

21st Century Skills as Correlates of Secondary School Students' Achievement in Biology in Abak Local Government Area, Akwa Ibom State

Atabang, Atim A.¹, Jonah, Glory E.², Duru, Chukwudi M.³
^{1,2,3} Department of Science Education, Akwa Ibom State University.

Article Info

Article History:

Published: 31 Jan 2026

Publication Issue:

Volume 3, Issue 01

January-2026

Page Number:

696-709

Corresponding Author:

Duru, Chukwudi M.

Abstract:

The study examined 21st Century Skills as correlates of secondary school students' achievement in Biology in Abak Local Government Area, Akwa Ibom State. In order to achieve specific objectives three research questions and correspondence hypotheses were raised to guide this study. The correlational research design was used. The population of this study comprised all 403 senior secondary I students in the 11 public secondary schools in Abak Local Government Area in the 2025/2026 academic year. A sample size of 399 students drawn through simple random sampling technique was used as respondents. The researcher-developed instruments named "21st Century Skills Questionnaire" and "Biology Achievement Test". The instrument was duly validated and the subjected to kuder-Richardson-21 (KR-21) reliability formula with reliability index value of 0.81 for critical thinking and problem-solving skill, 0.80 for collaboration skill, 0.78 for digital literacy skill and 0.79 for BAT. The instrument was duly administered to the respondents and the data collected were analyzed using Pearson product moment correlation. The results of the analysis were used in testing the hypotheses at 0.05 alpha level. The findings showed that critical thinking and problem-solving skill, collaboration skill and digital literacy skill has a significant relationship on secondary school students' achievement in Biology. Based on the findings of the study, it was concluded that 21st Century Skills are significant correlates of secondary school students' achievement in Biology in Abak Local Government, Akwa Ibom State. It was recommended that students should effectively use their critical thinking skill and problem-solving skill, collaboration skill and digital literacy skill in learning Biology since it significantly improves their achievement in Biology.

Keywords: Critical thinking, problem-solving, collaboration, digital literacy and academic achievement.

1. Introduction

Biology is a branch of natural science concerned with the study of life and living organisms, including their structure, functioning, growth, evolution, distribution, identification and taxonomy (Atabang, Edikpo, & Akpan, 2024; Duru, Uko and Utibe, 2024). Being a science of life, Biology occupies a very important position in the secondary school curriculum. In Nigeria, the Secondary

School Biology Curriculum is designed to prepare students to acquire adequate laboratory and field skills, meaningful and relevant knowledge in Biology. It is also to enable students apply scientific knowledge to everyday life in matters of personal, community, health and agriculture among others (Federal Ministry of Education, 2019).

According to Duru, Uko and Utibe, 2023; Onyegegbu (2016), Biology provides a platform for teaching students to develop the ability to apply science concept and principles in solving everyday life problems and building a progressive society. There are records in the field of Biochemistry, Physiology, Molecular Biology among others that made Biology subject a central focus in most human activities including problem like respiration, radiation, family life, food scarcity management and conservation of natural resources as well as ethics. Academic achievement is very important in any educational level.

Academic achievement is generally referred to as how many marks a student achieves in school subjects. It could be measured through tests, examinations, assignments and projects. Academic achievement is used in the school to refer to students' success in learning specified curriculum contents as revealed by continuous assessments or examinations. According to Itighise (2024) and Olusi (2020), academic achievement is a measure of the degree of success in performing specific tasks in a subject or area of study by students after a learning experience. It is the outcome of education that indicates how well a student is doing academically. Academic achievement is a major issue to teachers, students, parents and guardians as well as other stakeholders in the country. A high academic achievement for a student is an indication of teaching/learning effectiveness while poor academic achievement, on the other hand, is an indication that the teaching/learning process is ineffective.

However, the learning of Biology seems not to have yielded the desired outcomes as achievement of students in the subject is usually poor as observed in external examinations like WASSCE. The WAEC Chief Examiner's Report show that from 2022 to 2025, Akwa Ibom State has consistently maintained the 17th position in the overall students' achievement in all subjects, including Biology in the country. This position signifies that the achievement is not satisfactory.

Achieving high quality Biology education may be difficult if students lack important basic knowledge and skills needed to be successful at the more advanced science disciplines. By implication, poor achievement in Biology at the secondary school level could invariably translate to poor quality science education, specifically in Biology related disciplines at tertiary institutions. Poor achievement has negative implications on aspirations of students as it could be detrimental to optimal development of their potentials. Akwa Ibom state may not attain her goal of developing great and dynamic scientifically and technologically sound economy using her own human resources. Undoubtedly, achievement of students will necessarily affect their educational progression and the human capital

base of the state (Edikpo, Akpan, & Atabang, 2024). In the context of Biology education, which often requires students to understand complex systems and engage in scientific inquiry, the integration of 21st-century skills can enhance their academic achievement and overall learning experience.

In the 21st century, the landscape of education has undergone significant transformations, driven by rapid technological advancements and changing societal demands. As the world becomes increasingly interconnected and complex, there is a growing recognition that traditional educational paradigms must evolve to equip students with the skills necessary for success in their future careers and daily lives. At the forefront of this evolution is the concept of 21st-century skills, which encompass a blend of cognitive, interpersonal, and intrapersonal competencies that empower learners to thrive in an ever-changing environment. Itighise and Akpan (2022) comments that concept of 21st-century skills encompasses a set of competencies that are deemed essential for success in today's rapidly changing, technology-driven world. Educational frameworks, such as those developed by the Partnership for 21st Century Skills, identify these skills broadly as critical thinking and problem-solving, communication, collaboration, and digital literacy. These skills are not only important for individual academic success but also for preparing students for the complexities of modern workplaces, where adaptability and innovation are crucial (Voogt & Roblin, 2020).

Recent studies by Hwang et al. (2020) suggests that embedding 21st-century skills into STEM education significantly improves student engagement and learning effectiveness. This integration is particularly relevant in subjects like Biology, where understanding complex systems and engaging in scientific inquiry are vital. In the context of this study, the researcher considered critical thinking and problem-solving, collaboration and digital literacy skills germane for the study.

Critical thinking and Problem-solving skill involves analyzing information, making connections, and applying knowledge to solve complex problems. In biology education, students are often tasked with formulating hypotheses and designing experiments, which fosters their ability to think critically (Beers, 2023). Critical thinking and Problem-solving skill is about using logic, as well as imagination, to make sense of a situation and come up with an intelligent solution (Hugar, 2017). In fact, the best problem solvers actively anticipate potential future problems and act to prevent them or to mitigate their effects. Bradshaw and Hazell (2017) explored the differences in students' approaches to problem solving in mathematics using lesson studies. Consequently, key themes relating to the mediation of gender, ability, and academic motivation surfaced, the paper subsequently reflected upon pedagogical practices which might effectively develop students' ability to solve Biology problems (Jonah, Duru, Akpan, & Thomas, 2023).

Collaboration skill is defined by Chavan (2020) as the ability to work with individuals from diverse backgrounds. Teamwork encompasses flexibility, adaptability, cooperativeness and

respectfulness. According to the report from the National Council of Teachers of Mathematics (2019), Collaboration skill is essential in students' question acquisition and in criticizing constructively, all leading to productive and beneficial outcomes in student learning. Collaboration skills are used by students to rely on each other in some capacity and are willing to support others when called upon. Kuncorowati et al. (2017) conducted a study to ascertain if collaborative learning improves the effectiveness in learning Mathematics. Worked examples and collaborative learning have both been shown to facilitate learning. However, the testing of both strategies almost exclusively has been conducted independently of each other. The main aim of this study was to examine interactions between these two strategies. Two experiments ($n = 182$ and $n = 122$) were conducted with Grade-7 Indonesian students, comparing learning to solve algebra problems with higher and lower levels of complexity, collaboratively or individually. Results from both experiments indicated that individual learning was superior to collaborative learning when using worked examples. In contrast, in experiment 2, collaboration was more effective than individual learning. Again, in experiment 2, collaboration was superior to individual learning in solving problems, particularly for more complex problems. Collaboration skill is essential for working effectively in teams, which is reflective of real-world scenarios in scientific research. Group projects in Biology encourage students to share diverse perspectives, negotiate roles, and collectively solve problems, enhancing their cooperative learning experiences (Johnson & Johnson, 2020).

Digital literacy skill as technology integrated into education has emerged as a critical skill. In Biology, students use various digital tools for data analysis, simulations, and research. Proficiency in these tools not only aids their understanding of complex biological concepts but also prepares them for future scientific endeavors (Gao et al., 2022). However, despite the acknowledged importance of 21st-century skills, there remains a considerable gap in empirical research examining the correlation between these skills and academic performance specifically within the field of Biology. Many educators still adhere to traditional instructional methods that prioritize rote memorization over skills development, potentially hindering students' ability to apply biological knowledge in real-world contexts. This lack of integration raises concerns about students' preparedness for higher education and future careers in science-related fields.

It is based on this background that this study examined correlation between 21st-century skills and students' academic achievement in Biology in Abak Local Government Area, Akwa Ibom State, providing insights that can inform curriculum development and pedagogical strategies. By understanding how these skills impact learning in a specific subject area, educators can better prepare students for the complexities of the 21st century.

Statement of the Problem

Despite the recognized importance of 21st-century skills in enhancing educational outcomes, there is a noticeable gap in empirical research linking these skills directly to academic achievement in specific subjects, such as Biology. Many educators still rely on traditional teaching methods that do not incorporate these competencies, leading to suboptimal student engagement and achievement (Ng, 2021). Furthermore, existing literature primarily focuses on general educational outcomes without delving into subject-specific contexts, leaving a critical void in understanding how 21st-century skills can directly impact academic success in Biology.

Previous researches have deliberated extensively on this problem of persistence poor achievement exhibited by students, however, it is noted that very few studies have addressed the role of 21st century skills on students' academic achievement. It is based on this problem that the researcher deemed it necessary to find out if 21st Century Skills could correlate with students' achievement in Biology. Hence, this study examined 21st Century Skills as correlates of secondary school students' achievement in Biology in Abak Local Government Area, Akwa Ibom State.

Purpose of the Study

The main purpose of this study was to examine 21st Century Skills as correlates of secondary school students' achievement in Biology in Abak Local Government Area, Akwa Ibom State. The specific objectives of the study were to:

- i. Ascertain the extent of relationship between Critical thinking and Problem-solving skill and secondary school students' achievement in Biology.
- ii. Assess the extent of relationship between collaboration skill and secondary school students' achievement in Biology.
- iii. Determine the extent of relationship between digital literacy skill and secondary school students' achievement in Biology.

Research questions

The research questions were raised and answered in the course of the study.

- i. What is the relationship between Critical thinking and Problem-solving skill and secondary school students' achievement in Biology?
- ii. What is the relationship between collaboration and secondary school students' achievement in Biology?
- iii. What is the relationship between digital literacy skill and secondary school students' achievement in Biology?

Research Hypotheses

The following research questions were formulated to guide this study.

- i. There is no significant relationship between critical thinking and problem-solving skill and secondary school students' achievement in Biology.
- ii. There is no significant relationship between collaboration skill and secondary school students' achievement in Biology.
- iii. There is no significant relationship between digital literacy skill and secondary school students' achievement in Biology.

2. Research Methods

Correlational research design was used in carrying out this study. This is a research design that seeks to find relationship between independent and dependent variables. This design was considered suitable for the study because the event has already occurred. The independent variables are studied in retrospect for their possible effect on the dependent variable or variables. This design was considered appropriate for this study because it enabled the researcher to examine 21st Century Skills as correlates of secondary school students' achievement in Biology in Abak Local Government Area, Akwa Ibom State.

Abak is in Akwa Ibom State, south-south region of Nigeria and is a town and a local government area of Akwa Ibom State. Abak is situated between coordinates: latitude 4°59'N and 7°47'E and longitude 4.983°N and 7.783°E.

The population of this study comprised all 403 senior secondary I students in the 16 public secondary schools in Abak Local Government Area in the 2025/2026 academic year. Senior secondary I students were used for this study because they were not preparing for external examinations and so had the time to concentrate and respond to the instrument. A sample size of 399 students was used for this study. The sample size was determined using Taro Yamane formula. The sample size was selected using simple random sampling technique. The determination of the sample size is illustrated as follows:

$$n = \frac{N}{1+n(e)^2}$$

Where n = Sample size

N = Population

e = acceptable error level

N = 403

e = 0.05

$$n = \frac{403}{1+403 (0.05)^2}$$

$$n = \frac{403}{1+403 (0.0025)}$$

$$n = \frac{403}{1.01}$$

$$n = 399$$

The instrument used for data collection was developed by the researcher. It was titled “21st Century Skills Questionnaire” and “Biology Achievement Test”. The 21st Century Skills Questionnaire was used to measure students’ 21st Century Skills. It has five items each that measured the independent sub-variables (critical thinking and problem-solving skill, collaboration skill and digital literacy skill). The items were carefully framed declarative statements and were weighted on a 4-point scale of strongly agree (4 points), agree (3 points), disagree (2 points) and strongly disagree (1 point). The Biology Achievement Test has 30 items. The items are multiple-choice items with one correct option and three distracters. In order to ensure face validity of the 21st Century Skills Questionnaire and Biology Achievement Test, experts in Educational Evaluation and Science Education from the Department of Science Education, Akwa Ibom State University, validated the instruments. These experts ensured that the items on the instruments measure the selected variables and their comments guided the review of the items in the instrument. These experts therefore ensured the face validity of the instrument through the validation.

To determine the reliability of the 21st Century Skills Questionnaire and the Biology Achievement Test, the researcher trial tested them on 30 senior secondary II students who were not part of the main study. The data collected were subjected to kuder-Richardson-21 (KR-21) reliability formula. The reliability coefficients were 0.81 for critical thinking and problem-solving skill, 0.80 for collaboration skill, 0.78 for digital literacy skill, and 0.79 for the Biology Achievement Test. These reliability indices showed that the 21st Century Skills Questionnaire and the Biology Achievement Test were appropriate for use in conducting this study. The reliability coefficients are shown in Table 1.

Table 1: Reliability results

Variables	Number of Items	kuder-Richardson-21 (KR-21) Estimate
Critical thinking and Problem-solving skill	5	0.81
Collaboration skill	5	0.80

Digital Literacy skill	5	0.78
Biology Achievement Test	30	0.79

Source: Field Data, 2025

The researcher with the help of research assistants administered copies of the 21st Century Skills Questionnaire and the Biology Achievement Test to the students in their various schools. Before administering the instrument, the researcher introduced himself and encouraged them to give their candid opinion on the instruments. Face-to-face method of administration was used to administer the instruments. The respondents were informed that their decision regarding participation would be handled confidentially and for the research purpose only. The names of the students were not required on the instruments so that they remained anonymous. Only students who agreed to participate in the study responded to the instruments. 399 students sampled agreed to participate in the study. Each student was given sufficient time to respond to the instruments. The administration of the instruments lasted for two weeks. The statistical tool used for data analysis was Pearson product moment correlation. The results obtained from the correlation analysis were used in testing the hypotheses. This statistical tool made it possible to determine the relationship between 21st Century Skills and students' achievement in Biology. The analysis was done using SPSS. The coefficient of correlation provided by Udoh (2019) was used to describe the relationship between the independent and dependent variables, which are .00 to .20 (very low relationship), .21 to .40 (low relationship), .41 to .60 (moderate relationship), .61 to .80 (high relationship) and .81 to 0.99 (very high relationship). In testing the hypotheses, if the p-value is less than 0.05 alpha level, the null hypotheses is rejected, but if the p-value is greater than 0.05 Alpha level, then the null hypothesis is not rejected.

3. Results

The hypotheses raised were tested in order to ascertain if 21st Century Skills correlate with secondary school students' achievement in Biology in Abak Local Government Area, Akwa Ibom State.

Hypothesis One

There is no significant relationship between critical thinking and Problem solving skill and secondary school students' Achievement in Biology.

In order to test hypothesis one, Pearson product moment correlation was used and the result is presented in Table 2.

Table 2: Summary of Pearson correlation between critical thinking and problem-solving skill and secondary school students' achievement in Biology

21 st Century Skill	N	Mean	SD	df	r-value	p-value
Critical thinking and Problem-solving skill	399	20.27	4.50222	398	0.59*	0.000*
Achievement in Biology	399	14.43	3.79868			

*Significant at $P < 0.05$ level of significance

The result in Table 2 indicates the relationship between critical thinking and problem-solving skill and secondary school students' achievement in Biology. The result indicates that the correlation coefficient is 0.590, which indicates a moderate positive relationship between critical thinking and problem-solving skill and secondary school students' achievement in Biology. The result also shows that the correlation coefficient is significant at ($p\text{-cal} = 0.000$; $df = 398$) less than the declared probability level of 0.05. Thus, the null hypothesis is rejected, which implies that there is a significant relationship between critical thinking and problem-solving skill and secondary school students' achievement in Biology.

Hypothesis Two

There is no significant relationship between collaboration skill and secondary school students' achievement in Biology.

In order to test hypothesis two, Pearson product moment correlation was used and the result is shown in Table 3.

Table 3: Summary of Pearson correlation between collaboration skill and secondary school students' achievement in Biology

21 st Century Skill	N	Mean	SD	df	r-value	p-value
Collaboration skill	399	13.49	3.67287	398	0.64*	0.000*
Achievement in Biology	399	18.76	4.33128			

*Significant at $P < 0.05$ level of significance

The result in Table 3 indicates the relationship between Collaboration skill and secondary school students' achievement in Biology. The result indicates that the correlation coefficient is 0.640, which indicates a high positive relationship between collaboration skill and secondary school students' achievement in Biology. The result also shows that the correlation coefficient is significant at ($p\text{-cal} = 0.000$; $df = 398$) less than the declared probability level of 0.05. Thus, the null hypothesis is rejected,

which implies that there is a significant relationship between collaboration skill and secondary school students' achievement in Biology.

Hypothesis Three

There is no significant relationship between digital literacy skill and secondary school students' achievement in Biology.

In order to test hypothesis three, Pearson product moment correlation was used and the result is indicated in Table 4.

Table 4: Summary of Pearson correlation between digital literacy skill and secondary school students' achievement in Biology

21 st Century Skill	N	Mean	SD	df	r-value	p-value
Digital literacy skill	399	19.40	4.40454	398	0.72*	0.000*
Achievement in Biology	399	14.76	3.84187			

*Significant at $P < 0.05$ level of significance

The result in Table 4 indicates the relationship between digital literacy skill and secondary school students' achievement in Biology. The result indicates that the correlation coefficient is 0.720, which indicates a high positive relationship between digital literacy skill and secondary school students' achievement in Biology. The result also shows that the correlation coefficient is significant at ($p\text{-cal} = 0.000$; $df = 398$) less than the declared probability level of 0.05. Thus, the null hypothesis is rejected, which implies that there is a significant relationship between digital literacy skill and secondary school students' achievement in Biology.

4. Discussion of Findings

Critical thinking and Problem-solving Skill and secondary school students' Achievement in Biology

The result of hypothesis one showed that there is a significant relationship between creative thinking skill and secondary school students' achievement in Biology. Critical thinking and problem-solving skills are vital for students' academic achievement, particularly in subjects like Biology, where analytical skills are crucial. This study is in line with the works of Smith and Johnson, (2023) who engage in critical thinking exercises demonstrate improved understanding and application of biological concepts. This finding is in line with that of Bradshaw and Hazell (2017) because they explored the differences in students' approaches to critical thinking and problem solving skill using lesson studies and reported that many students had better critical thinking and problem-solving skill, which they used in solving the problems presented compared to others who had low problem-solving skill. There seems

to be three themes characterized by the role of problem-solving skill. Firstly, problem solving is a content; the idea that problems and the solving of them are a means to achieve other things. Secondly, problem solving is a skill; this is the idea that it is a skill to be taught and not necessarily a unitary skill, but is a clear skill orientation. Thirdly, problem solving is an art; this is the idea that learning Biology through problem solving is an art of discovery for its methods and rules.

Moreover, problem-solving skills enable students to tackle complex biological problems, thereby enhancing their comprehension and retention of information. A meta-analysis by Lee et al. (2024) found a significant correlation ($r = 0.65$) between students' problem-solving abilities and their performance in Biology, suggesting that these skills play a crucial role in academic achievement.

This was in agreement with the study of Zaiyar and Rusmar (2020) who conducted a study on creative thinking skill and found that students with high creative thinking skill could solve mathematics problem than those with moderate and low creative thinking skill. Creative students differ from students who are less creative. Creative students may be more inclined to come up with questions that can help them find answers when solving a Biology problem and improve their performance. Similarly, Itighise (2016) that innovative teaching potentially support and affect learning and technology usage in classroom during course content delivery.

Collaboration Skill and secondary school students' Achievement in Biology

The result of hypothesis two indicated that there is significant a relationship between collaboration skill and secondary school students' achievement in Biology. Collaboration skills are increasingly recognized as essential for academic success in STEM fields, including Biology. This study is in consonance with the works of Martinez and Chen, (2024) demonstrated that collaborative learning environments positively affect students' understanding of biological concepts. Students who participated in group projects reported higher engagement levels and a 15% increase in their overall achievement. Furthermore, collaboration fosters peer-to-peer learning, which can enhance comprehension and understanding.

This finding is in agreement with that of Kuncorowati et al. (2017); Carter et al. (2025) that students who engaged in collaborative problem-solving activities scored higher in assessments, with a noted improvement of 10% in their Biology grades compared to those who worked individually. This suggests that collaborative skills not only promote teamwork but also contribute significantly to academic achievement. This finding could be due to the fact that in collaboration learning, students brainstorm, share Biology problems, tackle the problems together continuously within their members and learn from each other so their combined collaborative achievement and Biology achievement surpasses the simple sum of individual contributions.

Digital literacy Skill and secondary school students' Achievement in Biology

The result of hypothesis three showed that there is a significant relationship between digital literacy skill and secondary school students' achievement in Biology. In the digital age, digital literacy has become a crucial skill for students, particularly in the sciences. This study is in support by the works of Thompson and Green (2023) found that students with high digital literacy levels were more adept at utilizing online resources for research, leading to a 25% improvement in their Biology grades. Digital literacy enables students to access a wealth of information, engage with interactive simulations, and utilize data analysis tools effectively.

Additionally, the finding is in line with that of Patel et al. (2024) emphasized the importance of digital tools in enhancing the learning experience in Biology. They found that students who used digital platforms for collaborative projects exhibited a 30% increase in understanding complex biological processes. This underscores the necessity of integrating digital literacy into the Biology curriculum to enhance student achievement.

5. Conclusion

The integration of 21st-century skills-critical thinking and problem-solving skill, collaboration skill and digital skill into the secondary school Biology curriculum is essential for enhancing students' academic achievement. Based on the findings of the study, it was concluded that 21st Century Skills are significant correlates of secondary school students' achievement in Biology in Abak Local Government Area, Akwa Ibom State. By developing critical thinking skill, problem-solving skill, collaboration skill and digital literacy skill, students' achieve results that please everyone in school subjects, and even positively influence student personal life by checking what a student does and how learners does it. 21st- century skills help students to adapt to changing circumstances towards success in life and academic endeavours.

Recommendations

Based on the findings of the study, the following recommendations were made.

- i. Students should effectively use their critical thinking and problem-solving skill in learning Biology since it significantly improves their achievement in the subject.
- ii. Teachers should regularly give students projects and activities that involve collaboration so that students can use it to build relationships that foster desirable achievement in Biology.
- iii. Students should develop and use digital literacy skill effectively because it would help them to be analytical and well informed in solving Biology problems, and achieve good performance.

References

1. Atabang, A. A., Edikpo, L.V., & Akpan, A. O. (2024).Effect of improvised DNA model and flip-chart on students' performance and retention in Biology in Eket Local Government Area, Akwalbom State. *Interdisciplinary Journal of Science Education (IJ-SED)*, 6(1), 113-123.
2. Babayemi, J.O., Akpan, I.F, & Babalola, G.T. (2017).Issues and challenges from scienceeducation benchmark in Nigeria: comparative analysis of education in China andNigeria for repositioning basic science and technology in Nigeria. *African Journal of Education Assessors*, 3(3), 31-40.
3. Bradshaw, Z. & Hazell, A. (2017).Developing students' approaches to problem solving using lesson studies. *International Journal for Lesson and Learning Studies*, 6 (1), 34-48.
4. Carter, L., Smith, J., & Martinez, A. (2025). The impact of collaborative learning on Biology achievement. *Journal of Educational Research*, 118(2),145-162.
5. Chavan, S. V. (2020). The importance of soft skills. *International Journal of Science and Research*, 9 (5), 623-625.
6. Duru, C. M., Uko, P. J., & Utibe, U. J. (2024). Application of DNA animation, improvised model and realia in teaching and students' performance based on gender in Biology in Akwa Ibom State, Nigeria. *African Journal of Educational Foundations*, 5(1), 75-92.
7. Duru, C. M., Uko, P. J., & Utibe, U. J. (2023).Effect of DNA animation, improvised model and realia on teaching and students' performance based on school location in Biology in Akwalbom State, Nigeria. *Inter-disciplinary Journal of Science Education*, 5(1), 11-25.
8. Edikpo, L. V., Akpan, I. F., & Atabang, A. A. (2024). Teaching methods and Biology students' academic achievement in Eketfederal constituency of Akwalbom State. *Interdisciplinary Journal of Science Education (IJ-SED)*, 5(2), 25-34.
9. Falaye, B. A., & Afolabi, E. R. I. (2020). Presenting science and technology to children for national development. *International Journal of Children-in-Science and Technology*, 2(1), 25-31.
10. Hugar, D. (2017). The role of problem solving in the Mathematics classroom. (Retrieved on 16th May 2017 from http://www.lhup.edu/swillia6/MATH%20200/Documents_and_Files/Research_Papers_2011/DanielIe)
11. Itighise, A. E., & Akpaetor, F. B. (2014). Digital media and information dissemination in tertiary institutions in Akwalbom State, Nigeria. *Journal of Information Engineering and Application*, 4(11), 101-106.
12. Itighise, A. E. & Akpan, I. F. (2022). Acquisition of literacy skills using mobile handheld devices and Science Education students' academic performance in Universities in Akwa Ibom State, Nigeria. *Kampala International University (KIU) Journal of Humanities*, 7(2): 101-108.
13. Itighise, A. E. (2024). Dropbox file sharing strategy and academic performance of teachers' trainees in Universities in south-south, Nigeria. *Ibadan Journal of Educational Studies*,21(1), 189-198.
14. Itighise, A. E. (2021).*Exploring dropbox instructional strategies in teaching and learning process*,(ed) Ekpo, E., Ibeagha,]. andAllison,D. e-learning and information communication technology in Nigeria Educational System: Matters Arising Onitsha: West and Solomon Publishing Ltd.
15. Itighise, A. E. (2016). Innovation in higher teachers' education: An imperative for achievement of sustainable national development. *Journal of Educational Media and Technology*, 21(1), 264-273.
16. Jonah, G. E., Duru, C. M., Akpan, U I., & Thomas, N. A. (2023). Perception of teachers' motivational variables and students' academic achievement in Biology in Akwalbom State, Nigeria.*Inter-Disciplinary Journal of Science Education (IJ-SED)*, 5(1), 90-97.
17. Johnson, D. W. & Johnson, R. T. (2019). *Circle of learning: Cooperation in the classroom*. Interaction Book Company, Gurgaon.
18. Kozlowski, J. S., Chamberlin, S. A. & Mann, E. (2019). Factors that influence mathematical creativity. *The Mathematics Enthusiast*, 16(1), 505-540.

19. Kuncorowati, R. H., Mardiyana, D. G., & Saputro, R. S. (2017). Mathematics creative thinking levels based on interpersonal intelligence. *Journal of Physics*, 3: 1-7.
20. Lee, K., Johnson, R., & Patel, S. (2024). Problem solving in science education: A Meta-Analysis. *International Journal of STEM Education*, 11(1), 34-55.
21. Martinez, A., & Chen, R. (2024). Collaboration in science education: effects on student engagement and achievement. *Journal of Science Education and Technology*, 33(3), 267-278.
22. Meenu, D. (2016). Factors affecting the performance: A study of elementary school students of NCR Delhi, India. *Journal of Education and Practice*, 7 (4), 34-45.
23. National Council of Teachers of Mathematics (2019). *Curriculum and evaluation standards for school mathematics*. Author, Reston, p.132.
24. Olusi, F. I. (2020). Students' interest in science and technology. *Nigerian Journal of Educational Research*, 5(2), 69-84.
25. Obasi, V.A. (2019). The need for feminist intellectual specie in Nigeria academy. *Journey of Woman in Achievements*, 4(1), 162-171.
26. Patel, S., Thompson, R., & Green, L. (2024). Digital literacy and academic performance in science education. *Computers & Education*, 162, 104-116.
27. Perry, A., & Karpova, E. (2017). Efficacy of teaching creative thinking skills: A comparison of multiple creativity assessments. *Thinking Skills and Creativity*, 24, 118-126.
28. Raes, E. G.(2015). An exploratory study of group development and team learning. *Human Resource Development Quarterly*, 4: 46-60.
29. Smith, J., & Johnson, R. (2023). Inquiry-based learning in Biology: an evaluation of student outcomes. *Biology Education Research*, 15(4), 67-82.
30. Thompson, R., & Green, L. (2023). The role of digital literacy in student success in Biology. *Journal of Biological Education*, 58(2), 123-130.
31. Udoh, A. O. (2019). *Instrument development in education*. Abaam Publishing Company, Uyo.
32. Ukor, D. O. (2020). Achievement in Integrated Science as a predictor of success in senior secondary school science. *Journal of Curriculum and Teaching*, 5(1), 397-405.
33. Zaiyar, M., & Rusmar, I. (2020). Students' creative thinking skill in solving higher order thinking skills problems. *Jurnal Pendidikan Matematika*, 11 (1), 111-120.