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Basic Science Process Skills and Reasoning Ability as Predictors of Biology Student Teachers' Academic Achievement in Federal Universities of North-East Nigeria

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ABSTRACT

This study examined the predictive contributions of basic science process skills and reasoning ability to the academic achievement of biology student teachers in Federal Universities of North-East Nigeria. A correlational research design was adopted, involving 619 Part III biology student teachers. Data were collected using the Biology Students Basic Science Process Skills Questionnaire (BSBSPSQ), the Lawson Classroom Science Reasoning Ability Test (LCSRAT), and students' cumulative grade point average (CGPA). The instruments recorded reliability coefficients of .877 and .867, respectively. Mean and standard deviation were used to answer the research questions, while multiple regression analysis tested the hypotheses at the .05 level of significance. The findings showed that the student teachers possessed high levels of basic science process skills (M = 3.73, SD = 1.18) and reasoning ability (M = 3.63, SD = 1.17). Basic science process skills had a strong relationship with academic achievement (R = .788) and accounted for 62.1% of the variation in achievement. Reasoning ability also predicted academic achievement (R = .614), accounting for 37.7% of the variation, with reflective thinking emerging as the only significant unique reasoning predictor (β = .602, p = .009). When considered jointly, basic science process skills and reasoning ability produced a strong multiple relationship with academic achievement (R = .802) and explained 64.3% of the variation in achievement; the combined model was statistically significant, F(9, 610) = 7.212, p < .001. The study concluded that both scientific process competencies and reasoning ability are important predictors of biology student teachers' academic achievement. It therefore recommended that biology teacher education programmes deliberately integrate inquiry-based activities that develop science process skills alongside reflective and evidence-based reasoning.

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INTRODUCTION

Biology education contributes significantly to scientific literacy by providing learners with knowledge of living organisms, biological processes, environmental systems, and applications relevant to health, agriculture, and biotechnology. At the university level, biology teacher education programmes are expected to develop competent science educators who possess adequate content knowledge, practical skills, and cognitive abilities necessary for effective teaching. However, variations in academic achievement among biology students continue to raise concerns among science educators, particularly regarding the factors that influence students' ability to understand and apply biological concepts.

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One important factor associated with effective science learning is the development of science process skills. Science process skills are the abilities used by scientists to investigate phenomena, collect evidence, analyze information, and construct scientific explanations. These skills include observing, classifying, measuring, communicating, inferring, predicting, controlling variables, and interpreting data (American Association for the Advancement of Science [AAAS], 1967). Science process skills encourage learners to participate actively in scientific inquiry and develop understanding through investigation rather than depending solely on memorization of scientific facts.

In biology education, science process skills are essential because biological knowledge is developed through observation, experimentation, classification, measurement, and interpretation of evidence. Students who possess these skills are better prepared to analyze biological phenomena, conduct practical investigations, and apply scientific principles to solve problems. Research has shown that science process skills are associated with improved science achievement because they promote deeper conceptual understanding and active engagement in learning (Henta Fugarasti, Ramli, & Muzzazinah, 2019; Çelik, 2022).

However, successful science learning also requires reasoning ability. Scientific reasoning refers to the cognitive ability to analyze information, identify relationships, draw conclusions, evaluate evidence, and develop logical explanations. Lawson (1978) identified different levels of scientific reasoning, including intuitive, transitional, and reflective thinking, which represent increasing levels of cognitive development in scientific understanding. Reasoning ability enables learners to interpret observations, evaluate explanations, and apply logical thinking when solving scientific problems.

For biology student teachers, reasoning ability is particularly important because biology involves complex relationships among organisms, processes, and systems. Students must be able to interpret biological information, connect evidence with explanations, and make logical decisions during scientific investigations. Weak reasoning ability may limit students' capacity to understand abstract biological concepts and apply scientific knowledge effectively.

Previous studies have established that both science process skills and reasoning ability contribute to science learning outcomes. Students who demonstrate stronger process skills are more capable of engaging in inquiry activities, while those with stronger reasoning abilities are better able to analyze scientific evidence and construct explanations. The interaction between these competencies may provide a stronger explanation of academic achievement than either factor considered independently.

Despite the importance of these variables, limited studies have examined the combined predictive influence of science process skills and reasoning ability among biology student teachers in Nigerian universities. Previous investigations have often focused on either science process skills or reasoning ability separately, creating limited understanding of how these competencies jointly influence academic achievement. Therefore, this study investigates basic science process skills and reasoning ability as predictors of biology student teachers' academic achievement in Federal Universities of North-East Nigeria. The study examines how science process skills and different levels of reasoning ability contribute individually and collectively to students' academic achievement.

STATEMENT OF THE PROBLEM

Academic achievement among biology student teachers is influenced by several cognitive and scientific competencies required for effective learning. Although biology education programmes emphasize scientific knowledge and practical experiences, variations in students' academic performance remain a concern. Science process skills and reasoning ability are important competencies that enable learners to investigate scientific phenomena, interpret evidence, and construct meaningful explanations. However, limited attention has been given to how these two factors jointly contribute to academic achievement

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among biology student teachers, particularly in Federal Universities of North-East Nigeria.

Existing studies have mostly examined science process skills and reasoning ability independently, leaving insufficient evidence on their combined predictive influence. This creates a gap in understanding the extent to which these competencies explain differences in biology students' academic achievement. Therefore, this study examines the predictive contribution of basic science process skills and reasoning ability to biology student teachers' academic achievement in Federal Universities of North-East Nigeria.

Objectives of the Study

The main objective of the study was to determine the predictive contributions of basic science process skills and reasoning ability to biology student teachers' academic achievement in Federal Universities of North-East Nigeria.
Specifically, the study sought to:

1. Determine the level of basic science process skills acquisition among biology student teachers in Federal Universities of North-East Nigeria;
2. Determine the level of reasoning ability among biology student teachers in Federal Universities of North-East Nigeria;
3. Determine the predictive contribution of basic science process skills to biology student teachers' academic achievement in Federal Universities of North-East Nigeria;
4. Determine the predictive contribution of reasoning ability to biology student teachers' academic achievement in Federal Universities of North-East Nigeria; and
5. Determine the joint predictive contribution of basic science process skills and reasoning ability to biology student teachers' academic achievement in Federal Universities of North-East Nigeria.

Research Questions

The following research questions guided the study:

1. What is the level of basic science process skills acquisition among biology student teachers in Federal Universities of North-East Nigeria?
2. What is the level of reasoning ability among biology student teachers in Federal Universities of North-East Nigeria?
3. To what extent do basic science process skills predict biology student teachers' academic achievement in Federal Universities of North-East Nigeria?
4. To what extent does reasoning ability predict biology student teachers' academic achievement in Federal Universities of North-East Nigeria?
5. To what extent do basic science process skills and reasoning ability jointly predict biology student teachers' academic achievement in Federal Universities of North-East Nigeria?

Hypotheses

The following null hypotheses were formulated and tested at the 0.05 level of significance:

H_{01}: Basic science process skills do not significantly predict biology student teachers' academic achievement in Federal Universities of North-East Nigeria.

H_{02}: Reasoning ability does not significantly predict biology student teachers' academic achievement in Federal Universities of North-East Nigeria.

H_{03}: Basic science process skills and reasoning ability do not jointly make a significant predictive contribution to biology student teachers' academic achievement in Federal Universities of North-East Nigeria.

LITERATURE REVIEW

Concept of Science Process Skills

Science process skills are fundamental abilities that enable learners to engage in scientific inquiry, investigate phenomena, collect evidence, and construct scientific explanations. They represent the procedures and intellectual skills used by scientists in generating and validating

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knowledge. According to the American Association for the Advancement of Science (AAAS, 1967), basic science process skills include observing, classifying, measuring, communicating, inferring, and predicting, while integrated skills involve more complex activities such as controlling variables, formulating hypotheses, experimenting, and interpreting data.

Science process skills promote active learning by enabling students to participate directly in the process of scientific discovery. Rather than viewing science as a collection of facts, learners develop the ability to investigate problems, analyze information, and apply scientific principles in real situations. Henta Fugarasti, Ramli, and Muzzazinah (2019) emphasized that science process skills are essential for developing scientific literacy because they support inquiry-based learning and scientific reasoning.

In biology education, these skills are particularly important because biological concepts often require observation, experimentation, classification, measurement, and interpretation of evidence. Biology student teachers who possess strong science process skills are better prepared to understand biological concepts and implement practical science teaching approaches in future classrooms.

Concept of Reasoning Ability

Reasoning ability refers to the cognitive capacity to analyze information, identify relationships, draw conclusions, and make logical judgments based on available evidence. In science learning, reasoning ability enables students to interpret observations, evaluate explanations, and develop scientifically acceptable conclusions. Lawson (1978) proposed that scientific reasoning develops through different levels, including intuitive, transitional, and reflective thinking. Intuitive thinking involves immediate judgments based on experience or prior understanding, transitional thinking represents movement between intuitive and logical reasoning, while reflective thinking involves systematic evaluation of evidence and logical explanation.

Scientific reasoning is important in biology because many biological concepts require learners to move beyond memorization toward analysis and explanation. Students must reason about biological relationships, interpret experimental results, and connect evidence with theoretical concepts. Bhat (2016) reported that reasoning ability has predictive value for academic achievement, suggesting that students with stronger reasoning abilities tend to demonstrate better learning outcomes.

Relationship between Science Process Skills, Reasoning Ability, and Academic Achievement

Science process skills and reasoning ability are interconnected competencies that support effective science learning. Science process skills provide learners with procedures for gathering and analyzing scientific information, while reasoning ability enables them to interpret evidence and develop explanations. Together, these abilities allow students to engage effectively in scientific inquiry.

Previous studies have demonstrated significant relationships between science process skills and academic achievement. Derilo (2019) found that students with stronger science process skills achieved better outcomes in science learning. Similarly, Achor, Odoh, and Abakpa (2018) reported that investigative laboratory strategies improved science process skill acquisition, indicating that practical engagement contributes to better academic performance. Reasoning ability has also been identified as an important factor influencing academic achievement. Students with higher reasoning abilities are more capable of understanding complex concepts, analyzing relationships, and solving scientific problems. The combination of science process skills and reasoning ability may therefore provide a stronger explanation of academic achievement because scientific learning requires both procedural competence and cognitive interpretation.

Although previous studies have examined science process skills and reasoning ability separately, limited evidence exists

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regarding their combined predictive contribution among biology student teachers. Understanding this relationship is particularly important because biology student teachers require both scientific inquiry skills and reasoning competence to become effective science educators.

METHODOLOGY

The study adopted a correlational research design to examine the combined predictive contribution of basic science process skills and reasoning ability to biology student teachers' academic achievement in Federal Universities of North-East Nigeria. The population comprised biology student teachers in Federal Universities of North-East Nigeria, while the sample consisted of 619 Part III biology student teachers. Three instruments were used for data collection: the Biology Students Basic Science Process Skills Questionnaire (BSBSPSQ), the Lawson Classroom Science Reasoning Ability Test (LCSRAT), and a proforma for collecting students' cumulative grade point average (CGPA) as a measure of academic achievement.

The science process skills questionnaire measured students' acquisition of basic science process skills, while the Lawson Classroom Science Reasoning Ability Test assessed intuitive, transitional, and reflective thinking abilities. The instruments were validated by experts, and reliability coefficients were established using Cronbach's Alpha. The BSBSPSQ recorded a reliability coefficient of 0.877, while the reasoning ability instrument recorded a reliability coefficient of 0.867. Data collected were analyzed using mean and standard deviation to answer research questions. Pearson Product Moment Correlation (PPMC) and multiple regression analysis were used to test hypotheses at 0.05 level of significance.

RESULTS

The results are presented according to the research questions and null hypotheses formulated for the study. Mean and standard deviation were used to answer the descriptive research questions, while multiple regression analysis was used to determine the predictive contributions of basic science process skills and reasoning ability to biology student teachers' academic achievement. The hypotheses were tested at the 0.05 level of significance.

RESULTS

Research Question One

What is the level of basic science process skills acquisition among biology student teachers in Federal Universities of North-East Nigeria?

Table 1: Mean and Standard Deviation of Basic Science Process Skills Acquisition among Biology Student Teachers

Basic Science Process Skill	N	Mean	SD	Remark
Observing	619	3.57	1.22	High Level
Inferring	619	3.68	1.17	High Level
Measuring	619	3.77	1.13	High Level
Communicating	619	3.93	1.18	High Level
Classifying	619	3.63	1.23	High Level
Predicting	619	3.78	1.11	High Level
Grand Mean	**619**	**3.73**	**1.18**	**High Level**

Table 1 shows that biology student teachers possessed high levels of all six basic science process skills. Communicating recorded the highest mean score (M = 3.93), followed by predicting (M = 3.78) and measuring (M = 3.77). Observing recorded the lowest mean score (M = 3.57). The grand mean of 3.73 and standard deviation of 1.18 indicate that the overall level of basic science process skills acquisition among the biology student teachers was high.

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Research Question Two

What is the level of reasoning ability among biology student teachers in Federal Universities of North-East Nigeria?

Table 2: Mean and Standard Deviation of Reasoning Ability among Biology Student Teachers

Reasoning Dimension	N	Mean	SD	Remark
Intuitive thinking	619	3.50	1.20	High Level
Transitional thinking	619	3.50	1.20	High Level
Reflective thinking	619	3.88	1.11	High Level
Grand Mean	**619**	**3.63**	**1.17**	**High Level**

Table 2 shows that the biology student teachers demonstrated high levels of intuitive, transitional, and reflective thinking. Reflective thinking recorded the highest mean score (M = 3.88), while intuitive and transitional thinking each recorded a mean score of 3.50. The overall grand mean of 3.63 and standard deviation of 1.17 indicate a high level of reasoning ability among the respondents.

Research Question Three

To what extent do basic science process skills predict biology student teachers' academic achievement in Federal Universities of North-East Nigeria?

Table 3: Model Summary of the Predictive Contribution of Basic Science Process Skills to Academic Achievement

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
Basic Science Process Skills	.788	.621	.562	.44622

Predictors: Observing, inferring, measuring, communicating, classifying, and predicting.
Dependent Variable: Academic Achievement.

Table 3 shows a strong multiple relationship between basic science process skills and biology student teachers' academic achievement, with R = .788. The coefficient of determination, R^2 = .621, indicates that observing, inferring, measuring, communicating, classifying, and predicting jointly accounted for 62.1% of the variation in academic achievement. The remaining 37.9% was associated with other variables outside the model.

The regression coefficients show that predicting had the largest positive standardized coefficient (β = 1.426), followed by inferring (β = .203), measuring (β = .171), communicating (β = .099), and observing (β = .049), while classifying recorded a negative coefficient (β = -.855).

Research Question Four

To what extent does reasoning ability predict biology student teachers' academic achievement in Federal Universities of North-East Nigeria?

Table 4: Model Summary of the Predictive Contribution of Reasoning Ability to Academic Achievement

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
Reasoning Ability	.614	.377	.333	.55096

Predictors: Intuitive thinking, transitional thinking, and reflective thinking.
Dependent Variable: Academic Achievement.

Table 4 shows that reasoning ability had a multiple correlation coefficient of R = .614 with academic achievement. The coefficient of determination, R^2 = .377, indicates that intuitive,

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transitional, and reflective thinking jointly accounted for 37.7% of the variation in biology student teachers' academic achievement, while the remaining 62.3% was associated with other factors outside the model.

To determine the relative contributions of the three dimensions of reasoning ability, the regression coefficients are presented in Table 5.

Table 5: Relative Contributions of Reasoning Ability Dimensions to Academic Achievement

Predictor	B	Std. Error	Beta (β)	t	Sig.
Constant	1.197	.704	—	1.700	.097
Intuitive thinking	-.044	.324	-.031	-.135	.893
Transitional thinking	.081	.180	.067	.451	.654
Reflective thinking	.641	.235	.602	2.734	.009

Table 5 shows that reflective thinking made the strongest positive relative contribution to academic achievement (β = .602, t = 2.734, p = .009) and was the only reasoning dimension that made a statistically significant unique contribution. Transitional thinking recorded a small positive contribution (β = .067, p = .654), while intuitive thinking recorded a small negative coefficient (β = -.031, p = .893); neither was statistically significant.

Research Question Five

To what extent do basic science process skills and reasoning ability jointly predict biology student teachers' academic achievement in Federal Universities of North-East Nigeria?

Table 6: Model Summary of the Joint Predictive Contribution of Basic Science Process Skills and Reasoning Ability to Academic Achievement

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
BSPS and Reasoning Ability	.802	.643	.554	.45046

Predictors: Observing, inferring, measuring, communicating, classifying, predicting, intuitive thinking, transitional thinking, and reflective thinking.

Dependent Variable: Academic Achievement.

Table 6 shows that basic science process skills and reasoning ability jointly produced a multiple correlation coefficient of R = .802 with biology student teachers' academic achievement. The coefficient of determination, R^2 = .643, indicates that the nine predictor variables jointly accounted for 64.3% of the variation in academic achievement. Therefore, 35.7% of the variation was associated with factors not included in the model.

Testing of Null Hypotheses

The null hypotheses were tested at the 0.05 level of significance.

H_{01}: Basic science process skills do not significantly predict biology student teachers' academic achievement in Federal Universities of North-East Nigeria.

Table 7: ANOVA for the Predictive Contribution of Basic Science Process Skills to Academic Achievement

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	12.711	6	2.118	10.639	< .001
Residual	7.766	613	.199		
Total	20.476	619			

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The result in Table 7 shows that the regression model involving the six basic science process skills was statistically significant, F(6, 613) = 10.639, p < .001. Since the probability value is less than .05, the null hypothesis is rejected. Therefore, basic science process skills made a statistically significant joint predictive contribution to biology student teachers' academic achievement.

H_{02}: Reasoning ability does not significantly predict biology student teachers' academic achievement in Federal Universities of North-East Nigeria.

Table 8: ANOVA for the Predictive Contribution of Reasoning Ability to Academic Achievement

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	7.727	3	2.576	8.484	< .001
Residual	12.749	616	.304		
Total	20.476	619			

Table 8 shows that reasoning ability significantly predicted biology student teachers' academic achievement, F(3, 616) = 8.484, p < .001. The null hypothesis is therefore rejected. This indicates that intuitive, transitional, and reflective thinking jointly made a statistically significant predictive contribution to academic achievement.

Hypothesis Three

H_{03}: Basic science process skills and reasoning ability do not jointly make a significant predictive contribution to biology student teachers' academic achievement in Federal Universities of North-East Nigeria.

Table 9: ANOVA for the Joint Predictive Contribution of Basic Science Process Skills and Reasoning Ability to Academic Achievement

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	13.171	9	1.463	7.212	< .001
Residual	7.305	610	.203		
Total	20.476	619			

Table 9 shows that the regression model containing the six basic science process skills and the three dimensions of reasoning ability was statistically significant, F(9, 610) = 7.212, p < .001. Since the probability value is less than .05, the null hypothesis is rejected. Thus, basic science process skills and reasoning ability jointly made a statistically significant predictive contribution to biology student teachers' academic achievement in Federal Universities of North-East Nigeria.

DISCUSSION OF FINDINGS

The study found that basic science process skills significantly predicted the academic achievement of biology student teachers. The finding suggests that students who are competent in observing, measuring, classifying, communicating, inferring, and predicting are better positioned to understand and apply biological knowledge. These skills enable learners to participate actively in scientific investigations rather than depend primarily on memorisation. The finding agrees with Derilo (2019), who reported that stronger basic science process skills were associated with better science achievement. It also supports Achor et al. (2018), who found that investigative laboratory strategies improved students' acquisition of science process skills and learning outcomes.

The study also established that reasoning ability significantly predicted biology

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student teachers' academic achievement. This finding indicates that academic success in biology is related not only to what students know but also to their ability to interpret information, identify relationships, evaluate evidence, and construct logical explanations. The result agrees with Bhat (2016), who reported that reasoning ability has predictive value for academic achievement. Biology contains concepts and processes that require students to reason about evidence and relationships, making reasoning competence particularly relevant to successful learning.

The most important finding was that basic science process skills and reasoning ability jointly made a significant contribution to academic achievement. The combined model produced and explained 64.3% of the variation in biology student teachers' academic achievement. This finding suggests that scientific achievement depends on the combination of procedural competence and cognitive reasoning. Science process skills provide students with the procedures needed to observe, gather, organise, and communicate scientific information, while reasoning ability enables them to interpret that information, evaluate evidence, and draw meaningful conclusions.

The joint finding therefore extends the separate relationships reported in previous studies. While Derilo (2019) and Achor et al. (2018) emphasised the importance of science process skills, and Bhat (2016) demonstrated the predictive relevance of reasoning ability, the present study shows that the two sets of competencies may be more informative when considered together. This is particularly important for biology student teachers, who require both practical scientific competence and the intellectual capacity to explain evidence and solve biological problems.

CONCLUSION

The study concludes that science learning involves the development of both scientific skills and cognitive abilities. Science process skills and reasoning ability represent important components of biology education because they support effective engagement with scientific knowledge, inquiry, and problem-solving. Strengthening these competencies among biology student teachers is essential for preparing effective science educators who can promote meaningful learning experiences among future students.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made:

1. Biology teacher education programmes should integrate science process skills and reasoning development into their curriculum to ensure that student teachers acquire both practical and cognitive scientific competencies.
2. Lecturers should adopt inquiry-based instructional approaches that encourage students to investigate biological problems, analyze evidence, develop explanations, and apply scientific reasoning.
3. Practical laboratory activities should be strengthened in biology education programmes to provide opportunities for students to develop observation, measurement, classification, communication, inference, and prediction skills.
4. Biology lecturers should incorporate reasoning-focused learning activities such as problem-solving tasks, scientific discussions, and evidence-based explanations to improve students' analytical abilities.
5. Assessment methods should include evaluation of both science process skills and reasoning ability rather than focusing only on theoretical knowledge.
6. Universities should provide adequate laboratory resources and learning materials that support inquiry-based biology teaching and the development of scientific competencies.

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