



Contemporary Issues in Science, Technology and Society: Implications for Teaching and Learning of Chemistry – Towards Community Development

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Abstract

This paper examined current issues in Science, Technology and Society (STS) as an interdisciplinary field of study and analyzed the implications of the issues to chemistry teaching and learning, as they are pertinent to the human understanding of the human-built environment and the overall well being of the community and larger society. The issues identified were of two categories; educational issues which include gender gap, decline in enrollment, incompetent and poorly motivated teachers etc and environmental and health issues which include; depletion of mineral resources, nuclear energy and the environment, Pollution, Climate change etc. By implication, the paper advocates context-based chemistry programme such as chemistry in community (ChemCom) which aims at presenting chemistry along societal contexts on a “need to know” basis. The paper also supports the involvement of chemistry teachers who can provide good ideas related to the pedagogical aspects of the course, characteristic of Salters Advanced Chemistry. Another implication of STS issues for teaching and learning chemistry is the infusion of STS issues in chemistry curriculum starting from secondary level of education, to enable the students become acquainted with the issues, and to think towards providing solution to the challenges of STS and informing the community adequately. Based on the literature reviewed, the paper concluded that, due to the interdependencies between science, technology and society, most of the STS issues require fundamental changes in attitude of individual citizens such as chemistry students and therefore to foster community development, current STS issues should be infused into the chemistry curriculum at different levels, and context-based curriculum programme should be incorporated. Also good quality STS teachers should be employed and students should be educated on the proper use of technology as well as the consequences of misusing technology. Among the recommendations given was that innovative teaching strategies such as problem-based learning, educational visits and project method should be adopted by STS chemistry teachers in secondary school level as well as maintained at the tertiary level of education.

Introduction

The world is dominated and even driven by ideas and products from science and technology and it is likely, that the influence of science and technology on our societies will continue to increase in years to come. Science is a process of understanding, building and developing concepts and principles about the natural world (Allum, Sturgis, Tabourazi, & Brunton-Smith, 2018). It is a systematic enterprise that builds and organizes knowledge in the form of testable

explanations and predictions about the universe. It encompasses a wide range of field from mathematics to chemistry and from physics to geology. Chemistry is one of the most important sub-disciplines of science and emphatically, a branch of physical science. Agogo and Onda (2014) define chemistry as the science that deals with the study of the properties, composition and structure of substances (elements and compounds), the transformation they undergo and

the energy that is released or absorbed during these processes. Chemistry is also seen as a systematic investigation of the forces of nature, resulting in the acquisition of knowledge, skills and attitudes needed to satisfy man's needs (Alan, 2019).

Chemistry could therefore be defined as the area of science that deals with the study of matter; the composition, properties, structure, transformation or reactions that matter undergo under various conditions (such as heat, light, catalyst etc) and the use of such reactions to solve man's problems or to satisfy human needs. The teaching and learning of Chemistry as a science subject in senior secondary schools is very important because students can hardly offer most science courses in the tertiary institution without at least, a credit in chemistry at the senior secondary school certificate examination level. Teaching is a system of actions intended to induce learning (Rajagopalan, 2019). Teaching is also the guidance of pupils through planned activities so that they may acquire the richest learning possible from their experience. Learning on the other hand is relatively permanent influence on behaviour, knowledge and thinking skills which comes about through experience (Santrock, 2016). Developing an understanding of what chemistry is, and how we can use it, is therefore central to a successful development of any nation. Chemistry is connected to technology in many ways, including the materials used, the processes involved, and the properties of the compounds used. Chemistry is essential to many products including electronics, automobiles and clothing.

In the same vein, technology is the development of tools and techniques to improve or enhance human living condition and development. Science and technology have different purposes, distinctive needs and divergent ways of viewing and knowing the world and their relationship is often tense and complex (Brooks, 2014). Technology deals with tools that human have created for themselves during their own development as a species in order to make life more livable on planet earth. However, both science and technology are not as different from one another as might seem at first glance. Science is often said to be an inquiry into how technology alters our lives and technology is the application of scientific principles and theories for the improvement of man and its environment. Technology is often referred to as an applied science (Kline, 2015). Technology is also being called the driver of economic growth while science is often seen as the engine of technological

progress. The society drives technological evolution and scientific enquiry. A society could be seen as a group of people sharing the same spatial territory and are bound by the same political authority, culture and tradition (Yager, 2017).

Science, Technology and Society (STS) is an interdisciplinary field that studies the conditions under which the production, distribution and utilization of scientific knowledge and technological system occur and the consequences of these activities upon different groups of people (Bijker, 2021). However, the scientific and technological activities according to American Geophysical Union refers to the elucidation of unknown phenomena and to the creation of new knowledge through the discovery of new natural laws and principles and the new knowledge obtained is then utilized in the community and society (Agu, 2017). A community is a group of people living together in a particular area and have common interest. Goel (2020) defined community development as a process where the conditions of social and economic progress are created through participation within the community and reliance on community initiatives. Different communities tend to use different means to achieve this, but it is generally a universal concept regardless. For instance, science and technology can be used to improve communities in many ways, including education and environmental management. Community development helps people exercise their rights and responsibilities (contribute to a better society). Furthermore, the essence of how science and technology contribute to the society is the creation of new knowledge and then utilization of that knowledge to boost the prosperity of human lives and solve various issues facing the community and larger society.

Despite the contributions of science and technology to the society as well as the objectives of STS approach, as a new conceptual organization for science education, the society is undergoing a rapid change in the way it perceives and understands science and technology. Science, Technology and Society issues encompass social dilemmas with conceptual or technological links to science (Yager, 2017). Science and technology have become a crucial part of our everyday lives, but public confidence of its expertise is on the wane. Also, one might expect that the increasing significance of Science, Technology and Society (STS) should be accompanied by corresponding interest in the subjects as well as increasing understanding of basic scientific ideas and

ways of thinking. This does not seem to be the case. The evidence for such claims are in part based on hard fact (eg. educational statistics), in part based on comparative studies and in part based on research and on analysis of trends in our society (Parker, Acland, Armstrong, Bellingham & Sutherland, 2014). This paper sought to examine current issues in science, technology and society as an interdisciplinary field of study and analyze the implications of the issues to chemistry teaching and learning, as they are pertinent to the human understanding of the human-built environment and the overall well being of the community and larger society. To achieve this, it is crucial to expatiate the Science, Techonolgy and Society approach.

Science, Technology and Society (STS) Approach

. Science, Technology and Society (STS) approach emerged as a result of the crave to relate science to daily issues and life experiences of the students. STS was drawn from a variety of discipline such as history and philosophy of science and technology, sociology, anthropology, policy studies, cultural and literary studies. STS approach has been suggested as a new conceptual organization for science education (Sadler, 2014; Bybee & Mau, 2016). STS education enable students to connect with the global community (in other words, between the classroom and the society) to explore knowledge and still use the knowledge to develop their local communities. It helps the students to identify potential problems, collect data with regards to the problem, provide alternative solution and consequences of a particular decision (Yagar, 2017). STS approach has become one of the current goals for science education, it attempts to replace as much as emphasis on technology and society as on science in presenting a coherent idea of relationship between these three strands. Science, Technology and Society approach is expected to increase general interest and understanding of science. It is also expected to fill a very vital gap in our traditional curriculum.

Harms and Yager (2023) further generated four main purposes (objectives) of Science, Technology and Society (STS) approach, which are;

1. Preparing students to use science for improving their own lives and as a corollary to be able to better understand and cope with fast increase in technological society.

2. Enable students as they progress through life to deal with STS issues in a responsible manner.
3. Identifying a body of knowledge that would enable them to deal with STS issues.
4. Acquiring knowledge and understanding about career opportunities in the field. Enabling the students plan for their careers by comprehending the possible job opportunities available in their job market.

Science, technology and society approach, allows students to relate the scientific concepts to the problems they may have encountered, makes science education curriculum to be closely related to their lives in order to strengthen their understanding of the concepts and develop self-learning in the future in order to be good citizens and have the ability to make use of science as well as technology to help contribute immensely to the society.

In another context, the programme in Science, Technology and Society (STS) focuses on the ways in which scientific, technological and social factors interact to shape modern life. The programme brings together humanists, educationists, social scientists, engineers and natural scientists, all committed to transcending the boundaries of their disciplines in a joint search for new insights and new ways of reaching science students.

Furthermore, the distinct roles of science and technology have resulted in reasonable improvement in the quality of human lives. In health, the most important contribution of science and technology is the ability to provide cures or prevention measures for various ailments that afflict man. In agriculture, with the development of modern agrosience and technology, the soil quality has improved by using fertilizers and the production of agricultural machinery as well as processing of food and other agricultural biorenewable products are enabled. We have also learned to communicate and travel rapidly the entire globe and are surrounded by televisions, computers, electric light and all kinds of technology that would not have been possible without science and technology.

However, despite the objectives and contributions of STS as a field of study and advances of science and technology in making life more prosperous, there are issues arising from science, technology and society. According to Martin, Maris and Simberloff (2016) humanity faces a plethora of existential and environmental challenges as it relates to science and

technology; among them are depletion of mineral resources, Nuclear energy and environment, pollution, biodiversity loss, climate change etc. By implication, some of these issues arise from science and technology products.

Environmental and Health Issues in Science, Technology and Society

1. Depletion of mineral resources

Mining depletes finite resources and in a strict sense, is inherently unsustainable. For instance, there is only finite amount of copper in the earth crust and each unit copper extracted increases the fraction of the total copper resource base that is used. If we continue to mine, we will eventually exhaust the available supply of minerals degradation (United Nations, 2015). However, there are five factors that make the benefit of mining much more sustainable than they initially appear to be: (1.) In the process of exploration and development, mining companies continually reinvigorate, augment or sustain their reserves. Technological improvements in exploration increase the discovery rate of mineral deposit and at the same time reduce discovery costs. (2.) Technological change sustains mineral production. Technological improvement in mining and mineral processing reduce cost and permit profitable mineral production from previously uneconomic, mineralized rock. (3.) When a mine is physically depleted, recycling can be thought of as an extension of primary mining. Recycling is an important source of many metals. (4.) A scarce resource can sometimes be replaced by more abundant substance, for example, aluminium can replace copper in long distance transmission power lines. (5.) When a mine is physically depleted, its value may persist if an appropriate portion of the proceeds are invested in human capital (such as education or health care) or man made physical capital (such as infrastructure or technology).

2. Nuclear Energy and the Environment:

Nuclear energy is the energy in the nucleus, or core, of an atom. Nuclear energy can be used to create electricity, but it must first be released from the atom. The major

environmental concern related to nuclear power is the creation of radioactive wastes such as uranium mill tailings, spent (used) reactor fuel, and other radioactive waste. These materials can remain radioactive and dangerous to human health for thousands of years. The radioactive material can be extremely toxic, causing burns, and increase the risk of cancers, blood diseases and bone decay. Radioactive wastes are subject to special regulations that govern their handling, transportation, storage and disposal to protect human health and the environment. Human health and well-being are closely linked to the integrity of local, regional and global ecosystems (Herbert, Hill, Fails, Ajala, Boniface & Cushman, 2014).. For instance, the storage site for radioactive waste have become controversial in the united states. For years the government planned to construct an enormous nuclear waste facility near yucca mountain, Nevada, but environmental groups and local citizens protested the plan. They worried that the radioactive waste will leak into the water supply. The critics of nuclear energy worry that the storage facilities will leak, crack, or erode. Radioactive materials could then contaminate the soil and groundwater near the facility. This could lead to serious health problems for the people and organisms in the area. Underdal (2010) stated that environmental problems are product of complex, often nonlinear, interaction between people and the environment and our understanding of them is usually incomplete and clouded by profound uncertainties.

3. Climate change (Climate Imbalance):

Climate change is a complex, multi-dimensional problem. Climate change is as much an opportunity as it is a threat. Deforestation for instance, affects the climate in many ways. Trees release water vapour in the atmosphere which is compromised with lack of trees. This leads to an imbalance in the atmospheric temperature. Climate change also include the impact of global warming which is driven by emissions of greenhouse gases, resulting in large-scale shift in weather patterns. The problems of global warming are; making hot days hotter, rainfall and flooding

heavier, hurricanes stronger and droughts more severe. This intensification of weather and climate extremes is the most visible impact of global warming in our everyday life. It also causes dangerous changes to landscape of the world, adding stress to wildlife species and their habitat (Dow, Berk, Preston, Klein, Midley & Shaw, 2013).

4. **Pollution:** Pollution is the introduction into the environment of substances harmful to humans and other living organisms. Pollutants are harmful solids, liquids or gases produced in higher than usual concentrations that reduce the quality of our environment. Human activity influences the natural environment producing negative, direct and indirect effects that alter the flow of energy, the chemical and physical constitution of the environment and abundance of the species. In other words, Human activities have an adverse effect on the environment by polluting the water we drink, the air we breathe and the soil in which plants grow. Although the industrial revolution was a great success in terms of technology, society and the provision of multiple services, it also introduced the production of huge quantities of pollutants emitted into the air that are harmful to human health. The health of susceptible and sensitive individuals can be impacted even on low air pollution days. Short-term exposure to air pollutants is closely related to COPD (Chronic Obstructive Pulmonary Disease), cough, shortness of breath, wheezing, asthma, respiratory disease and high rates of hospitalization (a measurement of morbidity). The long-term effects associated with air pollution are chronic asthma, pulmonary insufficiency, cardiovascular diseases, and cardiovascular mortality. Water pollutants are of three major categories: oxygen-depleting pollutants (eg. Organic waste, fertilizers), toxic or harmful pollutants (eg. Poisonous heavy metal, ions, acids, bases; radioactive materials such as nuclear reactor waste); indirectly harmful substances (eg. Sediments, oil and high concentration of dissolved salts). Soil pollution occurs through the release of chemicals or the disposal of wastes, such as heavy metals, hydrocarbons, and pesticides.

5. **Water Supply and Waste Water Management at the Nexus of Science, Technology and Society:** Management of water supply, water resources and aquatic ecosystems have often been quite technocratic and sectoral. It has also been heavily influenced by past practices and infrastructure investments as well as legal and regulatory frameworks that do not sufficiently accommodate future needs or even adequately reflect some current situations and constraints. For example, the historical extent and function of aquatic ecosystems can provide valuable insight for future ecosystem management, but cannot serve as the model for restoration efforts because of the extensive alteration of these ecosystems. The future management of aquatic ecosystems as well as of infrastructure systems, will require that direct human needs are balanced with ecosystem function. In the future (and even in today's water-stressed regions), the increasing complexity of water infrastructure systems, increasing inter-linkages among the water and other sectors (example, energy and agriculture) and increasing pressure and demands on aquatic ecosystems call for more integrated and participatory approaches (Islam & Rapella, 2015).

Science, technology and society approach has been suggested as a new conceptual organization for science education (Bybee & Mau, 2016). This suggests the fact that science, technology and society has also been faced with some issues as an educational field.

Current Science, Technology and Society (STS) Educational Issues.

1. **Decline in Enrollment:** The lack of interest in science subjects is manifest at school level at the age where curricular choices are made. Public scientific literacy is allegedly in a period of serious decline (Rodriguez-Espinosa, 2015). In Nigeria there is noticeable decrease in number of students choosing some of the sciences. This trend is further extended to tertiary education. A similar trend occur in some area of technology and engineering studies. The fall in enrollment has hit the

harder part of Science and Technology subjects, in particular physics, mathematics and chemistry, with people becoming less engaged with science and technology (Parker et al., 2014). This concern about unsatisfactory enrollment is voiced from many interest groups. Industries are worried about the recruitment of qualified workforce, universities and research institute are also worried about recruitment of new researchers. Educational authorities are worried about already visible lack of qualified science and technology teachers. In some countries, the crave for recruitment of new teachers as well as the substitution of those who retire has caused great concern. This concern is often based on the current situation in educational sector and the labour market. In the UK, for example, over the last three decades the government has promoted evidence based decision policy to replace ideologically driven policy (Productivity Commission, 2018). The concern is not just about the actual numbers, but also about a more or less identifiable fall in the quality of newcomers. A less quality may of course be a consequence of the fact that very few candidate can compete to get places at institution where the entrance qualifications previously were very high.

2. **Gender Gap:** In many countries, one also observe a glowing gender gap in the choice of Science and Technology subjects, such as chemistry in secondary schools as well as at tertiary education. At a time when public knowledge is being accumulated at unprecedented rates and understanding of the natural world has never been so high although by no means complete (Rodriguez-Espinosa, 2015). Many countries have had a long period of steady growth in female participation in traditionally male field of study, but this positive trend seems to be broken in some countries like Nigeria, especially in northern region where gender equity has been a prime educational aim for decades.

3. Abuse of Technology

Abuse of technology is the improper use of devices such as mobile phones, computers and internet to access illegal or inappropriate

content which may be counter-productive to students. Misuse of technology could be to access information and download the content from the internet that is neither meant for the students' community nor for learning purposes. Misuse of technology can come in various forms, such as Overuse / Abuse of smart phones, computers and social media; Cyber Crime/Computer Related Fraud (Almeida & Bascolo, 2006). Cybercrime include many online swindles that involve false or misleading promises of love and companionship, property and money and wealth (through lottery scams, investment fraud, inheritance scams etc.) The ultimate goal of these scams is to trick the victims into revealing or otherwise providing personal information and funds to the perpetrators (a form of social engineering fraud). The practice of manipulating, deceiving, influencing or tricking individuals into divulging confidential information or performance that will benefit the social engineer (eg. student) in some way. This leads to systematic transfer and application of the knowledge.

4. Incompetent and Poorly Motivated Teachers:

Science and technology teachers are poorly treated in teacher's preparation for early years. Moreover, the students who choose to become primary school teachers are often those who do not take or did not like science themselves in school. The quality, qualifications and motivation of the teachers who are saddled with the implementation of STS curricula in many African countries are often inadequate; hence their performance on the job is generally below expectation (Njoku 2016). In Nigeria, for instance, the present decline in recruitment of science teachers are now felt in the secondary schools. Majority of teacher educators have so far failed to re-skill themselves with modern pedagogic technologies available for training modern STS teachers, who are expected to have not only sufficient subject matter content and pedagogical knowledge, but also sufficient technological knowledge that would enable him or her to use modern teaching technologies and operate effectively in

modern ICT driven STS classroom (Obanya, 2016). The current crop of students have access to a lot of information through ICT gadgets and their old teachers have to adapt fast. In addition, STS teachers in most African countries complain about their remuneration and other earned allowances which are not given to them when due. In several African countries, teachers have to embark on strike actions to press home their demand for their remunerations, allowances and better conditions of service. Thus, teachers in general feel demotivated and they fail to do their jobs well. Consequently, many teachers see their teaching jobs as temporary or part-time because they are willing to drop those jobs in order to engage in any other economic activities to make ends meet.

5. **Inadequate Teaching Strategies Adopted By Teachers in Implementing Science, Technology and Society Curricula:**

Ahmed, Oyelekan and Olorundare (2015) in the study, "Introduction of the Science, Technology and Society in Nigeria Curriculum, identified lack of classroom activities for the students as one of the implementation constraints to STS curriculum. Majority of teachers of science, technology and society subject at the primary and secondary levels of education use talk-and-chalk method as the dominant method of teaching. The teachers rarely use investigative and problem-solving teaching strategies such as project method, problem-based learning, educational visits and cooperative learning method. These innovative strategies and methods tend to prepare the learners for life in the 21st century world which needs a lot of team work and social skills for survival in the work (Obanya, 2016). According to Obanya, the dominant teaching methods and strategies used by the teachers do not encourage creativity and innovation among students.

6. **Low level of Education:**

Low level of education contributes against the growth of science and technology in Nigeria. Like most developing countries, a large number of the Nigeria population are illiterate which makes it hard for them to contribute effectively and efficiently to the development of the nation

science and technology. Better still the Nigerian government should make education free, at least from primary school, to secondary school level since our oil wells are still flowing and capable of shouldering the load.

It is important to understand the human and social dimensions of scientific and technological practices and its consequences. Science teaching requires pertinent pedagogical content knowledge for planning and enacting new strategies, scepticism, controversy, complexity, multiple perspectives and inquiry. Eilks, Franz, Ralle and Hofstien (2023) noted some pedagogical consideration about teaching and learning about socio-scientific issues in chemistry classes, especially relevant for students in emerging countries; taking into account that teachers and students interact with local and general curricula, institutions, educative policies, available technology, community, society and culture. New curricula are available although in practice in many countries especially Structure of the discipline (SOD) curricula or traditional chemistry curricula are still predominant. The reasons for change is a growing awareness about the problems in traditional chemistry teaching as it relates to Science, Technology and Society. In other words, the curriculum change is by far one of the implications of STS issues in chemistry teaching and learning. One big part of this movement for curriculum change in chemistry education is Context-based (CB) chemistry education.

Allocating Chemistry Curriculum between Science and Society

ChemCom: One of the pioneering context-based chemistry programmes was chemistry in community (ChemCom) developed in the US in the 1980s (Schwartz, 2016). The curriculum aims at presenting chemistry along societal contexts on a "need to know" basis. Such contexts include air and water quality, the use of mineral resources, the production of various sources of energy, industrial chemistry or chemistry of food and nutrition. Chemcom developers' intentions were chemistry education for all with a focus on preparing informed future citizens. Therefore, ChemCom is mainly driven by its society-related contexts and is less explicit, focusing on problem-solving, learning chemistry by inquiry,



understanding the sub-microscopic nature of chemistry. An additional feature of ChemCom is to give the students numerous decision making exercises of various complexity to allow them practice applying chemical knowledge in the context of addressing societal issues.

Within ChemCom, every unit followed the same pattern:

- Introducing students to societal theme involving chemistry
- Leading students to realize that they need to understand chemistry in order to evaluate ways of addressing the issue in an informed way, and
- Learning the relevant chemistry, showing its connection to the issue and using chemistry knowledge in decision making activities related to the scientific/technological aspects of the issue.

The report regarding the effectiveness of the programme, related to the students and teachers, provided mixed findings. Regarding the teachers, Ware and Tinnesand (2015) reported that most teachers that were familiar with the course had strong feelings about it, some were very enthusiastic and others doubted the effectiveness of the approach. However, five editions were published up until 2015 and more than 2 million students from different backgrounds and with differing characteristics and school-types were involved in the programme. This might serve as an indication for the success of the course implementation.

Salters Advanced Chemistry: Also in the UK, a context-based course was developed at the University of York from the 1980s (Benett & Lubben, 2016). There were two main characteristics of the Salters Chemistry beyond ChemCom. One feature was the intensive involvement of chemistry teachers into the development, who provided many good ideas related to the pedagogical aspects of the course. This bottom-up approach proved to have the potential to enhance teachers' ownership related to the programme, a fact that had positive influence on the effectiveness of the implementation of the course in schools. Another initiative was a thorough focus on student-centred methods to enhance students' interest and motivation to learn chemistry. In Salters Chemistry the chemistry concepts are outlined to fulfil the whole range of a typical chemistry syllabus. But the outline is not used as the structure for the curriculum. All chemistry

content is developed through everyday life contexts such as: Chemistry of life or Minerals and medicine. Today, starting from the Salters experience, a new CB approach has been developed by the same institute under the headline 21st Century Science), which strongly connects the CB approach with more societal driven curricula (Millar, 2016).

Implications of STS Contemporary Issues for Teaching and Learning of Chemistry in Nigeria

Current issues in Science, Technology and Society have various implications with regards to teaching and learning of chemistry as follows:

- **Incorporation of Context-based Chemistry Programmes:** More consideration should be given to context-based curriculum such as ChemCom and Salters Advanced Chemistry. ChemCom is mainly driven by its society-related contexts and is less explicit, focusing on problem-solving, learning chemistry by inquiry, understanding the sub-microscopic nature of chemistry. An additional feature of ChemCom that makes it very relevant is that it gives the students numerous decision making exercises of various complexity to allow them practice applying chemical knowledge in the context of addressing societal issues. Again, the Salters Advanced Chemistry involves chemistry teachers into the development, who provided many good ideas related to the pedagogical aspects of the course. It also gives a thorough focus on student-centred methods to enhance students' interest and motivation to learn chemistry.
- **Infusion of Science, Technology and Society (STS) issues in chemistry curriculum at different levels of learning:** Studies such as Yager and Lutz (2015) noted that there is an increasing interest in the infusion of STS issues in science curriculum. They gave the following reasons for including social issues in school science courses: It justifies information included in science courses; It allows students to find science classes relevant to their daily lives; It enables teachers to evaluate students' success at application and synthesis of ideas; It redefines the teachers' role to "facilitator" and relegates the textbook status to information source; It may allow for increased scientific

understanding of the concepts based on cognitive theories of learning; It provides a vehicle for tying the whole. Therefore, even the more current issues on STS should be included in the curriculum. The infusion of STS issues in the curriculum starting from secondary level of education will enable the students to become acquainted with STS issues earlier and to think towards providing solution to the challenges of Science, Technology and Society (STS) and informing the community adequately.

- **Adequate Supply of Good Quality STS Chemistry Teachers:** There is absolute need for the supply of competent, well motivated and committed STS chemistry teachers at all levels of the education system. Education system cannot yield the desired results without competent and effective teachers who are well motivated by improved conditions of service (Njoku, Nzewi & Nnaka, 2018). A good STS curriculum will fail if the teachers implementing it are ineffective or uncommitted.
- **Adoption of Active Learning and Group-Learning Teaching Approaches in STS Chemistry Classrooms in Nigeria to enable learners develop the essential soft skills needed in the modern work environment:** The modern work environment demands not only the hard skills of mastering of the discipline well, it also demands that workers should have adaptive skills (soft skills) to enable them function effectively in a multicultural dynamic work environment where the skills needed to function effectively are in flux due to changing technologies and the uncertainties of interpersonal relationships. The science and technology teachers have to prepare learners to fit into this type of work environment by adopting pedagogies that enable the learners learn together, share knowledge and resources, evaluate their own learning by critiquing themselves. Such group-learning teaching strategies include though not limited to, collaborative learning, cooperative learning, problem-based learning, field trips, group

project, peer teaching etc. (Eunice, 2018). These teaching strategies give the science and technology students the opportunities to learn together, review and critique one another's ideas and support themselves in learning task. In this way learners achieve much more academically but very importantly, they develop adaptive skills by learning how to work together in harmony to solve problem, relate to one another, respect one another's views, communicate effectively as team or group members and contribute to the resolution of learning tasks (Obanya, 2016).

- **Educating students on the proper use of technology:** Educating students on the proper use of technology and on the other hand the consequences of misusing or abusing technology will create awareness among students and help them in dealing with student safety in this information age.

Summary

The world is changing faster than ever before. Nowadays a lot of things are happening that were never thought possible in the past. These changes are in all aspect of life, from science to technology and education. Science is concerned about general explanation of reality; technology is concerned about finding workable solutions to practical problems in the society. Science and technology relate as forms of knowledge and as forms of activities. As much as STS enable students to connect with the global community, Science, Technology and Society, an interdisciplinary field of study, is faced with many issues currently. The paper discussed the contemporary issues in science, technology and the society, both in education and wider social settings which include; gender gap, decline in enrollment, incompetent and poorly motivated teachers, abuse of technology, depletion of mineral resources, nuclear energy and the environment, climate change etc. The implications of these issues in Science, Technology and Society to teaching and learning of chemistry which is geared towards community development were also discussed.

Conclusion

In this paper, contemporary issues in science, technology and society were explored and from the literature reviewed some of these issues which were



categorized as educational issues include; Falling enrollment, Gender gap, abuse of technology by students especially cyber crime which is a pertinent issue currently. Humanity faces a number of existential and environmental challenges as it relates to science and technology and in this paper such STS issues were categorized as environmental and health issues, among them are; depletion of mineral resources, nuclear energy and environment, pollution, biodiversity loss and climate change. Because of the interdependencies between science, technology and the society, most of the challenges in STS require fundamental changes in attitude of individual citizens such as chemistry students. This could be achieved by incorporation of context-based chemistry programmes, infusion of current science, technology and society issues in the chemistry curriculum at different levels, employment of good quality STS teachers and educating students on the proper use of technology as well as the consequences of misusing technology, to foster community development.

Recommendations

- Current Science, Technology and Society (STS) issues should be integrated into chemistry curriculum, this will help students acquire awareness of STS issues, to nurture as well as develop students' attitude towards science and to provide students with learning experiences that will enable them to contribute to the community. Also context-based chemistry programmes should always be considered during curriculum development.
- The relationship between science, technology and society and related issues should be taken into account as the cornerstone in the chemistry curriculum development process according to STS approach. This will promote the development of a scientifically and technologically literate citizenry capable of understanding STS issues, empowered to make informed and responsible decisions and able to act upon those decisions.
- Quality and highly motivated STS chemistry teachers should be employed at the required levels of education.
- Innovative teaching strategies such as problem-based learning, educational visits, cooperative learning and project method should be adopted by STS chemistry teachers in secondary school level as well as maintained at the tertiary level of education.
- Mineral resources assessment practices should be provided to ensure that the future research has sound basis and practitioners (students) can incorporate the appropriate tools in their work.
- Students should be educated on the proper use of technology to avoid cyber crime and should minimize the use of social media in order to enable them focus on important issues.
- Decentralization of water supply and wastewater treatment systems is important for greater flexibility and increased participation by system users.

References

- Agogo, P. O & Onda, M.O. (2014). Identification of students' perceived difficult concepts in senior secondary school chemistry in Oju Local Government Area of Benue State, Nigeria. *An unpublished project*, Benue State University, Makurdi.
- Agu (2017). AGU Scientific Integrity and Professional Ethic. AGU-American Geophysical Union, <https://ethics.agu.org/files>.
- Alan, J. R. (2019). *Chemistry / definition*. Lagos: T-Excel Publishers.
- Allum, N., Sturgis, P., Tabourazi, D. & Brunton-Smith, I. (2008). Science knowledge and attitudes across cultures: A meta-analysis. *Public Understanding of Science*, 17(1), 35–54.
- Bijker W. (2021). Understanding technological culture through a constructivist view of science, technology and society. Albany: State University of New York Press.
- Brooks, H. (1994). The relationship between science and technology. *Research Policy*, 23, 477–486.
- Bybee, R & Mau, K. (2016). *Science-Technology-Society*. Washington: National Science Teacher's Association.
- Dow, K., Berk, F., Preston, B., Klein, R. T., Midley, G & Shaw, R. (2013). Commentary: Limit to adaptation; Nature climate change. Vol.3, pp



- 305-307.
- Goel, K. (2020). Local communities' perceptions about the impact of protected areas on livelihoods and community development. *Global Ecology and Conservation*, 22, 9-19.
- Harms, A. B. & Yager, R. E. (2023). Science-Technology-Society as reform. *School Science and Mathematics*, 93 (3), 145-151.
- Herbert, K. G., Hill, E., Fails, J. A., Ajala, J. O., Boniface, R. T., & Cushman, P. W. (2014). Scientific data infrastructure for sustainability science mobile applications. *IEEE International Congress on Big Data*. pp. 804–805.
- Islam, S. & Rapella, A.C.(2015). Water diplomacy: A negotiated approach to manage complex water problems. *Journal of Contemporary Water Research & Education*. 155, 1-10.
- Kline, R. (2015). *Construing "technology" as "applied science": Public rhetoric of scientists and engineers*. United States: Universal.
- Martin, J. L., Maris, V., & Simberloff, D. S. (2016). The need to respect nature and its limits challenges society and conservation science. *Proceedings of the National Academy of Sciences*, 113, 6105–6112.
- Parker, Acland, Armstrong, Bellingham & Sutherland (2014). Identifying the science and technology dimensions of emerging public policy issues through horizon scanning. *Research Policy*, 9, 80-94.
- Rodriguez-Espinosa, J. M. (2005). The importance of scientific literacy in our society. *Proceedings of Astrophysics, and how to attract young people into Physics, a workshop of the JENAM 2005, "Distant Worlds", held in Liège. 4-7. Belgium*.
- Sadler, T. D. (2014). Informal reasoning regarding socio scientific issues: A critical review of research. *Journal of Research in Science Teaching*, 41, 513-526.
- Underdal, A. (2010). Complexity and challenges of long-term environmental governance. *Global Environmental Change*, 20, 386–393.
- United Nations World Water Assessment Programme (2015). *Water for Sustainable World*. Paris: UNESCO.
- Yager, R. (2017). *Science, Technology and Society as Reform in Science Education*. New York: University of New York Press.