



Nigerian Online Journal of Educational Sciences and Technology (NOJEST)

Volume 1, Number 2, 2020



NIGERIAN ONLINE JOURNAL
OF
EDUCATIONAL SCIENCES
AND TECHNOLOGY

NIGERIAN ONLINE JOURNAL OF
EDUCATIONAL SCIENCES
AND TECHNOLOGY (NOJEST)

<http://ujh.unilag.edu.ng>
nojest@unilag.edu.ng

Biology Education and Bio Entrepreneur Opportunities in Nigeria

Ganiyu Bello, Hafsat Imam Alabi, Aduke Rihanat Ahmed, Musa Mohammed Sulaiman,

Department of Science Education, University of Ilorin, Ilorin, Nigeria

Zakariyau Adebayo Bello

Department of Integrated Science, Kwara State College of Education Ilorin,

Abdulrasak Agboola Bello

Kwara State Polytechnic Secondary School Ilorin

To cite this article:

Bello, G., Alabi, H. I., Ahmed, A. R., Sulaiman, M. M., Bello, Z. A. & Bello, A. A. (2020). Biology education and bio entrepreneur opportunities in Nigeria. *Nigerian Online Journal of Educational Sciences and Technology (NOJEST)*, 1 (2), 1-17

This article may be used for research, teaching, and private study purposes.

Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

Authors alone are responsible for the contents of their articles. The journal owns the copyright of the articles.

The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of the research material.

Biology Education and Bio Entrepreneur Opportunities in Nigeria

Ganiyu Bello., Hafsat Imam Alabi, AdukeRihanat Ahmed, Musa Mohammed Sulaiman, Zakariyau Adebayo Bello & AbdulrasakAgboola Bello

Article Info	Abstract
<i>Article History</i> Received: 06 February 2020 Accepted: 06 May 2020	Nigeria has been experiencing various socioeconomic and environmental challenges such as unemployment, poverty, insecurity and climate change within the past few decades. These challenges are traceable to a lack of synergy between capital and nature. Knowledge and skills in various fields of biology such as Bioeconomics and Bio-entrepreneur are potent tools for building a strong synergy between capital and nature to enhance sustainable socio-economic development in the nation. This paper focuses on how biology education can be utilised to develop and promote Bio-entrepreneur opportunities among Nigerian youths for sustainable national development. The paper provided overviews of concepts such as biology education, bio-entrepreneur, bio-economics and so forth. The millennium development goals and the 21st-century skills within the context of sustainable development in Nigeria. Finally, the paper advocated for urgent realignment of biology and science education for sustainable national development.
<i>Keywords</i> Biology education, Bio-entrepreneur, Bio-economics, Sustainable development, and Science Education	

Introduction

Nigeria is experiencing economic challenges that are unleashing unprecedented socioeconomic, environmental and security challenges among other obstacles to sustainable national development. Indeed, the World Poverty Clock named Nigeria the poverty capital of the world in June 2018 as reported in the Punch Newspaper (2019 February 15). Unemployment and poverty rates are galloping while the conflict between farmers and herdsman over farm and grazing land is becoming more frequent and deadly than ever before. More and more citizens are migrating to Europe and other economically buoyant nations to seek for greener pasture. The rapid advances in the fields of biology within the past few decades have brought to light the relationships between socioeconomic challenges and ecologically interconnected global environment (Mijung & Doing, 2012). Thus, biology is indispensable in all spheres of human society. Indeed, Maliford (n. d.) noted that biology is one of the fundamental reasons why mankind has progressed and thrived in the last 2000 years. Also, Mijung and Doing (2012) acknowledged that the knowledge of biology 'is intrinsically related to building a sustainable relationship between nature and human society' (p.xi).

It is obvious from the above-mentioned fact that biology is a potent tool for ameliorating the socio-economic and sustainable development challenges that Nigeria is experiencing. This is because biology has some entrepreneurial related skills that graduates could use as a source of livelihood; a means of generating employment and away to poverty eradication without necessarily depending on government jobs. This agrees with the submission of Agommuoh and Ndirika (2017) that science students need to develop entrepreneurship skills as a way of reducing unemployment and becoming self-reliance as a means of tackling poverty. In a like manner, Ojone (2017) reported that the knowledge and skills acquired through biology can be

used to eradicate hunger and extreme poverty since it has the tendency of creating jobs and improved food production.

Several studies on developing and integrating entrepreneurial skills into the field of biology education have been carried out in Nigeria. However, there seems to be a dearth of studies sensitizing Nigerian graduates in the field of biology to the numerous Bio- entrepreneurial opportunities that they can successfully embrace. Thus, in this paper, concepts such as biology education, bio-entrepreneur, bio-economics, and so forth were amply clarified before examining the sustainable development goals and the 21st-century skills within the context of sustainable socio-economic development in Nigeria. The paper also highlighted how biology education can be utilised to develop and promote Bio-entrepreneur opportunities among Nigerian youths to revamp the economy and ultimately promote sustainable national socio-economic development. The study advocated for the realignment of biology education as science education sub-discipline for sustainable national development.

Biology Education

Biology is a unique branch of natural sciences that studies organisms. The invaluable roles of biology in the survival of mankind, socio-economic development and sustainability of the balance in nature necessitate effective and efficient sharing of knowledge and skills in the discipline through formal education. The task of sharing biological knowledge and its unique philosophy and methodology with learners lies within the field of biology education. The general aim of biology education is to stimulate and sustain curiosity about biological events and phenomena. Biology education is an established discipline and a profession concerned with facilitating the meaningful acquisition of biological knowledge, method, and philosophy by the learners and the general public. Also, biology education ensures the steady production of generations of research scientists in the field of biology and equips citizens with biology literacy required for making informed decisions on personal and societal issues based on sound biological knowledge. The field of biology covers working in biology content as well as the teaching and learning of biology contents, and process (Bello & Abimbola, 2015; Muriel, 2000; Wikipedia, 2017).

Scholars like Araoye (2016); Kurawa (2016) and Adom, Umachandran, Ziarati, Sawicka and Sekyere (2019); have conducted studies have been conducted on the relevance of biology knowledge on the sustenance of mankind. One of such is a study on biology education and national productivity: Implication for transforming Nigerian educational system by Araoye (2016), who observed that the knowledge of biology is inartistically connected to building a sustainable interaction between human and nature and that biology education is aimed at training and marketability of essential skills for the well-being of man. Hence, the knowledge of biology should afford the learner to develop skills which will make learners have improved livelihood.

Similarly, the training received in the field of biology is expected to expose the learners to the various career and entrepreneurial opportunities available in the face of increased unemployment in the country. Kurawa (2016) was also, of the view that knowledge and skills of key concepts in biology like reproduction, ecology and so forth could be applied into practical skills by the students to produce plants and animals on a commercial basis. Adom *et al* (2019) submitted that human being derived significance from bioresources in nature. The extent to which values are derived depends on the resource fullness of the users. The onus lies on the benefactor ability to tap and made use of these resources for wealth generation.

Bio-economics and Bio-entrepreneur

Socioeconomic activities especially under capitalism, the global dominant political economy often led to poverty among the masses and environmental degradation such as desertification, climate change, reduction in biodiversity and so forth. In capitalism economic system according to Masoud (2016) 'private profit-maximization motive lies at the core of its virtues and maladies'. Under capitalism, profit maximization often takes precedence over consideration for maintaining the delicate balance in nature. This lack of synergy between capital and nature is at the heart of challenges to sustainable socio-economic growth and development as well as environmental issues in Nigeria like many other nations. Tony (2014), highlighted the contribution of capitalism thus

“breaching of several ecological boundaries, concerning climate change, biodiversity loss and nutrient enrichment. At the same time as damaging the natural systems that sustain it, capitalism is also leading to increasing inequality, in turn creating social tensions that make it still more exposed.

The need to address the complex challenge posed by the discord between capital and nature among other considerations accounted for the birth of bio-economics as a discipline. Bio-economics is an interdisciplinary field of study that focuses on the integration of biology and economics. The aim of which is to create better theories to explain economic events on a biological basis. Bio-economics is sometimes considered as a theory of economic exploitation of bio-resources, focusing on population dynamics and the dynamics of economic systems. It is thus, obvious that Bio-economics is an integration of social and natural science disciplines, particularly biology and economics. (Geoffrey, n. d.; Investopedia, n. d.; Monsour, n.d.; Wikipedia, n. d; Wikibooks, n. d.).

Bio-economics is related closely to the early development of theories in fishery economics initially in the mid-1950s by Canadian economists Gordon (1954) and Scott (1955). Their ideas used recent achievements in biological fisheries modelling, primarily the works by Schaefer (1957) on establishing a formal relationship between fishing activities and biological growth through mathematical modelling confirmed by empirical studies, and also relates itself to ecology and the environment and resource protection. These ideas developed out of the multidisciplinary fishery science environment in Canada at the time. Fisheries science and modelling developed rapidly during a productive and innovative period, particularly among Canadian fisheries researchers of various disciplines. Population modelling and fishing mortality were introduced to economists, and new interdisciplinary modelling tools became available for the economists, which made it possible to evaluate biological and economic impacts of different fishing activities and Fishery management decisions.

In the like manner, Biswasa, Hossaina and Mondala (2017) delved into mathematical modelling applied to the sustainable management of marine resources in Bangladesh. They formulated and studied a non-linear mathematics model to conceptualize the dynamic of a fishery resource system in area water, the region was analysed to determine the existence of equilibrium point and to establish the stability and instability of the system. This is embarked upon in the order to understand the environmental trials that must be preserved, conserve and manage for the sustainability of the social, economic and ecological aspect of Bangladesh.

Bio-economics deals with economics realism, environmental realism, social realism, ethical realism and biological realism. It has been argued that in the present capitalism model, economic growth cannot continue indefinitely due to the depletion of biological resources. The environment cannot accommodate increasing economic growth as a result of increasing population and contamination of the environment. The present social reality indicates a continuous inequality in wealth distribution resulting in socioeconomic and political crisis. Thus, it is obvious that ethical realism reveals that citizens are not willing to accept unethical behaviours of businessmen inherent in capitalism. The numerous biological discontinuities

such as climate change, reduction in biodiversity and depletion of the ozone layer typify the present biological realism. Bio-economics is not anti-capitalist per se, rather, it is an innovative economy focusing on the synergy between capital and nature (Geoffrey, n. d.; Investopedia, n. d.; Monsour, n.d.; Wikipedia, n. d; Wikibooks, n. d.).

Several factors may drive the emerging bio-economy by creating opportunities for investment. In developing countries, increasing population and per capita income, as well as the use of biotechnology to meet the challenge of environmentally sustainable production, are all major drivers. This trend indicates that developing countries could be the main markets for biotechnology in primary production (agriculture, forestry and fishing). The increase in energy demand, when combined with measures to reduce greenhouse gases could also create large markets for biofuels (OECD, 2009). A sustainable bio-economy is an ensemble of elements because life sciences alone cannot contribute to development. The skills and resources required to carry out scalable biotechnology-based research and development depend on factors of increasing complexity and interconnection. The linkage between University, Industry and Government has been identified as a key element to jumpstart the process taking advantage of the global existing body of knowledge and know-how. Technological and logistics infrastructure, communication and energy development programs also require supporting policies and execution thereof. The state must take a leading role in the establishment and the maintenance of a truly enabling environment, the promotion of social acceptance and the development of key economic infrastructure and services in partnership with the private sector.

Bio-entrepreneur is also, a relatively new interdisciplinary field of study like bio-economics. It is sometimes referred to as bioscience entrepreneurship, life science entrepreneurship or bioscience enterprise according to David and John (2008). It combines social sciences, biomedicine, natural sciences and technology with innovation processes. Biotechnologies, medical technologies, and e-health each present major societal, technological, and economic challenges. Entrepreneurship in these sectors requires specific types of expertise that combine different disciplines and cultures, as well as a state of mind that fosters the emergence and development of technological innovation based on economic models that often require rethinking or reinventing (Berret, 2013). In the view of Uctu and Jafia (2013), Bio-entrepreneurship provided Scientists Avenue to bridge the gap between biotechnology and the commercialization of knowledge in the field of biotechnology. It thus moves biotechnologies from the field of academic into the industrial field (Lynn,2014). Bio-entrepreneurship is a value addition to innovations in biosciences it is about advancing bioscience discoveries from the research stage to the commercial market. It is characterised by (a) expensive and time-consuming research that is often laden with financial risks, (b) it is directed towards value addition in the market, and (c) it exploits the commercialization of innovations in biosciences (David & John, 2008).

Bio-entrepreneurship plays a significant role in advancing bioscience discoveries from the research stage to the commercial market. Aside from this, it is also capable of increasing the economic growth rate of Nigeria through its export market potential. Despite these significances, its actualization is hindered by several challenges, one of which is a lack of awareness of bio-entrepreneurship. Others are large classes, poor funding and assessment procedures (Ejilibe, 2012). Ahmed (2017) viewed bio-entrepreneurship as an integration of two different disciplines of science and business. Ojone (2017) defined bio-entrepreneurship as the application of biological knowledge to serve human needs by setting up a biology-based business, managing it and effectively bearing risks to achieve the set goals. Ojone (2017) studied the effects of students' awareness of bio-entrepreneurial opportunities in biology

education. The study concluded that though the students were interested in entrepreneurship skills in biology, they weren't aware of the bio entrepreneurship skills.

Uju, Chinwe, and Obioma, (2015) explored the attitude of the willingness of teachers to the integration of entrepreneurship into the secondary school curriculum in Anambra State. It was revealed that teachers show willingness and positive attitude towards the integration of entrepreneurship skill into the secondary school curriculum. Oyovwi (2016) examined how to develop entrepreneurial skills in biology education as a way of alleviating poverty. The findings revealed that both teachers and students of biology possess the competence for entrepreneurial skills and that inadequate provision of facilities for teaching entrepreneurial skills and capacity building strategies hinders the integration of entrepreneurial skills into the teaching process by the biology teachers. Kurawa (2016) also, examined how entrepreneurial skills could be developed among Colleges of Education students in Nigeria and recommended the use of cooperative learning or group work among the students on a semester basis and that the students should be rotated continuously from one group to another to have an insight into all the skills required to be a successful entrepreneur.

Recent Sustainable Development Programmes in Nigeria

Several efforts had been made to put the nation on the road to sustainable socioeconomic, development and join the league of developed nations since the attainment of independence almost six decades ago. The MDGs and SDGs are recent major attempts to eliminate obstacles to sustainable growth and development in all spheres of the nation. The growing number of people in poverty, and several other challenges to sustainable socio-economic and political development such as mass illiteracy, unemployment, insecurity, environmental degradation and so forth propelled Nigeria to team up with other nations to endorse the historic Millennium Development Goals (MDGs) at the United Nations Millennium Summit in 2000. The millennium development goals (MDGs) spelt out long term goals to eradicate poverty and improve socio-economic well-being, human development, environmental sustainability and regeneration in the under developing and developing nations. The MDGs consist of a set of eight laudable goals that each nation should achieve by 2015. The laudable goals are;

- 1: Eradicate extreme poverty and hunger,
- 2: Achieve universal basic education,
- 3 Promote gender equality and empower women,
- 4: Reduce child mortality,
- 5: Improve maternal health,
- 6: Combat HIV/AIDS, Malaria and other diseases,
- 7: Ensure environmental sustainability, and
- 8: Develop a global partnership for development,

The Federal Government of Nigeria (FGN) strived to achieve the MGDs through a homegrown programme tagged National Economic Empowerment and Development Strategy (NEEDs). At the state level, a similar programme tagged State Economic Empowerment and Development Strategy (SEEDs) was embarked upon to complement the efforts of the FGN to achieve the MDGs. Local Government Authority (LGA) level, strategies to achieve the MDGs include the setting up of implementation guidelines, benchmarks, timelines, and deliverables Abubakar, (n.d.). According to the report by the National Bureau of Statistics (NBS) (n. d.) Nigeria recorded an uneven degree of progress across all goals. The report noted that 'Goals 3.was achieved ahead of the 2015 deadline; while Goals 4 and 5 have strong prospects of being met by 2015' (p.6). The fact that the economy is in recession a year after the expiration of the target date for the attainment of the MDGs is a clear testimony that Nigeria failed to meet the MDGs.

However, the nation is exploring another opportunity to put the nation on the path to greatness through the recently launched United Nations-backed programme tagged Sustainable Development Goals (SDGs).

According to the Justice, Development & Peace Commission (2016), MDGs brought to light the agreement reached by the World Leaders in the year 2000 on the Millennium Development an understanding of poverty and associated issues. Hitherto, poverty was merely conceptualised as a multidimensional material phenomenon characterised by the absence of income and basic survival needs such as water, health services education and so forth. The MDGs stimulated the global community to realise that poverty is deeply rooted in socioeconomic and political structures of the society and that it is a human, lived experience. Consequently, the United Nations General Assembly (UNGA) replaced the MDGs with SDGs in line with the new broader conception of poverty. The SDGs is an expanded MDGs agenda, it caters for human capabilities, rights, widening inequalities both within and between nations and the danger posed to the environment and humanity by Climate change. SDGs consist of 17 goals and 169 targets set by the UNGA on the 25th September 2015 and endorsed by Nigeria and other member nations of the UNGA. The 17 sustainable goals to be achieved by member nations are summarized in Table 1

Table 1. Summary of Sustainable Development Goals

Goals	Targets	Role
1, 2, 3 & 8	People	Poverty/ hunger eradication, good health, decent work and economic growth
6, 11, 13, 14 & 15	Planet	To protect the planet from degradation, and ensure sustainable management of natural resources
7,8, 9, 10 & 12	Prosperity	Ensure that all human being enjoys a prosperous and fulfilling life
2, 4, 5 & 16	Peace	Foster peaceful co-existence, just and inclusive society free from fear and violence
17	Partnership	To mobilize the means required to implement partnership through a revitalized global enterprise

Source: Popoola (2019)

Goals 8, 13, 14 and 15 are of directly relevant to biology education because it emphasises the need to sustain all life forms in an ecosystem. Hence, biology education and bio-entrepreneur opportunities could be utilized to actualize the goals within the stipulated time frame. Nigeria has a population of 182.20 million with unemployment and youth unemployment rate of 13.00% and 25.00% respectively (National Bureau of Statistics (2017), coupled with tough environmental challenges, the attainment of the SDGs seems daunting. However, biology education could drive the attainment of the aforementioned four goals through the applications of bio-entrepreneur and Bio-economics knowledge and skills needed to open up new job opportunities in an economically sustainable environment. Most nations are now transiting from MDGs to SDGs and expectedly Nigeria is not standing aloof. Although Jadesimi (2016) noted that the response of the Nigeria government to the SDGs is relatively muted yet the nation could still realise the SDGs especially goals 8, 13, 14 and 15 through biology education. However, biology education in Nigeria must subscribe to the 21st-century skills to fulfil this task.

The 21st Century Skills and Bio-entrepreneurship Opportunities in Nigeria

The 21st century is undoubtedly characterised by advances in modern digital Information and Communication Technologies (ICTs), which paved the way for the emergence of globalisation. Indeed, every aspect of human endeavour are now driven by modern digital Information and Communication Technologies consequently, the 21st century is often described as the information age (Bello & Abimbola, 2017). The Partnership for 21st Century Skills listed three types of skills that every student must possess to be successful in this information-based economy according to Thoughtful Learning (2017) namely; Learning Skills, Literacy skills and Life skills. The various components of each set of skills are shown below:

Learning Skills	Literacy Skills	Life Skills
Critical Thinking	Information Literacy	Flexibility
Creative Thinking	Media Literacy	Initiative
Collaborating	Technology Literacy	Social Skills
Communicating		Productivity

There is no doubt that the 21st century has ushered in new ways of doing business and new jobs that equally require new skills. This has important implications for the education industry which charged with the responsibility of human capital development. Biology education and education industry in general now must produce students who can think deeply on critical matters, and be able to creatively solve problems. Students must be capable of handling flood of information and be ever ready to acquire new knowledge in the ever-changing modern digital technologies. Besides, they must be able to communicate lucidly using several media outlets, possess the ability to work in teams, take initiative and be ready to lead whenever the need arises. Students should be innovative, and be able to produce new useful products or services (Thoughtful Learning, 2017). Biology teachers must employ appropriate pedagogic methods to facilitate the development of the 21st-century skills by their students.

Employment opportunities drivable from new careers in various biology fields especially bio-entrepreneur and Bio-economics elucidated in this paper demand a good mastery of the aforementioned 21st-century skills. The significance of these fields of biology is more glaring than ever before. For instance, entrepreneurship is now a core cause in Nigerian secondary schools as stated in the National Policy on Education (FGN,2013), while the governments have continued to support small and medium scale enterprises (SME) to encourage job creation and speedy economic recovery.

1. Biology Online Businesses

Creating and selling biology resources online is an avenue to make money that is yet to be fully explored by many Nigerian graduates in the field of biology. The current generation of Nigerian graduates are digital natives, they are born in the era of modern digital Information, and Communication Technologies (ICTs). Hence, they can successfully participate in Biology-related online businesses by providing digitalized biology recourses such as Biology Blogging, Bio-edutainment, Selling Online Biology courses. Biology Podcast, Creating and Selling Biology e-books and selling digital Biology Photos among others.

1. **Biology Blogging:** There are several online biology resources such as Webquest, Virtual class, and Blog among others. Essentially a biology blog is an online publication mechanism that provides an avenue for exchanging biology-related information, opinions, and ideas. Blogging is very popular among adolescents, they accounted for 51.5% of all blogs according to Henning (2003) as reported by Bello (2018). Biology blog provides opportunity for experts in the field of biology to publish text and graphics online without

necessarily possessing a sophisticated technical ICT knowledge. In the view of Bello (2018) immediate “feedbacks on posts by readers, archiving of posts and hyperlinks with other bloggers are examples of major attractive features of blogs”(p.14). A biology blogger can choose any area of biology as the content of his/her blog and the audience could range across all leaders of education and could also, include the general internet users. Although blogging is not “a get rich quick ordeal as observed by Knapp (2017) lots of people are already making money profit with their blogs. Usually bloggers monetize their blog by providing avenue for advertisements (ads) on their blog sites. There are several types of ads on blog sites such as; (i) Call Pay Per Click (CPC/PPC Ads) and (ii) Cost Per 1,000 Impressions (CPM Ads) .In the CPC/PPC type, ads which are usually banners are place on the blog content or sidebar. Whenever a reader clicks on the ads, the blogger get paid per click but in the CPM Ads, the blogger is paid a prearranged fixed amount of money based on the number of viewers. Google AdSense is one of the most popular network for place these two types of ads as noted by Knapp (2019).

(b) **Bio-edutainment** is another entrepreneurial opportunity open to biology graduates. Bio-edutainment is simply a media design to educate people about biology contents and issues through entertainment. Most often it includes content intended to teach but has incidental entertainment value. Bio-edutainment is use to teach biology at all levels of education ladder and the general public on a wide range of platforms such as the classrooms, television, radio, film, and music. Social media outlets like Facebook, WhatsApp, Instagram, Twitter, YouTube, WeChat among others are other outlets for bio-edutainment.

(i) **Biology Songs**, especially Hip up and Rap songs are very popular bio-edutainment among students. teachers and other internet users. There are several biology songs on different topics such as Cell, Respiration, Evolution, Physiology, etc. hosted on the YouTube and other websites like Song for Teaching (www.songsforteaching.com). It is not necessary to be a professional singer to make use of songs / music to teach biology. A biology graduate can collaborate with singers and other experts in the field of music to produce songs on any biology content and issues, he/she only need to provide the biology content to the singer/music expert. Biology songs can be monetized like biology blogs. Biology game is another type of bio-edutainment, that biology graduates can produce and market online.

(ii) **Biology games** are either explicitly design primarily to teach biology contents or have secondary educational value. There are varieties of biology games such as digital biology board games, digital biology card games and digital biology video games, each of which can be monetized and play online. Van Eck (2006) “. The mere popularity of games has created a billion-dollar industry” As stated earlier the current generation of Nigerian graduates are digital natives hence, they can successfully create and monetize biology games as a business venture.

(iii) **Biology Film / Science Fact and Fiction Movies** is another avenue for biology graduates to become self-employed. Nigerian graduates in any field of biology can collaborate with experts in the film industry to produce biology movies design to teach biology contents such as difficult concepts and controversial biology issues. It has been well established that science fact and fiction movies captivate the interest of children and adults alike. Science fact /fiction movies are as popular even more popular than games, it’s obviously another billion-dollar industry that graduate can delved into for employment generation.

(c) Online Biology Courses: The traditional face-to-face physical classroom teaching is rapidly giving way to virtual class. Students can enroll for online biology courses at all levels of education. A virtual class is an online learning environment that provides teachers and students to communicate, interact, collaborate, and explain ideas. A virtual class can be Synchronous or Asynchronous. The Synchronous virtual class is essentially similar to the physical classroom in the sense that students must attend the class virtually at the same time. In contrast, in the the Asynchronous class students do not have to be in the class at a specified time. They are free to access the class at any time to complete the tasks. The common features of synchronous virtual class include;

- Video conferencing ability that enables teachers and students to see each other.
- Audio conferencing for students and teachers talk and hear each other.
- Real-time text chat for exchange of ideas.
- Interactive online whiteboard which allows students and teacher to interact on the same online page.
- Library of learning materials for providing structured lessons, and
- Teacher tools and controls similar to the physical classroom situation.

Nigerian graduates in any field of biology can learn how to create their virtual class from www.diy.com and other similar websites or subscribe to premium version of virtual class such as Google Class, School Rack, Quiz, etc. Thereafter, they just need design and upload their courseware to their virtual class. The virtual class can be monetized through student subscription or through ads.

2. Aqua Culture; this is also known as aquafarming, and it includes fish farming. Prawn farming, crab culture, aquatic plants and other aquatic organisms. The act is used specifically for producing seafood for human consumption, enhancing wild fish and restoring the population of threatened and endangered aquatic species. Fish farming also known as pisciculture is an important aspect of aqua farming as it involves raising fish in commercial quantities. The total fish demand of Nigeria based on 2014 population was estimated to be 3.32 million metric tons while the domestic production at that same time stood at 1.123 million metric tons. This shows that fish farming in Nigeria is yet to be fully tapped based on the fact that there is an ever increase in its demand because it is the best alternative in meeting the protein needs of the populace. It is an economically viable option for graduates of biology as it provides them with an opportunity of having an alternative source of income.

3 AgroConsultancy Service: Most farmers are regularly searching for honest and non-biased expertise advice for the improvement of their farm output at minimum unit cost. At present in Nigeria, many retirees end up in agro-business, but there are relatively very few individuals and organizations in agro-consultancy service. Farmers will always need expert advice on the fertilizer, nutrients, irrigation, seed variety, plant protection, and harvesting and post-harvest management system and so forth (MyTopBusinessideas.com, 2017). Charges are paid to the consultant by the farmers for the services render thereby serving as source of income for the concerned individuals.

4. Beekeeping: It includes the preparation of an artificial hive to attract the honey bees. Bees could be used for bee therapy which is an efficient and effective way of controlling Arthritis, multiple sclerosis, high blood pressure and even premenstrual syndrome. The honey gotten from the bees also contains flavonoids, antioxidants which help reduce the risk of some cancers

and heart disease. Thus, the act of keeping bees for its honey is a lucrative business for any potential biology entrepreneur. Professional beekeeping is organised around the world, with China leading the pack with an annual production of 450,300 tons while South Africa produces about 1,500 tons annually (Wolfaardt, 2016). Apart from the honey derived and the medicinal benefit, bees are also used for commercial pollination, with South Africa recording between R12-15 Billion annually on paid pollination. Wide range of opportunities abound in bee-keeping business for young entrepreneurs, hence Nigerian youths can also key into its production, in order to diversify the economy especially in this period of recession and falling oil prices in the global market.

5. Breeding Edible Insects: The protective covering of insects often referred to as the exoskeleton are made up of chitin which are high source of protein could serve as an alternative source of proteins to plants and larger animal protein. With their low space and input requirements, people can venture into their production on a large scale. Insects that can be produced for consumption include crickets, wood cockroaches, winged termites, scorpions, mealworms and silkworms (Bradley, 2014). These insects aside the protein content, contains essential amino acids, minerals and vitamins and are delicacy for human. The act of eating insects is called entomophagy (Insectbreeders.com, 2011)

6. Biotechnology Training School: Biology education graduate can set up a Training school for training of prospective bio-entrepreneurs and even conduct research into innovative life improvement programme

7. Biodiesel Production: The seemingly insatiable demand for energy to power socioeconomic activities created large demand for fuel. Biodiesel is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol for diesel engines (Romano & Sorichetti, 2011). There is also, increasing search for renewable sources of energy such as biofuel. Small or medium scale business can be set up to produce biofuel from *Jatropha* oil, fungi and many other sources and in the process helping the nation to generate alternative source of power as well as serving as source of income to the proprietors of such small and/or medium scale businesses (MyTopBusinessideas.com, 2017).

8. Composite Fertilizer Production: With the high rate of land pollution and excessive use of fertilizers, young entrepreneurs can invest in composite fertilizer production by making use of crop wastes, vegetables and kitchen wastes which are biodegradable and environmentally friendly. This can be sold to farmers or operators of vegetable gardens at reasonably lower price when compared with the artificial fertilizers that are hazardous to both human and soil organisms.

9. Ecotourism: Ecotourism is the responsible travel to natural areas that conserve the environment, sustain the development of local population, and involves interpretation and education (TIES, 2015). This contributes to the Nigeria economy in terms of increasing the GDP, but much attention is geared towards wildlife display. Nigeria has about eight National parks namely: Chad-basin, Cross River, Kanji Lake, Kamuku, Gashaka-Gumti, Okomu, Old Oyo National park and the Yankari game reserves that has been taking over by Bauchi State government. Ecotourism is one of the most developing fields where the students will be able to guide tourist who might either be foreign or locals to show the bio-diversity that are in abundance in the country. Ijeomah (2011) observed that a cumulative number of 424,252 tourists visited surveyed ecotourism destinations in Plateau State alone in 2004. This goes a

long way in showing that if properly harnessed, ecotourism can generate foreign exchange earnings for the nation.

10. Fish Hatchery: a fish hatchery is an area set aside specifically for artificial breeding, hatching and rearing through the early life stages of the animals primarily to support the aquaculture industry where they are transferred to fish farmers that will eventually rear them to reach harvest size (Wikipedia, 2017). The hatchery can rear the fishes that are of improved quality or hybrid over the wild type to the juvenile level before selling off at reasonable prices because of the expertise it requires.

11. Floriculture; this is the cultivation flowers or flowering plants for ornamental values, usually for export as well as for domestic market. This is a branch of horticulture that deals with the science of growing, managing, and processing of fruit crops, vegetables crops, medicinal crops, flowers and other ornamental crops. Floriculture is an international, multi-billion-dollar industry. In 2015 alone, floriculture item sales at all retail outlets in the United States were \$31.3 billion (Naeve, 2016). Flowers are often given to loved ones if not all the time on special occasions; flowering plants are used in beautifying our homes and offices, the highways amongst others. This shows that it is a lucrative business which the nation can diversify into in order to generate employment opportunities for its teeming numbers of unemployed youths.

12. Horticulture: This is the science of growing and management of fruits, vegetables, tubers, ornamental, medicinal and aromatic crops or simply the growing fruits and vegetable. It is wide field of science that is divided into seven groups via: pomology (fruit culture), Olericulture (vegetable culture), floriculture (ornamental culture), arboriculture (study, selection, care, and removal of trees, shrubs, vines and perennial woody plants), turf management (production and maintenance of turf grasses), landscape management, and viticulture (production and marketing of grape). Some of the benefits of diversifying into horticulture include: strengthening the sustainability of a farm, spread economic risk, exploit profitable niche markets, create new industries and building the domestic food production (Byers, 2014). China is one of the leading producers of vegetables, medicinal and aromatic plants with an estimated income of about 62 Billion U.S Dollars which is expected to rise to the tune of 5 trillion dollars by 2050 (Naeve, 2016). The products can be exported as well as can be used for domestic market.

13. Mushroom Culture: the market for mushroom continues to grow because of their nutritional and health benefits. Some 260 U.S growers produced more than 844 million pounds of mushrooms in 2002-2003 with a farm gate value of \$889 million. It is a source of protein and has good export market value. It can either be sold fresh or dried, but it is often better to have a ready market before one venture into it on a large scale. Prospective biology graduates could also tap into this vast market by growing high quality mushroom which will meet the international standard and hence can be exported out of the country. This not only generates income for the investors but also bring about more foreign earnings for the country.

14. Biological Pest Control: Pests are known to reduce the quality of agricultural produce be it field pests or storage pests, thus reducing the monetary value of the goods. In order to curb this menace, there is the need to have in place an effective and efficient pest control system. The era of excessive use of chemicals to control pests is fast becoming outdated and this accounts for the banning of some of the Nations agricultural produce in the advanced world. This has caused the country loss of revenue in millions of Dollars. This trend could, however,

be overturned by adopting the use of biological control measures or engaging the services of entomologist (Biologist that are specialised in the study of insects) to assist in controlling the pests in a cost-effective and environmentally friendly manner

15. Poultry: Poultry farming is one of the most lucrative business in Nigeria. It deals with the rearing of birds for human consumption. About 160 million Nigerians consume poultry products, ranging from chickens, turkeys, eggs, and a lot more. This shows that opportunities abound in poultry farming for people to key into (Edom, 2016). There are various breeds that can be raised by prospective poultry farmers. The farmer can choose from Chickens (Broilers, Growers & Layers), Turkeys, Guinea Fowls, Quails, Peacocks, Ducks, Geese, etc. depending on one's interest and start-up capital. Poultry products are a good source of protein with high market potential because of the high demand for its products.

16. Preservation of Soil Fertility: In order to prevent global warming and desert encroachment is another important area in conservation. Biologist and entrepreneurs can key into this area by working as conservation agents which will assist in preserving the scarce resources, thereby creating employment opportunities for themselves and also help in preserving nature.

17. Rabbitry: This is the act of rearing rabbits for commercial purposes. Rabbit farming requires modest investment as it needs simple facilities and small land area. Rabbits can be raised by either adopting the use of deep litter system or use of a cage (Abimbola, 2017). Rabbits are essentially reared for their wools, furs, meat and sometimes testing specimens in the laboratories (American Rabbit Breeders Association, n.d). Rabbit farming has many advantages in that they are highly prolific, has quick returns on investment, and rich in poly-unsaturated fatty acids (Agricfarming, 2014).

18. Sericulture: This is the rearing of silkworms for the production of raw silk which is the yarn obtained out of cocoons spun by the silkworm (Central Silk Board, 2017). This is an agro-based industry that has employment potential, eco-friendly, women friendly and provides vibrancy to village economies among others. The silk gotten can be weaved to produce twine for clothing.

19. Soil Improvement: Arable lands are essential requirement for the attainment of food security in any nation. In Nigeria soil is subjected to abuse daily through human activities, thereby creating scarcity of this invaluable resource. The scarcity of arable crops is the major source of conflict between the farmers and herdsmen. Bio-entrepreneurs can invest into bio-regeneration and bio-augmentation of soil to restore arable lands and make farmlands more productive.

20. Waste to Wealth: With the ever-increasing quantity of waste been generated annually in Nigeria, individuals can exploit the large and growing waste market by either embarking on waste management collection, inorganic waste management and organic waste management. John (2013) submitted that the amount of waste generated on our continent is expected to double in the coming years hence smart entrepreneurs are turning the massive waste produced into money-making products. Recycling Waste Water is another waste to wealth venture. The demand for clean water is on the rise globally while the supply is decreasing majorly as a result of the ever-expanding population and global warming that has led to sharp rise in the atmospheric temperature. One way to solving this ugly scourge is to step up efforts in

conserving water. Nigerian biology graduates can thus rise up to the challenge by owning water treatment plants where wastewater could be recycled.

Conclusion

In this paper, an attempt was made to elucidate how biology education could further contribute to employment generation thereby put the nation on the path to speedy economic recovery from recession. The paper also illuminates the relevance of biology education in the realisation of the SDGs within the stipulated target time frame. In addition, the paper sensitizes biology teachers to the need to facilitate the development of the 21st-century skills in their students to enable them to succeed as bio-entrepreneurs in the nearest future. Finally, twenty career opportunities that require applications of knowledge in the areas of bio-entrepreneurs and bio-economics were examined in the paper.

Recommendations

- Curriculum experts should incorporate bio-entrepreneurship and bio-economics into biology education at all level of the education ladder.
- Biology Teacher Education Institutions should provide avenue for in-service biology teachers to acquire knowledge in the areas of bio-entrepreneurship and bio-economics
- The Science Association of Nigeria (SAN) and the Science Teachers Association of Nigeria (STAN) among other professional bodies should popularize career opportunities in the field of biosciences to attract entrepreneurs and encourage students to take up jobs in this field
- Biology textbook authors should emphasis entrepreneurship opportunities drivable from biology topics included in every textbook.
- The government should provide enabling the business environment to stimulate the growth and development of bio-entrepreneurship in Nigeria.
- Biology and other science subjects should be restored to the status of core disciplines in the senior secondary school curriculum.

References

- Abimbola, I. O. (2017). Professional growth and development of biology teachers. In I. O. Abimbola (Ed) (267-295) *teaching methods*. Ilorin: Biology Education Group, Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Nigeria.
- Abubakar, M., B.(n.d.). Millennium development goals: The Nigeria situation. Retrieved from www.gamji.com>NEWS7953.
- Adom,D., Umachandran, K., Ziarati, P., Sawicka, B., Sekyere, P. (2019). The concept of biodiversity and its relevance to mankind: A short review. *Journal of Agriculture and Sustainability*, 12 (2), 219 – 231. Retrieved from www.infinitypres.info
- Agommuoh, P. C., & Ndirika, M. C. (2017). Strategies for promoting entrepreneurial skills in science education students for poverty eradication. *IOSR Journal of Research and method in Education (IOSR- JRME)*, 7 (3),45-49. Retrieved from www.iosrjournals.org.
- Agri Farming (2014). Rabbit farming info and project guide. Retrieved from www.agrifarming.in/rabbit-farming
- Ahmad, H. (2017). Bioentrepreneurship: Beginner’s guide. Retrieved from <https://techoid.com>>Money
- American Rabbit Breeders Association (n. d).Start a rabbit farm. Retrieved from www.startupbizhub.com/start-a-rabbit-farm.htm

- Araoye, M. I. (2016). Biology education and national productivity: Implication for transforming Nigerian educational system. *International Journal of Advanced Academic Research*, 2(7), 1-6.
- Bello, G. & Abimbola, I.O. (2015). Re-Engineering science education for sustainable national security. *West African Journal of Education* 35(20), 145-155.
- Bello, G. & Abimbola, I.O. (2017). Nigerian basic school teachers' knowledge and use of ICTs for teaching and learning. In Jekayinfa, S.O. (Ed.). *Achievements of Millennium Development Goals in Nigeria*. Germany: Cuvillier Verlag Gottingen.
- Bello, Z.A. (2018). *Analysis of misconceptions and alternative conceptions of difficult topics in online senior secondary school biology resources* (Unpublished Ph.D. thesis). University of Ilorin, Ilorin, Nigeria.
- Biswasa, M. H. A., Hossain, M. R., & Mondal, M. K. (2017). Mathematical modelling applied to sustainable management of marine resources. *Procedia Engineering*, 194, 337-344. Available online at www.sciencedirect.com.
- Bradley, K. (2014). Farming edible insects (Hello, zero- footprint protein). Retrieved from <https://www.milkwood.net/2014/06/12/farming-edible-insects-hello...>
- Collins English Dictionary (2017). Definition of pisciculture. Retrieved from www.collinsdictionary.com/us/dictionary.....
- David, A. & John, S. (Eds.) (2008). Enterprise for life scientists: Developing innovation and entrepreneurship in the biosciences. *Journal of Commercial Biotechnology*, 14, 355 – 356. doi: 10.1057/jcb.2008.21
- Ecotourism.org (2015). What is ecotourism? Retrieved from <http://www.ecotourism.org>> what iseco....
- Edom, S. (2016). How to start a profitable poultry farming business in Nigeria. Retrieved from <http://startuptipsdaily.com/how-to-start-poultry-farming-in-nigeria/>
- Ejilibe, O. C. (2012). Entrepreneurship in biology education as a means for employment. *Knowledge Review*, 26 (3), 96-100.
- Geoffrey, H.(n. d). Nature of Bio-economics. Retrieved from <http://www.scienceofbioeconomics.com/bioeconomics/what-is-bioeconomics/23-nature-ofbioeconomics>
- Gordon, H. S. (1954). The Economic Theory of a Common Property Resource: The Fishery. *Journal of Political Economy*, 62(2), 124–142.
- Henning, J. (2003). *The blogging iceberg: Of 4.12 million weblogs, most little seen and quickly abandoned*. Braintree, MA: Perseus Development Corporation
- Ijeomah, H. M. (2011). Edible insects for humans. Retrieved from insectbreeders.com
- Insectbreeders.com (2011). Edible insects for humans. Retrieved from www.insectbreeders.com
- Investopedia, (n.d). Bioeconomics. Retrieved from <http://www.investopedia.com/terms/b/bioeconomics.asp.#ixzz4btT2UDLC>
- Iwuoha, J. (2013). From waste to wealth-How to build a profitable business out of Africa's huge waste market. Retrieved from www.smallstarter.com/browse-ideas/make-money-....
- Jadesimi, A. (2016, November, 26). *Nigeria and the sustainable development goals: Setting the course to 2030 Forbes*. Retrieved from <http://www.forbes.com/leadership>
- Justice, Development & Peace Commission (2016). Sustainable development goals (from MDGS – SDGS): Action towards 2030 + Paris declaration on climate change. Retrieved from www.jdpcijebuode.org
- Kayode, M. (2015). Lessons from the MDGS: Why Nigeria failed to attain MDG5. Practical Initiatives Network. Retrieved from <https://practicalinitiativesblog.wordpress.com/>
- Knapp, J. (2017, Dec. 26). How to Make Money with Your Blog in 2019. Retrieved from

- <https://www.bloggingbasics101.com/how-can-i-make-money-from-my-blog>
- Kurawa, L. A. (2016). Utilization of biological gardens to develop entrepreneurial skills among biology education students in colleges of education. *Capital Journal of Education Studies*, 4(1), 1-11.
- Lynn J. L. (2014). Building a curriculum for bioentrepreneurs. *Nature Biotechnology*, 32,863–865
- Maliford, J. (n.d). What is the importance of biology to mankind? Retrieved from www.Blurti.com
- Masoud, M. (2016). Does capitalism have to be bad for the environment? World Economic Forum. Retrieved from <https://www.weforum.org/>
- Mijung, K., & Diong, C. H. (Eds.) (2012). *Biology education for social and sustainable development*. Netherlands: Sense Publishers. Retrieved from www.sensepublishers.com
- Muriel, P. (Ed.) (2000). Science education for contemporary society: Problems, issues and dilemmas. Final report of the international workshop on the reform in the teaching of science and technology at primary and secondary level in Asia: Comparative references to Europe .Beijing: International Bureau of Education, Chinese National Commission for UNESCO
- MyTopBusinessideas.com (2017). 10 Small business ideas in the biotechnology industry. Retrieved from <http://www.mytopbusinessideas.com>
- Naeve, L. (2016). Floriculture. Retrieved from www.agmrc.org>....>specialty crop
- National Bureau of Statistics (n. d.).The millenium development goals performance tracking survey 2015 report. Retrieved from nigeriastat.gov.ng>pdfuploads
- National Bureau of Statistics (2017). Nigeria Unemployment Rate 2016-2017. Retrieved from <http://nigerianstat.gov.ng/>
- Ojone, A. S. (2017) .Effects of students’ awareness of bio entrepreneurship opportunities in biology education in biology education on combating economic recession in Nigeria. *International Journal of Education and Evaluation*, 3(10), 22-29.
- Oyovwi, E. O. (2016). Developing entrepreneurial skills in biology education: A necessary tool for poverty alleviation. *Ibadan Journal of Educational Studies*, 16(2), 31-42
- Popoola, L. (2019). *Biodiversity and the achievement of the sustainable development goals*. 7thFaculty of Agriculture Public Lecture Delivered on 20th June 2019 at the University of Ilorin Auditorium
- Punch Newspaper (2019, February 15).Retrieved from www.punching.com
- Romano, S. D., & Sorichetti, P. A. (2011).Dielectric spectroscopy in biodiesel production and characterization. *Green Energy and Technology*, DOI: 10.1007/978-1-84996-519-4_2.
- Scott, A. (1955). *The Fishery: The Objectives of Sole Ownership*". *Journal of Political Economy*, 63 (2), 116– 124. [doi:10.1086/257653](https://doi.org/10.1086/257653).
- The International Ecotourism Society (2015).Ecotourism. Retrieved from <http://www.ecotourism.org>> what is eco....
- Thoughtful Learning (2017).What are the 21st-century skills? Retrieved from www.https://k12.thoughtfullearning.com/
- Tony, J. (2014). Capitalism versus environment: Can greed ever be green? *The Guardian*. Retrieved from <https://www.theguardian.com/uk/sustainable-business>
- Uctu, R., & Jafia, R.C.C. (2013). Bio-entrepreneurship as a bridge between science and business in a regional cluster: South Africa’s first attempts. *Science Public Policy*, 41 (2), 219-233. Retrieved from <https://doi.org/10.1093/scipol/sct049>.
- Uju, U., Chinwe, O. J., & Obioma, U.G. (2015). An attitude of the willingness of teachers to the integration of

- entrepreneurship into the secondary school curriculum in Anambra State. *British Journal of Education, Society & Behavioral Science*,10(1), 1-10. Retrieved From www.sciencedomain.org.
- United Nations Development Programme UNDP(n. d.). Sustainable development goals-.*UNDP*. Retrieved from www.undp.org>SDGs_Booket_Web_En
- Van Eck, R. (2006). Digital game-based learning: It's not just the digital natives who are restless..."(PDF). *Educase Review*, 41 (2). 1–16. *Archived(PDF) from the original on 2016-12-29*.
- Wikipedia (2017). Aquaculture Retrieved from <https://en.wikipedia.org/wiki/Aquaculture>
- Wikipedia (n.d.) Bioeconomics. Retrieved from <https://en.wikipedia.org/wiki/Bioeconomics>
- Wolfaardt, J.(2016). Professional bee keeping in Africa Challenges and opportunities. Retrieved at <http://ananzi.co.za/ads/professional-services/be>.

Author Information

Ganiyu Bello

University of Ilorin, Ilorin, Nigeria
Department of Science Education, Faculty of Education
bello.g@unilorin.edu.ng

Hafsat Imam Alabi

University of Ilorin, Ilorin, Nigeria
Department of Science Education, Faculty of Education

Aduke Rihanat Ahmed

University of Ilorin, Ilorin, Nigeria
Department of Science Education, Faculty of Education

Musa Mohammed Sulaiman

University of Ilorin, Ilorin, Nigeria
Department of Science Education, Faculty of Education

Zakariyau Adebayo Bello

Kwara State College of Education, Ilorin
Department of Integrated Science

Abdulrasak Agboola Bello

Kwara State Polytechnics Secondary School
