Department of Chemistry at Case Western Reserve University, Cleveland, Ohio, USA runs the Chemistry Entrepreneurship Program (CEP), a two-year professional M.Sc. in Chemistry Entrepreneurship where the students study state-of-the-art Chemistry, practical business, and technology innovation while working on a real-world entrepreneurial project with an existing company or the student’s own start-up. The CEP also helps connect students with mentors, advisors, partners, funding sources and job opportunities.

The following are some of the general reasons for advocating Chemistry entrepreneurship or entrepreneurship in general as opined by Oyeku, et al. (2015).

a. The Need to Tackle Unemployment

Enrolment in tertiary institutions in Nigeria is increasing day-in-day out. The reality is that government and the organized private sectors, do not have enough capacity to absorb the graduates of these institutions. The National Bureau of Statistics put the unemployment rate in the first quarters of 2013 at 23.9% (Odia and Odia, 2013). The situation of unemployment in Nigeria is indeed alarming (Ogunsola, 2009; Aja-Okorie and Adali, 2013). The graduate unemployment problem has generated several other socio-economic problems in the country manifesting in the following: militancy in the Niger Delta, political thuggery among youths, increased rate of armed robbery and kidnapping and even the Boko Haram saga (Ibe, 2012). The most potent way out of this problem is to go technological entrepreneurship to develop a virile MSMEs sector.

b. The Need to Grow the National Economy
The recent rebasing exercise indicated that Nigeria economy is now the 26th largest in the world and the largest in Africa. Recently, Nigeria economy was rated as the third fastest growing in the world. The nation is not far from its target of attaining the 20th largest economy by 2020 (Nigeria Vision 20: 2020); there is a need to avoid economic retrogression especially in the light of dwindling oil revenue if we must achieve the objective of Vision 20:2020.

c. The Need to Create Wealth to Reduce Poverty

Hunger is an indication of poverty. Globally, one in seven people goes to bed hungry everyday (International Food Policy Research Institute, IFPRI). Nigeria ranks 40th among 118 nations on hunger list; based on Global Hunger Index (GHI) Ranking computed by IFPRI (2012). This rating is not too good for a nation who is the largest producer of cassava, yam, melon etc.

d. Incessant Civil/Social Unrest is an Indication of Poverty

Most civil/social unrest activities in Nigeria are carried out by people that are not engaged in profitable ventures/enterprises. These have resulted in very poor rating for Nigeria in the Global Peace Index Rating with country rating of 148th out of 162 nations in 2013.

Chemistry World Entrepreneur Award

In recognition of chemistry entrepreneurship as a discipline, and profession, as well as to promote and encourage Chemistry entrepreneurship, the Royal Society of Chemistry, has instituted an award, i.e. Chemistry World Entrepreneur of the Year. This is an annual award valued a cash prize of £4,000 given to individuals who demonstrated creativity and vision, driving chemistry innovation to commercial success for their businesses. Professor Paul Workman of the Institute of Cancer Research received the 2012 award based on his work as a scientific pioneer and serial entrepreneur whose numerous commercialized discoveries and academic research led to his founding two successful chemical companies: Piramed Pharma and Chroma Therapeutics The award for 2013 was received by Professor Chad Mirkin of the North-western University, USA based on his scientific and academic achievements involving spherical nucleic acid (SNAT) nano-particle conjugates while Professor Tom Brown of University of Oxford received the 2014 award for pioneering research on nucleic acids which was successfully commercialized. The question we all should ask ourselves is, “when will a Nigerian Chemist/researcher receive the next Chemistry Entrepreneur Award? This can only be possible when we commercialized chemistry education through Chemistry entrepreneurship which has to be our utmost focus for sustainable development.

Science Teachers and Entrepreneurial Skills

Science teachers are great sources of ideas for learning activities that provide experience in entrepreneurial skills and often they don't even know they are doing so. Any science teacher in the secondary schools can help students understand the opportunities of our entrepreneurial economy by infusing entrepreneurship-related activities in their regular course of study. Such experiences may change the vision of the future for many of our youth. Science teachers should be sure that their activities encourage students to think creatively not just to determine how business operates now. They should also help students to ask questions about how businesses might be created in new and better
ways, using new and different processes. Science teachers should also open the students’ eyes to the entrepreneurial opportunities that are all around them.

The science teachers of the 21st century need to understand and appreciate the dependence of a modern society in science and the changes in the social structure that have been brought about by the achievement of science and technology. They should not only be able to appreciate and wonder at the modern marvels of science in business world but should also understand the social use of entrepreneurial skills in their day to day science affairs in the classroom, outside the classroom and in the society at large. The science teachers are not necessary to open schools or any business related to science education but need to understand and acquire the basic entrepreneurial skills that will make them function effectively in the school setting (Das, 2006).

Teaching science is a dynamic enterprise and so any teaching procedures centre around three pivotal factors; the pupils, the teachers and the subject. According to Adeyemo, (2009); in science teaching enterprise/business, the raw materials are the pupils (science students), the factory is the school environment, and the teachers are the managers/entrepreneur of resources using a specified blue print (science curriculum). The interaction among these three major factors justifies why the science teacher must possess requisite entrepreneurial skills that will facilitate transactions in the classroom business climate. The outcome is to bring out a refine and discipline product (i.e. science graduates) at any level. Based on this, science teachers need some essential entrepreneurial skills that will increase their efficiency and effectiveness in knowledge delivery and management of resources in the school environment. These include: instructional leadership skills, management skills, communication skills, collaboration skills, vision development skills, change management skills, analysis skills, process skills, evaluation skills and parsimony/economy skills.

**Promoting Chemistry Entrepreneurship Opportunities Through Chemistry Education**

Promoting entrepreneurial opportunities through chemistry education can be effectively achieved through an active learning of the process skills. What learners learn is greatly influenced by how they are taught. For the learners to develop the process or entrepreneurial skills (since they are one and the same), the teachers must have a theoretical and practical knowledge and abilities about chemistry teaching and learning. The decision about content and activities that teachers make, their interactions with students, the selection of assessment, the habits that teacher demonstrate and nurture among their students and the attitudes conveyed all affect the knowledge, understanding, ability and attitudes that students develop. There is considerable research evidence that if learners are active in the class, they will learn more effectively (NCCE, 2009).

Active learning as a teaching-learning strategy emphasizes that the planning, teaching and assessment are focused on the needs and abilities of the learners. The learners are actively engaged in doing most of the work by using their hands and brains in the teaching and learning process. In active learning, learners are to manipulate, observe, measure, record, communicate, etc; which are involved in science process/entrepreneurial skills. Many advantages accrue when learners are active participants in the classroom activities. The advantages include information retention, learner-teacher interaction, learner-learner interaction, academic achievement, communication skills, team work and positive attitudes towards the subject and the motivation to learn (NCCE, 2009).
Sustainable development is about creating a positive future, considering the interdependence of social, economic, environmental, and political aspects of our world. It helps us address major global challenges facing the Nigeria today, such as climate change, security and economic depression. Some entrepreneurship opportunities in Science and Technology which teachers can engage their students are:

* Students should produce alcohol from fermentation of starch, soaps through saponification process, margarine from the hydrogenation of fats, and cloth through dyeing which can be used for exhibitions.

* In food science experiment with product development: Study the effect of heat/temperature on yeast products. Dissolve yeast for bread in three different temperatures. Make the bread and describe the results.

* Choose an important nutritional concept. Develop an advertising plan to sell the idea. Develop a product line of nutritional snacks and decide how to sell them. Establish and name a company that will market the nutritional snacks. Organize the company. Identify positions and careers possible.

* Students locate food adverts in a magazine, mount them on index cards, and evaluate their nutritional content. Make a bulletin board display. Discuss the role of advertising in promoting nutrition.

* Do bacterial tests around school. Collect data and generate a report. Sell anti-bacterial soap or wipes for students to use before lunch, etc.

* Set up a weather station in which students take weather readings and market results in some form.

* Study crystal formation by making rock candy. Discuss how a new product might be created from crystal formations.

* Experiment with emulsions. Make salad dressing with and without emulsifier. Describe results, taste, etc. Conduct research on what emulsifiers are and how they are used in products.

* Collect flowers and plants to study. Press them and make book marks to be sold at a school book fair. You can also get different indicators from them.

* Plan a student-run service of water sampling.

* Students collect, sort, weigh materials collected from school trash for one day (paper, glass, metal etc.). Record results; collected for a week. Describe amounts that would be accumulated over time, problems of disposal, types of businesses disposing of materials, and costs associated with trash. Describe problems of accumulation.

* Start a recycling project. Collect cans and sell to a local recycle centre. Analyze costs and income per pound. Structure a business format for the recycle project. Identify roles of individual class members.

* Invite business people to speak to students on science-related businesses.
Entrepreneurial Skills that can be Integrated into Chemistry Curriculum

The 21st century student-activity centred approach to learning should innovate ways of teaching and in classroom situations for entrepreneurial skills development, using well developed lesson contents that stimulate, orientate and motivate students’ interest towards entrepreneurial skills acquisition and individual sustainability. Chemistry lessons should evolve creative ways of integrating entrepreneurial skills into chemistry curriculum contents involving models of learning as a challenge to helping teachers think about teaching and learning for self-reliance (Ugwu and Etiubon, 2009; and Jack, 2012).

Some entrepreneurial skills contents include:

- Production of indicators and pH paper from plant or flower extracts
- Production of ethanol from palm wine, cassava, potatoes and other stem tubers
- Production of margarine from fats
- Production of sugar and salts from sugarcane extracts and sea water
- Production of reagents from bark of trees, flowery seeds of organic chemicals
- Production of soap and detergent from seeds of palm, groundnut and coconut
- Production of food additives from plant and dyes
- Production of pulp and paper from gmelina plants
- Production of school chalk from gypsum
- Production of slaked lime from limestone
- Production of fibres from plant and banana plant peels, etc.

There are many active strategies that can be used in the chemistry classroom to ensure the acquisition of these entrepreneurial skills. They include: discussion, Games, Excursion, Role playing and Drama, project, Demonstration, Discovery/Inquiry, Brainstorming, Problem-solving method and process-based approach. These methods develop in students, critical thinking skills, creativity, open-mindedness, intellectual honesty, etc. These attitudes will not only help students in developing the process skills but also their entrepreneurial skills and their socio-economic lives. These activity-based strategies yield better quality and entrepreneurial learning/skills acquisition.

Conclusion

One of the purposes of science education is to ensure that every learner acquires such a good grasp of science as to be able to apply it to his/her need. This has to be pursued through active participation of the learners. The learners should be taught through the handling of materials. They should be taught how to carry out experiments, observe, classify, hypothesize, communicate, report, record and conclude. Through acquisition of the above skills, unemployment and its attendant social vices will be highly reduced in Nigeria. In this present world of economic depression, if the youths are well equipped with entrepreneurial skills in their chemistry classes, then they will be able to use the skills acquired to plan their own businesses as young entrepreneurs. By so doing, they will help in promoting entrepreneurship for sustainable development in the 21st century Nigeria.

Recommendations

The government has a significant role to play in developing entrepreneurial skills in our Nigerian youths through Chemistry education. There should be a continued and increased government support for
Chemistry and science in general to meaningfully contribute to socio-economic development. This could be achieved through:

- Provision of facilities for active participation of the learners;
- Periodic review of science (chemistry) curriculum;
- Integration of entrepreneurship skills in chemistry curriculum;
- Establishment of business incubation centres; and
- Provision of soft loans to chemistry graduates as a takeoff grant.

Development of chemistry process skills will lead learners in the acquisition of the skills that successful entrepreneurs use to enable them to be self-employed, self-reliant and self-sufficient. In view of the enviable role of skills-based approaches in the teaching and learning of chemistry and in entrepreneurship education, learners should be actively engaged in chemistry lessons. It is recommended that the chemistry teacher should:

- focus and support inquiries while interacting with the learners;
- initiate discourse among teachers about scientific ideas;
- challenge learners to accept and share responsibility for their own learning;
- recognize and respond to learners' diversity and encourage all learners to participate fully in science learning;
- encourage and model the skills of scientific inquiry; as well as the curiosity, openness to new ideas and data and attitudes that characterize science (National Science Standards, 2005);
- relate chemistry concepts to basic human experiences;
- relate chemistry concepts to human needs;
- teach chemistry using career-oriented teaching approach;
- Emphasize the connection of chemistry concepts between school learning and the world of work.

References


