Assessment of Scientific Literacy Skills of College of Education Students in Nigeria

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ABSTRACT

The study randomly sampled one hundred and thirty-three integrated science students of a College of Education to assess their scientific literacy skills. The study was a survey design method. Data for the study was obtained through both qualitative and quantitative approaches. The research instruments were the Scientific Literacy Skills Test (SLST) and a semi-structured interview protocol. Eight skills were investigated which were grouped into three clusters. The study provided answers to three research questions. Data obtained were analyzed using the statistical tools of the t-test, descriptive statistics and thematic coding. Findings showed that students did not possess the scientific literacy skills required for them to function effectively after graduation in society. Besides, male students possessed more scientific literacy skills than their female counterparts in all three clusters of skills examined. Also, finding revealed that students used scientific literacy skills to solve real-life problems such as taking decisions and solving security problems. The paper made some recommendations for further study to enhance students' scientific literacy skills.

Keywords: *Authentic learning, Collaboration, Critical thinking, Employability, Decision-making, PCK, Scientific literacy.*

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Highlights of this paper

- The paper focuses on the scientific literacy skills of the college of education science students in Nigeria.
- The skills had been considered necessary for every graduate to function in modern society for employability, decision-making and others.

1. INTRODUCTION

Scientific literacy may not have consensus meaning (Ogunkola, 2013) however, the convergence viewpoint is that it helps the use of scientific knowledge to solve practical problems in society (Ajayi, 2018). The problem with scientific literacy is due to the misinformation and misunderstanding of scientific information (Siarova, Sternadel, & Szőnyi, 2019) experiencing in our society today. Scientific literacy is a broad construct incorporating scientific opinions and concepts within and across different scientific disciplines and practices (Shwartz, Ben-Zvi, & Hofstein, 2006).

According to Anelli (2011) scientific literacy is the degree to which science education helps people solve personally meaningful, everyday challenges and make critical decisions related to science. Being able to overcome everyday challenges, sensitive to one environment, hypothesis the globalisation results while taking the right measure is scientific literacy (Genc, 2015). According to Udompong and Wongwanich (2014) UNESCO had a view that the scientific literate people could do much to reduce various challenges in society and also enhances sustainable development. Educational reform around the globe in decades ago called for the scientifically literate populace, especially in the US (Dani, 2009). According to Siarova et al. (2019) critical thinking is one significant component of scientific literacy, which is a vital repertoire to allow someone to function as a responsible citizen in the present changing world. A scientifically literate person should be able to utilized skills, values and knowledge associated with science for critical thinking, problem-solving and decision-making (Genc, 2015). Glaze (2018) observed that scientific literacy could reduce the level of misconception in learning. To be scientifically literate is to understanding science and its application; being able to critically think about science and deals with scientific expertise (Holbrook & Rannikmae, 2009). The building of a modern world that is scientifically literate is believed to be the focus of science education (Glaze, 2018). It is a general opinion that the evolvement of scientific literacy is critical to science education (Gormally, Brickman, & Lutz, 2012). Investigating the scientific literacy skills of students enhances the assessment of learning gain in science education (Segarra et al., 2018).

The position of scientific literacy in the functionality of any science student in modern society cannot be overemphasised. For any science student or graduate to be able to fit into society is dependent on his/her scientific literacy skills. In Nigeria, there are different types of tertiary institutions where students learn science. Therefore, due to differences in curricula, the scientific literacy expected from these institutions differ. The scientific literacy in Nigeria is low; thus; the curriculum is designed to inculcate the scientific knowledge and enhancing understanding of concept thought for a real-life situation (Afolabi & Mwakapenda, 2014).

The university is the highest level of these institutions, and the scientific literacy in this level of the institution is higher than all others. Another category of the tertiary institutions is the college of education established to train professional teachers for the primary education and lower secondary schools. The level of scientific literacy skills in these schools is a bit lower than that of the university. Nonetheless, there are some skills peculiar to the colleges of education that shall be a focal point for this study. It is germane that all students in science class should have an understanding of the risks and the benefits derived from science (Holbrook & Rannikmae, 2009) as scientifically literate students.

The gender gap in science enrolment and achievement are not strange in science education and most countries of the world including Nigeria (Aina, 2017; Koul, Lerdpornkulrat, & Poondej, 2016; Moore, Combs, & Slate, 2012; Murphy, Whitelegg, & Elizabeth, 2006). Thus, the acquisition of any skill in learning is equally gender bias (Kelly, 2016; Lock & Hazari, 2016). In every global society men and women responses to issues like decision-making, problem-solving and leadership styles differ to a great extent. The decision-making and problem-solving skills are dependent on the level of scientific literacy of an individual.

Research studies show that most Nigerian college of education graduates in recent times are indigent in applying scientific knowledge to solve real-life problems (Aina, 2017). The typical school of thought on this is that science learning in these institutions is by rote learning. This mode of learning is by memorization and devoid of authentic learning.

Given this, the present study is making a Nigerian college of education a focus of the investigation to determine the scientific literacy skills of science students. Principally, the study is investigating the scientific literacy of a College of Education students in Nigeria. The specific purposes of the study are to determine (1) the adequate scientific literacy skills possessed by the students to function after graduation; (2) any gender gap in scientific literacy skills among the students; and (3) students' application of scientific literacy skills to solve real-life challenges.

1.1. Research Questions

Three research questions were drafted to guide the study as stated below:

1. Do College of Education students possess adequate scientific literacy skills required to function after graduation?
2. Is there any gender gap in the scientific literacy Skills of the College of Education students in Nigeria?
3. In which areas did Nigerian College of Education students solve real-life problems using scientific literacy skills?

2. METHOD

The study employed a descriptive method of research design. It utilized both quantitative and qualitative approach to obtain data for the study (McCombes, 2019).

2.1. Participants

The participants were the science students of a College of Education (Technical) in Nigeria. These students were majored in integrated science and minored in any of the following: biology, chemistry, computer science, mathematics and physics. The choice of this cohort of students was because integrated science is a course that has to do with all other science subjects (Adu-Gyamfi & Ampiah, 2016; Aina, 2015). One hundred and fifty students were targeted among all levels (100 to 300 Levels). However, due to attrition, only 133 students were able to participate in the study, which comprises of seventy male and sixty-three female students.

Before the start of this study, permission was obtained from each of the participants. The participants took part in the research voluntarily. The researchers ensured no harm or injury of any form comes to any of the participants as a result of the study. The dignity and integrity of the participants are essential and were not violated. For anonymity purpose, the real name of the sampled college was not mentioned throughout the study (pseudonym). Anonymity also was applied to the collation of data from the interviews. Interviews were conducted in private. The

recorded information remained in the custody of the researchers for safekeeping until such time that it can be disposed of safely.

2.2. Research Instruments and Procedure

The instrument for the study was the Scientific Literacy Skills Test (SLST) and a semi-structured interview protocol. According to Adams (2015) Semi-structured interviews enable the researcher to ask probing, open-ended questions and to know the independent thoughts of every participant in a group. This type of interview is the most widely used for qualitative research studies (DiCicco-Bloom & Crabtree, 2006). The SLST was adapted from Gormally et al. (2012) to assess the scientific literacy skills of the students. There are eight skills in the test which were grouped into three clusters for analysis purpose. The questions below were properly scrutinized by science education experts and asked during the interviews. However, as a semi-structured interview, there are some probing questions asked which were not in the protocol.

- Are you aware of the security challenges in Nigerian schools today?
- Have you been able to solve any security challenge using your scientific knowledge?
- Can you mention a few of these challenges and how you solved any of them?
- As you interact with people at home and community have you ever encounter any problem solved through scientific knowledge?
- Give one example and how you solved the problem
- Since the time you enrol in science class can you remember any academic challenge you solved using scientific knowledge
- Briefly narrate how you solved the problem
- Can you remember any significant decision you made that is due to the influence of your scientific knowledge?

The test was administered to randomly sampled students by an author in one of their classes. Those students who were interested voluntarily attended the test and submitted after the stipulated time. The test was marked to supply answers for the research questions one and two. After the test, specific numbers of participants were randomly selected for the interviews. The audio record of the interviews was transcribed to provide an answer to the research question three.

2.3. Data Gathering and Analysis

The data for the study were collected through the Scientific Literacy Skills Test (SLST) and structured interviews. The SLST were made of twenty-four questions made of eight skills grouped into three. The three groups are the scientific argument, use and misuse of scientific information; conducting scientific research; and problem-solving in a real-life situation. The scores of students from SLST were tabulated, showing the number of students with correct answers: only the students who got the correct answer were recorded.

The statistical tools considered suitable for the study are the descriptive, t-test and thematic coding. The t-test is best employed when the study contains small continuous variables and also comparing the mean scores of two different groups of conditions (Derrick, Toher, & White, 2017; Pallant, 2011). The descriptive statistics were used to allow a concise description of the various data in the study, both statistically and graphically (Pallant, 2011). The thematic analysis was employed to get useful and credible results from the interviews conducted (Maguire & Delahunt, 2017).

2.4. Research Findings

The eight skills in the SLST were grouped into three clusters which are the scientific argument, use and misuse of scientific information (**SK1**); conducting scientific research (**SK2**); problem-solving in a real-life situation (**SK3**).

Do College Education students possess adequate scientific literacy skills required to function in society after graduation? Is there any gender gap in the scientific literacy Skills of the College of Education students in Nigeria?

Table 1 shows only the number of students who had the right answers for the questions under skill 1 (SK1), skill 2 (SK2) and skill 3 (**SK3**).

Table-1. Correct Answers in the Skills.

Skill	Male (Only correct answers)		Female (Only correct answers)	
Cluster SK1	No	%	No	%
4	23	32	26	41
12	37	53	32	51
14	27	39	15	24
17	27	39	20	32
18	20	29	24	38
21	11	16	08	13
Cluster SK2				
1	2	03	02	03
3	11	16	06	10
5	21	30	14	22
7	35	50	21	33
11	15	21	14	22
15	20	29	13	21
16	20	29	16	25
19	21	30	20	32
20	08	11	14	22
22	24	34	14	22
23	02	03	05	08
24	05	07	09	14
Cluster SK3				
2	05	07	07	11
6	26	37	12	19
8	12	17	20	32
9	23	33	18	29
10	07	10	05	08
13	13	19	12	19

Table 1 shows the inadequate scientific literacy skills of the students. The table indicates that less than 50% of one hundred and thirty-three students did not have adequate scientific literacy skills. The students were indigent in many of the skills investigated in this study. The students did reasonably well in the cluster of **SK1,** where over 50% of the student had the right answer to the skill in *evaluating the use and misuse of scientific information.* However, the students did poorly in question 21, which is *identifying a valid scientific argument.*

Similarly, in SK2, the number of students that got questions 1, 3, 23, 24 correctly were deficient. Mainly, only 3% got question 1 right, which is *reading and interpreting graphical representations of data.* In SK3 questions 2 and 10 also had shallow students' scores: less than 10% of the students have a correct answer to the skill of *understanding elements of research design and how they impact research findings/conclusions.*

In light of the above findings, it is now concluded that the students investigated in this study do not possess the required scientific literacy skills to function in the present society after graduation. Thus, this provides an answer to research question one.

Table-2. Gender descriptive statistics.

	Sex	N	Mean	Std. Deviation	Std. Error Mean
Skils	Male	24	17.2917	9.82224	2.00496
	Female	24	14.4583	7.31276	1.49271

Table 2 shows that male students have better scientific literacy skills than their female counterparts. The statistics in the table shows that male students have a mean of 17.3 while the female had a mean of 14.5. The statistics in Table 1 suggests that male students have better skills in the three clusters than female students. In **SK1**, 35% of male students had correct answers to all the questions in the cluster while the female had 33%. For **SK2** and **SK3** male students had 22% and 21% respectively, and female had 20% in both clusters. However, this gap is minimal, and its statistical significance is verified by conducting the t-test analysis of the data as seen in Table 3.

Table-3. Independent t-test analysis of gender gap in scientific literacy skills.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	95% confidence interval of the difference	
									Lower	Upper
Score	Equal variances assumed	3.67	.061	1.13	45	.263	2.833	2.499	-2.20	7.864
	Equal variances not assumed			1.13	42.50	.263	2.833	2.499	-2.21	7.876

Table 3 indicates that the difference in scientific literacy between male and female is not significant. It is shown in the statistics as the Sig. (2-tailed) of the group is 0.263 and it is higher than the probability level of 0.05.

Given the findings above, it thus implies that minimal insignificant gap exists in scientific literacy between male and female students. It is sufficient enough to answer research question two.

In which areas did Nigerian College of Education students solve real-life problems using scientific literacy skills?

Sixty-four participants were interviewed to answer research question three. The interview is critical to gather data for any qualitative research to have robust results. The interview has essential purposes in research to explore the personal views, experiences, beliefs, and motivations of on particular issues (Gill, Stewart, & Treasure, 2008). Through interviews, participants have opportunities for discussing the meaning of the world around them and also express how they view situations based on personal perspective (Cohen, Manion, & Morrison, 2007). Cohen et al. (2007) asserted that an interview is a tool flexible for collecting data that enables the use of different sensory channels like verbal, non-verbal, spoken and heard. The interview was conducted to get students' opinions on how they applied scientific literacy skills to solve real-life problems.

More than 90% of the interviewees agreed there are security challenges in Nigeria in recent time. However, the result obtained from the interview indicates that significant numbers of the students have not been able to use scientific knowledge to solve any of the challenges. Many of the students admitted they use scientific knowledge to solve problems within the students and even in society. Some of the common problems solved are dispute resolution, security problem, marriage problem and food production. Significant numbers of the students do not solve academic problems using scientific knowledge. However, few applied their science knowledge to solve financial problems, missing grade and lack of conceptual understanding.

The students solved the financial problem through engagement in farming activities and borrowing; the students seeking for the help of more knowledgeable students for lack of conceptual understanding; and the boldness to approach the departmental official used to resolve missing grade.

Mostly all the students submitted that their decisions had been influenced by the scientific knowledge in the following areas:

Financial matters.

Health issues.

Academic related issues.

Career.

Food security (farming).

Few of the transcripts are capture as shown:

Researcher: *Have you been able to solve any security challenge using your scientific knowledge?*

Goody: *No! I have not been able to solve any of such problems using my science knowledge*

Sadiq: *No!*

Nonetheless, few interviewees concurred to have used scientific knowledge to solve security challenge and mentioned some areas like kidnapping, stealing and cultism.

Researcher: *Can you mention a few of these challenges and how you solved any of them?*

Favour: *I have solved the problem of cultism using my knowledge of science*

Brother: *I solved a kidnapping problem using scientific knowledge*

Tree: *I did settle the dispute using my knowledge of science*

Researcher: *As you interact with people at home and community, have you ever encounter any problem solved through scientific knowledge? Give one example and how you solved the problem*

Bayuss: *Yes! I have solved problems at home and community problem like dispute resolution.*

Mohamad: *I have solved a marriage problem like divorce.*

Researcher: *Since the time you enrol in science class can you remember any academic challenge you solved using scientific knowledge. Briefly narrate how you solved the problem.*

Kekere: *I solved the financial problem by farming and borrowing*

Cute: *I overcame the conceptual understanding challenge through collaboration with more knowledgeable classmates.*

Operati: *I used boldness to confront departmental official to solve missing grade problem.*

Researcher: *Can you remember any significant decision you made that is due to the influence of your scientific knowledge?*

Koko: *The scientific knowledge helped me in making a financial decision*

Contel: *Deciding the health-related issue has been the influence of scientific knowledge*

Cricket: *Many of my academic decision can be attributed to the knowledge of science*

Gentle: *My choice of career is as a result of my scientific knowledge*

Growthi: *I made decisions about food security*

The above findings indicate that students applied scientific literacy skills to solve real-life problems in areas of security, academic and in making decisions. This, therefore, provides an answer to the research question three.

3. DISCUSSION

The findings of this study are not strange as many earlier studies had also confirmed the results. The study of Afolabi and Mwakapenda (2014) indicates that Nigerian students have low scientific literacy. The problem of scientific literacy is not only a Nigeria issue; even the countries that are more advanced in education had a similar

challenge (McFarlane, 2013; Stefanova, Minevska, & Evtimova, 2010). Many of the challenges students encountered are attributed to the classroom instruction as the English language is a second language of the learners (Adu-Gyamfi & Ampiah, 2016). The present results require a critical consideration because science education is primarily meant to develop scientific literacy (Dragoş & Mih, 2015). The outcome of this study also confirms the Purwani, Sudargo, and Surakusumah (2018) result on student's scientific literacy skills on biodiversity topics. The low level of scientific literacy in the current study is also supporting (Siagian, Silitonga, & Djulia, 2017) on scientific literacy skills of seventh-grade junior high school.

The outcome of this study suggests that students are having problems in conducting scientific research. This result is consistent with the earlier studies that there are challenges in researching in developing countries (Akyürek & Afacan, 2018; Vose & Cervellini, 2015). According to Amerson and Strang (2015) insufficient resources or an inadequate infrastructure to support research are considered to be challenging in developing country.

The result also indicates that students have inadequate skills in a scientific argument. Scientific argumentation is significant to learning in science education (Osborne, Simon, Christodoulou, Howell-Richardson, & Richardson, 2013). Science students engaging in scientific argumentation develops and improves scientific knowledge (Aufschnaiter, Erduran, Osborne, & Simon, 2008).

The outcome of the study is germane to the instructional models employed in science education. Most of the teaching paradigms employed in Nigerian schools enhance memorization than critical thinking (Aina, 2017). Sekerci and Canpolat (2014) believe that students could develop scientific literacy through a collaborative learning strategy like argumentative. Research studies show that argumentative strategies promote scientific literacy (Soysal, 2015). The level of misconception in science is high in Nigerian schools, and it might be linked to this finding (Eraikhuemen & Ogumogu, 2014; Watkins & Mazur, 2013) observed that scientific literacy could reduce the level of misconception in learning.

The outcome also indicates that students are likely to have problems of conducting useful scientific research which might be the reason students are having challenges in postgraduate studies across the globe (Holtman & Mukwada, 2014; Oni, Onyenania, & Momoh, 2017; Talebloo & Baki, 2013). To be successful in postgraduate studies in universities requires that students must be able to conduct a research study independently with little or no supervision. The students need critical ability and some skills in scientific literacy.

The debate on the gender gaps in science education has been trending for an extended period (Abdullahi, Abubakar, Abubakar, & Aliyu, 2019; Day, Stang, Holmes, Kumar, & Bonn, 2016; Koul et al., 2016; Sax, Lehman, Barthelemy, & Lim, 2016). Many factors are attributed to the issue of gender gaps in science education which could also influence the current study. According to Aina. (2014) and Abdullahi et al. (2019) the poor enrolment and academic performance of female students in science education in Nigeria is due to culture, religion and poverty. Other factors are the school environment (Legewie & DiPrete, 2012); interest and attitude (Alexakos & Antoine, 2003) societal influence (Moses & Daniel, 2008) and school levels (Kristyasari, Yamtinah, Utomo, Ashadi, & Indriyanti, 2018).

The outcome of the current study on the gender gap in scientific literacy is on the same page with Moses and Daniel (2008) which shows the difference between male and female students' achievement in integrated science. However, it is slightly different from the outcome of Kristyasari et al. (2018). Kristyasari et al. (2018) observed that mastery of science literacy of male students is better than that of the female-only based on the school level. It thus implies that quality teachers are required at all levels of schooling.

Several research studies suggest the needs of students to be able to apply scientific knowledge to solve real-life problems (Fortus, Krajcik, Dershimer, Marx, & Mamlok-Naaman, 2005; Rule, 2006). Thus, the advocate for

authentic learning in science should be supported. According to Pearce (2016) authentic learning is the one designed to link what students learn in the classroom to the real-life issue, problem and applications. The present study shows a significant level of scientific knowledge application in solving real-life problems. Rule (2006) authentic learning is targeted towards a real problem that will have a possible impact outside the classroom.

Science learning should mirror the real-life situation (Herrington, Reeves, & Oliver, 2010). Science should be about solving problems (Fortus et al., 2005). The objective of learning is defeated when what was learned cannot be applied to solve problems outside the classroom (Al-Fadhli & Khalfan, 2009). Students should be able to transfer their knowledge and skill learned at school into their everyday lives outside of school (Mims, 2003). Authentic activities are essential because it assists students to understand the complexity of the real-life situation outside the learning environment (Hui & Koplin, 2011).

Two elements of authentic learning are identified from the interviews, which are collaboration and articulation. Students solved the problem of the lack of conceptual understanding when collaborated with their colleagues. Collaboration allows the students to solve problems together (Herrington et al., 2010). According to Har (2013) collaboration is required for task completion in learning. The knowledge and understanding of learners can be facilitated by collaborative dialogue between peers (Osborne et al., 2013).

There are debates in media that most Nigerian graduates are not employable because they lacked employability skills. One of these skills evident here is communication skill (Ang, 2015). Students confronting departmental official to resolve missing grade problem must no doubt have utilized this skill. Another employability skill exhibited here was teamwork skill (Suarta, Suwintana, Pranadi, & Hariyanti, 2017) when students collaborated to resolve an academic challenge.

Articulation affords students the chance to publicly defend a proposition (Herrington et al., 2010). Students in the study have the courage to meet individuals for the missing grade. This is articulation in authentic learning.

Decision-making is central to scientific literacy. Several students deciding on some issues as revealed by the interview is in support of Anelli (2011) and Genc (2015) about scientific literacy. It equally indicates that the students possessed the employability skill of decision-making. It is suitable for students to be excellent in the subject matter but to be employable is essential in this 21st century. Most graduates are jobless not because they did not pass their exams, but it is a matter of employability skills.

Research studies in science education in Nigerian schools are ironclad that it is facing lots of challenges. These challenges are but not limited to quality teachers, fund, infrastructure, scientific literacy and corruption (Aina.. 2013; Nwoye & Moses, 2019; Omorogbe & Ewansiha, 2013; Osuolale, 2014).

The quality teacher is required for research-based pedagogy that would enhance students' scientific literacy. For students to be scientific literate requires the teacher that has excellent pedagogical content knowledge (PCK). Pedagogical content knowledge (PCK) is a characteristic of how to teach the subject matter. It is a unique form of teacher professional knowledge (Koh, Chai, & Tsai, 2010). PCK is how a teacher combines the knowledge in a discipline with that of the teaching (Nuangchalerm, 2012).

Quality education requires adequate funding. For instance, what is in vogue today in education is technology. No doubts about it, the anecdote of students in most advanced countries are more scientifically literate than those in developing nations: the principal reason for this suggests that students are technology savvy in developed countries. However, in Nigeria, because of the low budget in education, it is challenging to make use of technologies in classrooms. Therefore, it is impacting students' learning, particularly scientific literacy.

4. CONCLUSION

There are many things this study revealed about the scientific literacy skills among the college of education students examined. However, given the guided research questions, the overview of the significant findings is at this moment stated.

1. It shows that students did not have adequate skills in the scientific argument, use and misuse of scientific information; conducting scientific research; and problem-solving in real-life situations.
2. There exists gender gaps in scientific literacy skills in scientific argument, use and misuse of scientific information; conducting scientific research; problem-solving in real-life situations.
3. Students applied scientific literacy skills to solve real-life problems such as security, academic and in decision-making.

5. RECOMMENDATIONS

In light of the above conclusion on the scientific literacy skills, the following are the recommendations:

- The government should revise the science curriculum to include science literacy as a concept for teaching.
- Science teachers should be vast in the research-based paradigms of teaching as the convectional lecture method is not sufficient to enhance scientific literacy skills.
- It is essential to replicate this study in another college and university as these findings cannot be generalized for the Nigerian students.

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