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Assessing the Level of Scientific Literacy Ability of Fresh Science Education Students in Tertiary Institutions in South-South Nigeria

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Abstract: The changing and demanding nature of the world around us requires man to advance his knowledge and skills for him to be able to cope with the changes and demands. This survey study therefore assesses the level of scientific literacy (SL) ability of year one science education students in tertiary institutions in South- South Nigeria using a scientific literacy test (SLT) developed by the researchers based on three competencies (explaining phenomena scientifically, designing and evaluating science investigations, and interpreting data and evidence scientifically). The instrument was administered on a sample of 2,025 students in the 2022/2023 session from selected institutions. Results showed that majority of the students have low ability to design and evaluate investigations, and low ability to interpret data and evidence. However, a good proportion of them show high ability in explaining phenomena and high ability in the overall SL. The results implicitly revealed integrated science (ITS) education students to be better in all the three competencies and the overall SL than their colleagues in biology, chemistry and physics education. It was recommended that science teachers, students and government should play their roles to ensure meaningful science teaching and learning in schools as to help the students gain higher scientific literacy.

Keywords: Scientific literacy, Science, education, students.

INTRODUCTION

Globally science education is recognized as the tool that transforms the individual as well as the society. It provides man with skills necessary for him to function and be relevant in any environment he finds himself. The increasing importance of science has made every nation to introduce science subjects into the school curriculum and is compulsorily learnt by the citizens either at the primary, secondary or tertiary level of education.

Science is a way of knowing and its learning helps man gain knowledge about the nature, interactions and uses of things in the universe. The learning of science encourages the development of scientific skills such as critical and logical thinking, problem-solving skill, intrapersonal and interpersonal skills that are crucial for man to develop their full potential, survive, work and improve himself and the environment. These skills and abilities are needed by science students especially the would-be science teachers to equip them in science teaching to promote science learning. DeBoer's (2000) comprehensive analysis of the historical development of science education revealed the existence of a minimum of nine discrete objectives associated with science education, all of which are intricately linked to the overarching objective of fostering scientific literacy.

In the comity of scientists, scientific literacy has come to be an important global discourse in relation to the aims and relevance of science education (McGregor &Kearton, 2010). For, according to Osborne (2007) the primary goal of any science education should be to develop scientific literacy. Gyllenpalm et al. (2010) highlighted scientific literacy as a general goal of

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science education, stressing that students need to develop in scientific knowledge and understanding about scientific concepts and skills.

The concept of scientific literacy lacks a universally agreed-upon definition (Millar, 2008; Osborne, 2007). Instead, multiple definitions exist, influenced by various perspectives and interpretations (Fensham, 2004; Kolstø, 2001). However, all these definitions emphasise the importance of students' capacity to apply scientific knowledge in addressing real-world issues that are relevant to their daily lives (DeBoer, 2000; Ajayi, 2018). Scientific literacy, as defined by the Programme for International Student Assessment (PISA), refers to the ability to utilise scientific knowledge to discern inquiries and formulate evidence-based inferences, thereby comprehending and facilitating decision-making regarding the natural environment and the modifications induced by human actions (Organisation for Economic Co-operation and Development, 2013). Science literacy necessitates individuals to possess knowledge and comprehension of scientific principles, procedures, and applications, enabling them to effectively employ scientific methods to address human, environmental, and social challenges encountered in daily existence.

However, Norris and Phillips (2003) have posited that scientific literacy encompasses various components, namely: (i) a comprehensive understanding of the fundamental concepts and principles of science, and the ability to differentiate them from non-scientific information, (ii) a comprehension of the relevance and significance of science, (iii) knowledge of the characteristics and criteria that define scientific inquiry, (iv) the freedom to engage in the process of learning about science, (v) the capacity to think in a scientific manner, (vi) the ability to apply scientific knowledge to solve problems, (vii) the acquisition of knowledge necessary for informed participation in science-related matters, (viii) an understanding of the nature of science and its interaction with culture, (ix) an appreciation for and comfort with science, including its capacity to inspire wonder and curiosity, (x) the capability to comprehend the risks and benefits associated with scientific advancements, and (xi) the aptitude to critically analyse scientific information and effectively engage with scientific expertise.

To Simpson and Anderson (1981:96), one is said to be scientifically literate if he/she;

- Demonstrates proficiency in comprehending and applying fundamental concepts, principles, laws, and theories of science in appropriate contexts.
- Exhibits a comprehensive understanding of the nature of science and the scientific enterprise.
- Utilises scientific processes effectively for problem-solving, decision-making, and other applicable purposes.
- Recognises the interdependence between science, technology, and society, and comprehends their reciprocal interactions.
- Possesses a well-developed set of science-related skills that facilitate successful engagement in various careers, leisure activities, and other roles.
- Exhibits attitudes and values that align with those upheld by the scientific community and a society that values freedom.
- Cultivates interests that contribute to personal fulfilment, enhanced quality of life, and a lifelong commitment to science and continuous learning.

A scientifically literate person can survive in the face of fast-paced social life with changes in lifestyle. Scientific literacy is connected to several competencies, having knowledge and understanding, and the capacity to co-opt scientific values (Sengdala &Yuenyong, 2021). Scientific literacy is a major goal of science education. This central goal for teaching science at schools can only be achieved when the schools (through the teachers) develop and promote in learners the understanding of the following values which underlie science and to a large extent

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are still relevant today. These are:

- Longing to know and to understand
- Questioning of all things (be suspicious of certainty)
- Search for data and their meaning
- Demand for verification in an active and continuing way of what he/she knows
- Respect for logical reasoning
- Consideration of premises i.e. be aware of biases and premises influencing decisions,
- Consideration of consequences of any action (EPC, 1966:11-13).

Fitria et al. (2022) study on Students' literacy competence in science learning in Junior High Schools based on the reading to learn model reported improvement in scientific literacy of the students on comparing the scores obtained before and after learning with the HOTS literacy-based reading to learn learning method.

According to Ratcliffe and Millar (2009), the findings from the pilot trials of the Twenty First Century Science courses indicated several key observations. Firstly, there was a noticeable improvement in students' understanding throughout the duration of the course, across various contexts. Secondly, students exhibited relatively weaker performance when it came to generating explanations in both familiar and unfamiliar contexts. Lastly, students' responses to questions pertaining to scientific concepts were significantly superior to those of the comparison group, particularly in comparison to questions related to data and its limitations. There was no significant difference observed in the overall performance of the students enrolled in the Twenty First Century Science programme, in terms of their ability to comprehend fundamental scientific concepts and processes, as well as their aptitude in utilising scientific ideas to construct explanations, when compared to the control group.

In a comparative study conducted by Noor (2021), the scientific literacy of secondary school students in Suburban Schools in England was examined and compared to that of Malaysian students. The findings revealed that English students demonstrated a higher level of scientific literacy in comparison to their Malaysian counterparts across three key competencies: explaining phenomena, designing and evaluating investigations, and interpreting data and evidence. The analysis conducted by Murti and Aminah (2018) examined the science literacy of high school students using the nature of science literacy test (NOSLiT). The findings revealed that students in Class X of Science 4 achieved an average science literacy score of 57.14%.

Studies have demonstrated that low scientific literacy of students is as a result of the teacher deficiency in teaching science creatively; not using the necessary materials and process of science to bring about teaching learning makes students not to understand but to memorize a concept (Yuliati, 2017 in Fitria, 2022). Students' SL such as logical thinking skills have not been increased is probably due to the kind of learning process the learner is exposed to. Learning process that limits the learners to theories do not provide the learner with problem-solving skills and so making the learner to experience difficulties thinking logically when presented with real life problems (Amini & Sinaga, 2021). Again, some teach students to pass with high grade rather than helping them to see the importance of science learning in equipping them with skills and competencies to be able to face problems in everyday life (Laslo & Baram-Tsabari, 2021). For example, a teacher that has the ability to think logically can teach and ask his students questions that evoke logical thinking.

Based on the importance of scientific literacy (SL) coupled with the paucity of studies on the level of SL of fresh university science education students, this study assumes that students entering university to study science education, having gone through science learning in secondary schools must have a good knowledge and application of science in solving man' problem and that of the society. Hence this study examines the level of scientific literacy among year one science education students in tertiary institutions.

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Research Questions

1. What is the level of students' ability to explain phenomena scientifically?
2. Will the level of students' ability to design and evaluates science investigations be high or low?
3. What is the level of students' ability to interpret data and evidence scientifically?
4. Will the students have high level of scientific literacy?

THE RESEARCH METHOD

The research design utilised in this study was descriptive in nature. The study employed a combination of quantitative and qualitative methodologies to gather data (McCombes, 2019).

Subjects

The subjects consisted of 2,025 fresh (year 1) science education students in the 2022/2023 academic session, specifically, those studying education combined with either, biology (BIO), chemistry (CHE), Integrated science (ITS), and physics (PHY) in selected tertiary schools in South-South, Nigeria.

Instrument

The instrument used to gather data was scientific literacy test (SLT) developed by the researchers based on the three science literacy competencies advocated by OECD (2013), which include explaining phenomena scientifically, designing and evaluating science investigations, and interpreting data and evidence scientifically. SLT consisted of 40 multiple choice objective questions and 20 essay questions covering selected topics in basic biology, chemistry and physics. The test was subjected to content, construct and face validity. Its reliability value was 0.784.

Before engaging the subjects in the study, consent was obtained from the Dean of faculty, Head of Departments as well as the subjects. Afterward, the subjects were given the SLT to respond to. In some of the institutions, the instrument was administered by research assistants.

Data analysis

Responses from the subjects were scored (For the multiple choice, correct option =1mark, wrong option = 0, and Essay = 3marks each), and then analysed using percentage.

RESULTS AND DISCUSSION

Results

Table 1 shows science education students' ability to explain phenomena scientifically. It shows that while 22.57% of the total respondents have low ability, 77.43% of them possessed high ability to scientifically explain phenomena. The table also indicated that the average score for the students was 71.11%. On the percentage responses classified by course of study, the table indicates that while low level of students' ability to explain phenomena decreases in the order: PHY (34.16%) > CHE (25.31%) BIO(21.95%) > ITS (12.50%), the high ability followed the sequence: ITS (87.50%) >BIO (78.05%)> CHE (74.69%) >PHY(65.84%).

Table 1: Levels of students' ability to explain phenomena scientifically

SCORE (%)	TOTAL RESPONDENTS	RESPONDENTS BY COURSE OF STUDY				LEVELS OF ABILTY
		BIO	**CHEM**	**ITS**	**PHY**	
0- 49	457 (22.57%)	178 (21.95%)	165 (25.31%)	45 (12.50%)	69 (34.16%)	Low
50- Above	1568 (77.43%)	633 (78.05%)	487 (74.69%)	315 (87.50%)	133 (65.84%)	High

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Total	2025 (100%)	811 (100 %)	652 (100%)	360 (100%)	202 (100%)	
AVERAGE SCORE = 71.11%						**High**

Table 2 shows that 69.68% of the total respondents have low ability level while 30.32% show high ability level indicating that majority (above 69 %) of the science education students cannot design and evaluate investigations scientifically. But on the average, the table showed that the students had 24.85 % as their average score

The table also shows that, by course of study, the proportion of students with low level ability to design and evaluate science investigations is in the order: BIO (76.33%) PHY (74.75%) > CHE (72.09%) > ITS (47.50%), while that of high level ability is in the order: ITS (52.50%) > CHE (27.917%) >PHY(22.67%) >BIO((23.67%).

Table 2: Levels of students' ability to design and evaluate science investigations

SCORE (%)	TOTAL RESPONDENTS	RESPONDENTS BY COURSE OF STUDY				LEVEL OF ABILITY
		BIO	**CHE**	**ITS**	**PHY**	
0-49	1411 (69.68%)	619 (76.33%)	470 (72.09%)	171 (47.50%)	151 (74.75%)	Low
50-Above	614 (30.32%)	192 (23.67%)	182 (27.91%)	189 (52.50%)	51 (22.25%)	High
Total	2025 (100%)	811 (100 %)	652 (100%)	360 (100%)	202 (100%)	
AVERAGE SCORE = 24.85%						Low

Table 3 shows science students' ability to give interpretations to data and evidence scientifically (IDES). It shows that 72.94% of the respondents are low in the acquisition of the ability to scientifically give interpretations to data and evidence as 27.06% show high ability to interpret data. Data in the table also indicated that the average score for science education students was 49.93 %. On the percentage responses classified by course of study, the table indicates that while low level of students' ability to IDES decreases in the order: BIO (84.33%) > CHE (81.29%)> PHY(43.57%)>ITS (40.61%) the high ability to IDES follow the sequence: ITS(59.39%)> PHY (57.43%) > CHE (18.71%) >BIO (36.62%) .

Table 3: Levels of students' ability to interpret data and evidence scientifically

SCORE (%)	TOTAL RESPONDENTS	RESPONDENTS BY COURSE OF STUDY				LEVEL OF ABILITY
		BIO	**CHE**	**ITS**	**PHY**	
0-49	1477 (72.94%)	688 (84.33%)	530 (81.29%)	173 (40.61%)	86 (43.57%)	Low
50-Above	548 (27.06%)	123 (15.17%)	122 (18.71%)	187 (59.39%)	116 (57.43%)	High
Total	2025 (100%)	811 (100 %)	652 (100%)	360 (100%)	202 (100%)	
AVERAGE SCORE = 48.93 %						Low

Table 4 presents the levels of fresh science education students' scientific literacy (SL). From the table, 44.84% and 55.16% of the entire sample respectively have low and high level of scientific literacy. The table also shows that the average score for the students was 56.75% on the average.

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However, considering literacy of the respondents by course of study, the table revealed that, while the percentage of students with low ability level of SL follows the order: PHY(50.99%) > BIO (48.09%) > CHE(44.32%) >ITS(35.0%), the high level SL is in the order: ITS (65.0%) > CHE (55.67%) > BIO(51.91%)> PHY(49.01%). This implies that above half of the science education students are scientifically literate with the exception of their counterparts in physics education. However, integrated science education students are more scientifically literate than their colleagues in chemistry, physics and biology education.

Table 4: Level of scientific literacy of science education students

SCORE (%)	TOTAL RESPONDENTS	RESPONDENTS BY COURSE OF STUDY				LEVELS OF SL
		BIO	**CHEM**	**ITS**	**PHY**	
0- 49	908 (44.84%)	390 (48.09%)	289 (44.32%)	126 (35.0%)	103 (50.99%)	Low
50- Above	1117 (55.16%)	421 (51.91%)	363 (55.67%)	234 (65.0%)	99 (49.01%)	High
Total	2025	811 (100 %)	652 (100%)	360 (100%)	202 (100%)	
AVERAGE SCORE= 56.75%						High

Discussion

Three scientific literacy competences of fresh science education students are examined in this present study following the three scientific competencies which include competence to explain phenomena scientifically; evaluating data and designing scientific investigations; and interpret data and scientific evidence. Findings expose that, while fresh science education students' scientific literacy skills for explaining phenomena are high, the other competencies are somewhat low. Majority of the students have problems interpreting data and evidence, as well as designing and evaluating investigations. However, on the general scientific literacy as shown in table 4, the students, with the exception of students in physics education demonstrated high SL. Again integrated science education students indicated high level acquisition of SL.

Contrary to Sutrisna and Anhar (2020) that notice low average competence of students to explain phenomena, the present study observed high ability of students to explain phenomena scientifically which is in support of the results obtained by Noor (2021) and Henukh et al. (2021). They found that students possessed good scientific literacy. This finding can be connected to the fact that the students learnt in relation to the materials being taught and with the scientific phenomena (observable natural events occurring in the universe). Science which primarily connotes the study of nature and the universe offers man the ability to understand the world around him and hence the natural occurrences and be able to explain or predict such occurrences using the knowledge gained from science. This finding revealed that the students understood the environment around them and the materials learnt in their various science subjects/courses especially at the secondary school level which make them to be competent in providing a more detailed explanation in their own words about a concept.

Result on the ability to design and evaluate investigations disagrees with that of Henukh et al.'s (2021) study that found the average score obtained by students to be 65%, but agrees with that reported by Noor (2021) for Malaysian students that scored an average of 37%. The inability of the students to devise, describe and assess scientific investigations and suggest ways of tackling questions could be linked to the way science is taught at the secondary school (Adu-Gyamfi & Ampiah, 2016; Purwani, 2018; Sutrisna &Anhar ,2020; Yuliati, 2017 in Fitria, 2022; Laslo & Baram-Tsabari, 2021). Adu-Gyamfi and Ampiah, (2016) condemned the use of English language (that is a second language of the learners) in science instructions as a reason for students

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acquiring low SL. Science students in some schools have not perform a single science practical or experiments either because of lack of facilities or the teacher could not engage the students in practical classes (Yuliati, 2017 in Fitria, 2022). Again, some teachers teach students to pass with high grade rather than helping them to see the importance of science learning in equipping them with skills and competencies to be able to face problems in everyday life (Laslo & Baram-Tsabari, 2021). Many of the strategies promote memorization than critical thinking (Aina, 2017).

Strategies such as guided discovery (Chatila & Sweid, 2020), scientific argument (Soysal, 2015).collaborative learning (Sekerci & Canpolat (2014) could be utilized to develop and promote students' SL. According to Agustin and Supahar (2021) the mode of science teaching and learning that does not change or give room for the learner to actively engage in learning but only aims enhancing students' test scores cannot enhance students' scientific literacy skills.

Purwani (2018) profess that student scientific literacy competencies can be improved or obtained if students are learning with scientific problems. The students need to be taught with scientific problems capable of engaging them in learning that will cause them to be motivated and curious to go into discovery and inquiry.

Students' ability to interpret data and evidence scientifically was found to be low. This finding is in accord with the finding of Sutrisna & Anhar (2020) and Henukh et al. (2021) but in disaccord with the finding of Noor (2021). Henukh et al. (2021) reported that the average score obtained by students was 49% while Noor (2021) reported 60 % for Malaysian student. Again, the low ability of students to interpret data and evidence could be attributed to the teachers role in science teaching, student' learning and evaluation of science learning. The pattern of teaching and evaluation of science has great influence on the way students learn. Instead of presenting science to students using strategies and materials that promote analytical thinking skill that can help them to interpret or give meanings to data and evidence, science teachers adopt strategies that encourage memorization. For example, some teachers often evaluate science leaning with questions that require students to list, mention, state or define instead of questions that will require them to distinguish between A and B, calculate or deduce from the information presented in charts, tables or diagrams amongst others.

The success of scientific literacy hinges on the role played by the teacher throughout the learning process. It is the teacher that plans and execute the learning the learning process. His efforts can bring the students to gain or improve their scientific literacy skills and so improve scientific literacy in schools (Adnan , et al, 2021 in Fitria, 2022) or mar students' acquisition of scientific literacy skills

Although the average score of the overall scientific literacy presented in table 4 is lower than 24.4 (68.6%) reported by Garner-O'Neale and Ogunkola (2015) for undergraduate chemistry students in Barbados, the result demonstrated that many of the students showed good level of scientific literacy. This result corresponds with that of Murti and Aminah (2018) which found out that the average score for Indonesian students was 59.6%.

Worthy of note is the highest proportion of ITS students with high ability level in all theSL competencies stated above as well as in the overall SL measured. This indicates that, among the fields of study in science education, ITS has the highest proportion of students that are scientifically literate. This outcome of the study does not come as a surprise. The study of Integrated Science (ITS) offers students numerous possibilities to gain a full understanding of nature due to its foundation in the interconnectedness of the cosmos. This approach provides a wide range of evidence that contributes to a holistic comprehension of the natural world. The study of integrated science provides learners with the opportunity to develop a knowledge of the underlying interconnectedness of scientific disciplines, the shared methodologies employed in addressing scientific problems, and the practical applications of science in daily life.

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CONCLUSION AND RECOMMENDATIONS

The outcome of this study disclosed that science education students are somehow scientifically literate despite their low level ability in the components of scientific literacy that require designing and evaluating investigations as well as interpretation of data and evidence. The study also revealed a high level of scientific literacy among ITS education students compared to students in biology, chemistry and physics education.

As a result of the above it was recommended that:

1. Science teachers, as a matter necessity, should:

a) Be using strategies that will motivate and encourage the learner to be involved in the learning, promote problem-solving and analytical skills.

b) Engage students in experimental and practical work.

c) Develop evaluation tools for science students based on scientific literacy using questions that call for synthesis and evaluation or analysis of data to evoke critical thinking rather than questions that require mere recalling of facts.

d) Take students on science tours to museums, industries, game reserves where they can obtain real-world experiences and knowledge

2. Students should see themselves as the future scientists and so they should engage in collaborative learning, ask questions and develop the spirit of inquiry and discovery.

3. Government and school authorities should provide science materials (both projected and non-projected audio, visual and audio-visual) necessary for effective teaching and learning of science in schools

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