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Gender and Scientific Literacy Levels: Implications for Sustainable Science and Technology Education (STE) for the 21st Century Jobs.

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Abstract
Thriving in the 21st century knowledge-intensive, technology-driven economy requires that students be equipped with the pre-requisite life skills such as those of critical thinking, cognition, information technology, problem solving and entrepreneurship. These skills are also attributes of scientific literacy. Attainment of scientific literacy at reasonable levels is therefore important. In line with the 21st century global demands, existing Science and Technology Education (STE) curricula in Nigeria were reviewed and restructured. The Basic Science Curricula at the primary and junior secondary school levels are examples of such curricula. These emphasize adequate acquisition of scientific literacy as their primary objective. The significance of scientific literacy therefore demands that their levels of attainment among pupils exposed to such Basic Science Curricula be investigated. In the present study, extent of attainment of scientific literacy at its various levels by male and female Basic Science students was investigated, using an instrument - Test of Scientific Literacy Levels (TOSL) - on students from four schools randomly selected from co-educational schools in Abia State of Nigeria. Results indicated very low performance in the attainment of aggregate scientific literacy attributes as well as in the four various scientific literacy levels. However, male students significantly performed better than their female counterparts. These findings imply that the competencies needed for thriving in the 21st century competitive global market and which are also attributes of scientific literacy and entrepreneurship development are not being adequately acquired. Inquiry oriented/problem solving - interactive pedagogical approaches that will enhance scientific literacy attainment by youths should be implemented.
Keywords: Literacy, gender, Science education

1. Introduction

Science and Technology have become the mediating culture in the global community affecting all facets of life-socially, economically morally and politically. Effective science and Technology Education (STE) has become an instrument par excellence for the development of citizens to their full potentials in keeping up with global economic challenges and demands. Thriving in 21st century knowledge-intensive, technologically-driven economy, also characterized by rapid changes and diversity requires students to be equipped not only with technical knowledge of various subjects but more importantly with certain competencies or real life skills. Skills acquisition, which is the central issue in STE, gives it the sustainable development enhancement characteristics. These skills that can be acquired using effective STE and which are attributes of scientific literacy include those of communicating, creativity, critical and reflective thinking, taking responsibility, decision making, problem solving, cognitive and entrepreneurial skills. These skills enable human beings to survive, develop their full capacities, live and work in dignity, improve the quality of their lives and environment, participate fully in their community development, and make informed decisions concerning their present and future. Thus education in science and technology that responds to the 21st century global perspectives which must have the acquisition of scientific literacy as its central theme, becomes imperative and has made every nation in the world crave for its advancement. This need for advancement of science and technology that responds to global perspectives has led to the adoption of scientific literacy as a contemporary goal of STE all over the world. Scientific literacy has been defined as the knowledge, understanding and application of scientific concepts, and processes (which include skill acquisition and development of desirable attitude) for personal decision making as well as participating in civic and cultural affairs and economic productivity (National Education Standards, 2005).

According to the Biological Science Curriculum Studies (BSCS, 1993) the pursuit of scientific literacy is a continuous life-long process. Individuals in a changing society should keep learning to learn in order to attain a reasonable scientific literacy levels. This becomes necessary since it is more appropriate to recognize that each individual occupies a position somewhere along a continuum of scientific literacy for different scientific concepts. Accordingly the task of science educators is to move all students to different positions that imply richer understanding and application of science. BSCS (1993) describes four levels of scientific literacy used in this study, namely nominal, functional, structural and multidimensional scientific literacy levels. Shamos (1995) identified three levels of scientific literacy which are cultural, functional and true scientific literacy levels. In this study the acquisition of the literacy levels according to BSCS 1993 will be investigated. At the Nominal scientific literacy levels; students recognize the domain of science and certain words as belonging to the realm of science as opposed to other disciplines such as art or political science. Most students come to class scientifically

literate in "name only" without meaning or importance (cf cultural scientific level of Shamos 1995). At the Functional scientific literacy level, students are able to define certain scientific and technological terms but have limited understanding of or personal experience with them. Students at this level lack interest, enthusiasm and knowledge of scientific investigation.

At the Structural scientific literacy level, the student is able to understand the subject well enough to explain it to another person in his or her own words. The students at this level also appreciate the significance of science and are able to apply information about the subject to novel situation. Thus this level forms the foundation on which understanding of other related scientific concepts is based. At the Multidimensional Literacy level, students (i) recognize personal deficiencies in knowledge or skills through scientific investigations; (ii) apply knowledge, skill and attitude to understand related concepts and solve problems or answer questions (cf True scientific literacy level of Shamos 1995). This level reinforces life- long learning in which individuals continue to apply the knowledge, skills and attitude to learning all through their lives – a condition that enhances thriving in a changing world. The purpose of scientific and technological literacy is for all students not just those individuals destined for careers in science and technology related courses and this is irrespective of their age, nationality, religion and gender. The development of a reasonable level of scientific literacy among all students is a vital tool for economic, social, political and environmental development, and therefore a pre-requisite for sustainable development. Sustainable development which is the development that meets the needs of the present generation without compromising the ability of the future generation to meet their needs cannot be actualized without sustainable science education that is anchored on scientific literacy acquisition. This demands that the appropriate outcome of education is for all students-males and females-to become scientifically literate to a reasonable and functional extent.

Science for all as an appropriate goal of science for the 21st century has led to reviewing and restructuring of science and technology curricula all over the world including Nigeria. Following Nigeria's endorsement of international protocols for Education for All and the Millennium Development Goals (MDGs), and their subsequent translation and adoption as National Economic Empowerment and Development Strategies (NEEDS) goals, it became imperative to update existing curricula of the nation to cater for dynamic global changes and the consequent contemporary needs of the nation as a country aspiring to be among the first twenty economies of the world by the year 2020 (Nigeria's Vision 20: 2020). In the Basic Science curriculum, the contemporary global development called for the infusion of relevant contents bordering mainly on human and environmental sustainability. In the upper Basic (i.e. the last three years/Junior Secondary School level), the theme "Science and Development was also added to expose all students (males and females) to development in science and technology alongside skills that will enable them face challenges, make informed decisions, develop survival strategies and learn to live effectively within the diverse global community of the 21st century. Thus the need to investigate the extent of attainment of the required scientific literacy levels by male and female students exposed to the re-structured 9-year Basic Science Curriculum. Studies in science and technology have indicated gender disparities in achievement and science process skill acquisition, in favor of males (Nwagbo 2006, Adaji, 2006). However Nwosu (1991 and 2001), Ibe (2006 and 2013), found that females can also acquire science process skills as much as males if exposed to inquiry based instructional methods. These researchers observed that gender disparity in performance in science does not indicate lower intellectual capacities of females, but rather, the effects of gender stereotyping by the society (home, schools, industries etc). Efforts should therefore be made to break gender barriers in STE.

1.1 Statement of the problem

Massive and Rapid changes have taken place all over the world altering the characteristics of societies in terms of demography, life style, values, culture, family structures, social institutions, economy, patterns of life as well as the nature and ethos of science. The totality of these changes and their interactions therefore calls for a new image of science and technology education to reflect to contemporary global changes and diversity of the 21st century. Thus the development of a reasonable level of scientific literacy among students becomes necessary as a vital tool to economic, social and political development in any country. Since "science for all" involves equity it becomes necessary that both males and females especially in developing nations like Nigeria, acquire scientific literacy attributes at reasonable levels as the 21st century needed skills, that will enable them cope with the knowledge intensive, information and communication technology driven world. This study therefore aims at finding out the levels of acquisition of this needed scientific literacy by Nigerian youths exposed to the current reviewed Basic Science Curriculum that has been infused with global issues.

1.2 Purpose of the study

The Study aimed at investigating the:

(i) Aggregate Scientific literacy of Upper Basic Science II students as tested by Test of scientific literacy (TOSL) items

(ii) Scientific literacy levels of Upper Basic Science II students as tested by TOSL for the various scientific literacy levels.

(iii) Scientific literacy by males and females of Upper Basic Science II for the various scientific levels as measured by TOSL.

1.3 Research Questions and Hypotheses

Three research questions were formulated and one hypothesis tested at .05 level of significance to guide the study.

1.4 Research Questions

(1) What is the aggregate scientific literacy possessed by Upper Basic Science II students

(2) What are the mean scores of Upper Basic Science II students for the various scientific literacy levels?

(3) What are the mean scores as measured by Test of Scientific literacy (TOSL) for male and female Upper Basic Science II students on the various scientific levels.

1.5 Hypotheses

Ho1 There is no significant difference in the mean scores of males and females as measured by Test of scientific literacy.

2. Methodology

2.1 Research Design and Area of Study

The survey research design was used in the study. The study was conducted in Ohafia Local Government Area of Abia State, Nigeria.

2.2 Sample and Sampling Technique

A sample of one hundred and sixty two (162) Upper Basic Science II students participated in the study. Four coeducational junior secondary schools were randomly selected from twenty three (23) coeducational schools in Ohafia local government Area of Abia State. An intact class was randomly selected from each of the four schools.

2.3 Instrument for data collection

The instrument used in data collection was researchers' developed test of scientific literacy (TOSL) made up of forty (40) test items. In the development of the research instrument, the characteristics of each scientific literacy levels as outlined by Biological Science Curriculum Study (BSCS, 1993) were carefully followed and considered and items were constructed measuring the levels of acquisition of scientific literacy at its various levels by students.

Part I was a practical section that demanded students activity and ability to communicate scientific ideas generated through problem solving while part 2 was made up of multiple choice objective questions. All questions were scored over one hundred points. The distribution of the marks according to scientific literacy levels were as follows:

Nominal = 23%
Functional = 23%
Structural literacy level = 27%
Multidimensional literacy level = 27%

Criterion Mean: Table 1 shows the means and their percentages for the various Scientific Literacy levels. The Nominal and Functional levels were each scored out of 23 points while the structural and multidimensional levels were each scored out of 27 points.

Percentage levels	Decision Rule for Mean Scores (Nominal and Functional Scientific Literacy Levels)	Decision Rule for Mean Scores (Structural and Multidimensional Scientific Literacy Levels)
0-39 (Fail)	Below 9.2	Below 10.8
40 – 49 (Fair)	9.2 – 11.4	10.8 – 13.4
50 – 59 (Pass)	11.5 – 13.7	13.5 – 17.5
60 – 69 (Good)	13.8 – 16.0	17.6 – 18.8
70 – 100 (Very Good)	16.1 – 23.0	18.9 – 27.05

Acceptable Pass Means (i) 11.5 and above for Nominal and Functional levels and (ii) 13.5 and above for structural and Multidimensional levels.

2.4 Analysis of Data

The three research questions were answered using mean and standard deviation scores of students while the hypothesis was tested at .05 level of confidence. Results are presented in tables 2 and 3 according to research questions and hypothesis.

3. Results and Discussion

Table 2: Mean scores of students on acquisition of scientific literacy by levels and by gender.

Gender of Respondents		Nominal	Functional	Structural	Multidimensional	Total
Males	**Mean**	9.0909	8.6364	6.7045	6.5227	31.0568
	N	88	88	88	88	88
	Std. deviation	2.25723	2.09093	1.78859	1.69500	5.52186
Females	**Mean**	8.0946	7.2703	5.6486	5.6486	23.2838
	N	74	74	74	74	74
	Std. Deviation	2.06848	1.95355	1.55654	1.47521	7.22348
Total		8.6358	8.0123	6.2222	6.1235	27.5062
		162	162	162	162	162
		2.22285	2.13515	1.76227	1.65227	7.43105

Table 3: t-Test for Equality of Means on Scientific Literacy Levels

	T	Df	Sig. (2-tailed)
Nominal	2.907	160	.004
Function	4.268	160	.000
Structural	3.969	160	.000
Multidimensional	3.467	160	.001
Total	7.755	160	.000

Table 2 shows that the aggregate mean score for all the scientific literacy levels acquired by all students is far below the average (27.5)which is less than 50.0 (average). The students performed poorly at all the levels of scientific literacy (performing below the average scores as shown on Table I). The highest score was obtained for nominal scientific literacy level (8.63) followed by functional (8.01), then structural (6.72), and then the lowest score for multi dimensional (6.12). These mean scores are far below the acceptable mean of 11.5 for the nominal and functional levels and 13.5 for structural and multidimensional levels.

Results on tables 2 also show that boys performed better than girls at all the levels of scientific literacy. However, both boys and girls performed poorly on the acquisition of scientific literacy test since the scores are far below the acceptable average mean scores. These findings support those of Nwagbo (2006) who reported low scientific literacy acquisition (but not at the various levels) by biology students.

Table 3 shows that males performed significantly better than females at all the scientific literacy levels. The t value for all scores are higher than the critical values of .004, 0.000 and .001 for nominal, functional, structural and multidimensional levels respectively.

These findings also agree with the observation of BSCS (1993) that most students come to school operating at the nominal level in which they are scientifically literate in name only but cannot provide valid explanations of science concepts and natural phenomena.

The finding of very low scores in the levels of acquisition of scientific literacy at all the literacy levels is very disheartening. Although Nwagbo (2006) did not investigate acquisition of scientific literacy at the various levels, she reported that student's unhealthy attitudes towards science and poor teaching methods must have contributed to poor performance of students on scientific literacy related tasks.

The finding of this study also suggests poor implementation of the Basic Science Curriculum newly reconstructed by NERDC (2007). Ajibola (2008) has reported poor implementation of laudable objectives in Nigeria due to some teacher, student, institutional and governmental factors. This may be the case as regards the Upper Basic Science Curriculum implementation.

Implications of Findings on Gender and Acquisition of Scientific Literacy at the Various Levels for Science and Technology Education (STE) for the 21st Century.

The results of this study indicate very low levels of acquisition of scientific literacy attributes at the four levels (nominal, functional, structural and multidimensional) by both males and females and that the males performed significantly better than the females at the four levels of scientific literacy. These results have implications on science and technology education for the 21st century

The 21st century has been described as knowledge-intensive and technologically driven era. The globalization process fuelled by new technologies has generated transcontinental and inter-regional flows and networks of activity, as well as social, political and economic interactions. These linkages in trades and other international

systems demand that youths be equipped with the needed competencies/skills to cope with the 21st century dynamic demands and challenges. These are skills that will help increase graduates marketability, employability, and effectiveness and efficiency at work and readiness for citizenship as well as adapting and thriving in the dynamics of the global economy (Adikwu 2008). Such skills are: Cognitive academic/technical skills (processing skills in language, science, technology etc as well as the ability to use these tools purposely and interactively; Problem solving skills (capacity to observe, analyze, think critically, question, challenge, suggest creative solutions, identify parts of a problem and innovate; Social/interpersonal skills (ability to interact, and communicate, relate well with others, work in team both as a leader and a member, negotiate, manage, and resolve conflicts etc and develop social/professional networks; Work ethics (Demonstrating commitment, interest, enthusiasm, motivation, responsibility at work, flexibility and adaptability, risk taking, global setting, initiative and entrepreneurship); Autonomy (motivation to learn, learning independently, concern with one's own development, self knowledge of one's capacities, self confidence, ability to form and conduct life plans and personal projects, and to defend and assert one's rights ,interests, limits and needs.

These life skills/core competencies which are largely acquired through effective science and technology education are indices or attributes of scientific literacy, especially at the structural and multidimensional levels.

Low level acquisition of scientific literacy therefore implies inadequate acquisition of these required skills by Nigerian youths, a situation which if not properly attended to may result to inability for adapting and thriving in the 21st century dynamic global economy. This issue thus needs to be squarely addresses by research and education in Science and Technology.

Again, these identified life skills will not only help students to find out, understand and use the scientific knowledge and technology of today, but also to find out, understand and use the scientific knowledge and technology of tomorrow. This sustainability attributes or characteristics of such life skills make their acquisition even more imperative. In developing countries like Nigeria, where curricula have been reviewed and restructured to accommodate the 21st century themes such as global environmental awareness; financial, ICT, economic, business and entrepreneurial literacy; civic literacy; health literacy (21st century skills.org, 2011), low level acquisition of scientific literacy implies inadequate or non-implementation of the curricula objectives. There is need for more emphasis on pedagogical approaches that are inquiry oriented/problem solving and interactive in Nigerian schools in practice and not just in theory. Teaching style should emphasize acquisition of entrepreneurial and problem solving skills needed for life. Hence, teaching styles should shift from those equipping our youths with the technical knowledge in their areas of specialization to those ensuring acquisition of the necessary core competencies/life skills. STE content should be multifaceted to ensure multiple learning and learning experiences that are rich. Also, contextualization of STE content should be pursued since concepts are difficult to learn because the entire context of STE as it is used in daily practice by men and women from different segments of the society is missing from conventional STE. There is also need to emphasize intensive use of ICT. ICT has the potential to enhance educational quality and acquisition of scientific literacy by increasing motivation, promoting enquiry and exploration and preparing individuals for the technology driven world. There must therefore be a drastic shift from the status quo to a more intensive use of ICT in schools. Also, the quality of teachers teaching in Nigerian schools must be improved and this must therefore be reflected in teacher preparation.

Lecturers can collaborate with other faculty members and other members of other faculties (especially social sciences, engineering, physical sciences, etc), students, administrators to identify the problems inhibiting sustainable STE for acquisition of life skills/scientific literacy. Grants from universities can be used to an extent instead of waiting for the government to solve these problems. Such problems will include professional development especially for teachers of the Teacher Education Institutions so that prospective teachers will be well equipped for developing the 21st century needed competencies/literacy in the students

Conclusion

In order to achieve scientific literacy in Nigeria where educational standards though emphasized are not implemented, standard based teacher education, contextualization of STE and authentic assessment for enhancing acquisition of scientific literacy/skills of adaptability and thriving in the 21st century knowledge-intensive economy are some of the issues to be vigorously pursued.

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