JOURNAL OF SCIENCE TECHNOLOGY AND EDUCATION 14(1), MARCH, 2026
E-ISSN: 3093-0898, PRINT ISSN: 2277-0011; Journal homepage: www.atbufstejoste.com

Correlation between Reasoning Ability and Biology Student Teachers Academic Achievement in Federal Universities of North-East Nigeria

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ABSTRACT

This study examined the correlation between reasoning ability and academic achievement of biology student teachers in Federal Universities of North-East Nigeria. The persistent poor performance of students in biology necessitated the investigation of cognitive factors such as reasoning ability, particularly intuitive, transitional, and reflective thinking. A correlational research design was adopted. The population comprised 4,289 undergraduate biology student teachers, with a sample of 619 Part III students selected for the study. Data were collected using an adapted Lawson Classroom Science Reasoning Ability Test (LCSRAT), which was validated by experts and yielded a reliability coefficient of 0.867. Mean and standard deviation were used to answer research questions, while Pearson Product Moment Correlation (PPMC) was used to test the hypotheses at a 0.05 level of significance. Findings revealed that biology student teachers possessed high levels of intuitive, transitional, and reflective thinking. The results further showed significant positive relationships between each component of reasoning ability and academic achievement. Intuitive thinking had a moderate relationship, transitional thinking had a weak relationship, while reflective thinking showed a strong relationship with academic achievement. The study concluded that reasoning ability is a key determinant of academic achievement among biology student teachers. It was recommended that teacher education programmes should integrate instructional strategies that promote higher-order thinking skills to improve students' academic performance.

ARTICLE INFO
Article History
Received: September, 2025
Received in revised form: November, 2025
Accepted: January, 2026
Published online: March, 2026

KEYWORDS
Reasoning Ability, Intuitive Thinking, Transitional Thinking, Reflective Thinking, Academic Achievement.

INTRODUCTION

Science education is globally recognized as a critical driver of national development, technological advancement, and socio-economic transformation. It equips learners with the knowledge, skills, and competencies required to understand natural phenomena, solve real-life problems, and contribute meaningfully to society. In the twenty-first century, the importance of science education has become even more pronounced due to rapid scientific and technological changes, which demand a workforce capable of critical thinking, innovation, and evidence-based decision-making. As a result, education systems worldwide emphasize the need for effective science teaching and the preparation of competent teachers who can foster inquiry-based learning and scientific literacy among students. In Nigeria, this importance is underscored in the National Policy on Education, which asserts that no education system can rise above the quality of its teachers (FRN, 2013). This highlights the need for well-trained science teachers, particularly in core science subjects such as Biology.

Biology, as a major branch of science, plays a vital role in understanding living organisms and their interactions with the environment. It

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provides foundational knowledge essential for addressing global challenges such as climate change, food security, disease control, and environmental sustainability. Biology education also serves as a gateway to numerous professional careers, including medicine, agriculture, biotechnology, and environmental management (Eugenia & Osuafor, 2021). In Nigeria, the relevance of biology is further emphasized by the country's rich biodiversity and ecological diversity, which require scientific knowledge for proper management and conservation (Oyedunni Adebunmi & Taiwo, 2023). Furthermore, biology education is crucial in training future teachers who will, in turn, shape students' understanding of science and promote scientific literacy across generations.

Despite the importance of biology to both individual and national development, students' performance in the subject has remained consistently poor, particularly in public examinations. Reports from the West African Examinations Council (WAEC) and National Examinations Council (NECO) have shown persistent low pass rates in biology over the years. Studies such as Uuguo and Ubaoh (2020) revealed that states in North-East Nigeria, including Adamawa, Bauchi, Gombe, and Yobe, have recorded alarming levels of poor performance in biology. Similarly, Omoseebi (2021) described the trend as worrisome, noting that a significant proportion of students fail to obtain credit passes required for further studies. At the tertiary level, this challenge persists, as evidenced by Ajetomobi, Sakiyo, and Okoronka (2023), who reported low and fluctuating graduation rates among biology student teachers in federal universities, ranging between 27.5% and 41.9%. These statistics indicate a serious concern regarding the quality of learning outcomes in biology education.

Several factors have been identified as contributing to the poor academic performance of students in biology. These include inadequate teaching methods, lack of instructional materials, insufficient laboratory facilities, overcrowded classrooms, and limited exposure to practical and inquiry-based learning experiences. Wola, Rungkat, and Harindah (2023) emphasized that practical activities are essential for enhancing students' understanding of scientific concepts and developing essential skills. However, Ogbonnaya and Madu (2017) observed that many biology student teachers in Nigeria have limited opportunities for hands-on learning, which negatively affects their academic achievement. In addition to these external factors, internal cognitive factors such as students' reasoning ability have increasingly been recognized as critical determinants of academic performance.

Reasoning ability refers to the cognitive capacity to think logically, analyze information, evaluate evidence, and draw valid conclusions. It is a fundamental aspect of scientific reasoning and critical thinking, which are essential for understanding complex scientific concepts. Mathesius et al. (2016) defined scientific reasoning as the competencies required to understand how scientific knowledge is generated. Similarly, Kuhn (2016) and Feraco et al. (2023) emphasized that reasoning ability involves both cognitive and metacognitive processes necessary for problem-solving and evaluation of scientific information. In biology, reasoning ability enables students to interpret experimental results, identify relationships among variables, and construct meaningful explanations of biological phenomena (Sneddon et al., 2020; Han et al., 2023). Therefore, students with well-developed reasoning skills are more likely to achieve higher academic performance.

Reasoning ability is often categorized into three major components: intuitive thinking, transitional thinking, and reflective thinking. These categories represent different levels of cognitive development and approaches to problem-solving (Dennin et al., 2022). Intuitive thinking involves quick, experience-based judgments; transitional thinking represents a blend of intuition and analysis; while reflective thinking involves deliberate, logical, and systematic reasoning. These components are essential for understanding how students process information and respond to academic tasks, particularly in science education.

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Intuitive thinking is characterized by rapid decision-making based on instincts, prior experiences, and subconscious processing (Sternberg, 2013; Călin, 2024). It allows student teachers to generate ideas quickly, make connections between concepts, and respond effectively to immediate classroom situations. Studies have shown that intuitive thinking can positively influence academic performance by enhancing creativity, adaptability, and engagement (Henriksen, Richardson, & Shack, 2020). However, its reliance on instinct rather than systematic analysis may lead to errors, biases, and superficial understanding of complex scientific concepts. This limitation suggests the need for a more balanced approach, leading to the concept of transitional thinking.

Transitional thinking represents an intermediate stage between intuitive and reflective thinking. It involves the ability to combine quick intuitive responses with logical analysis and critical evaluation (Jiang, 2023). Transitional thinkers are able to connect theoretical knowledge with practical experiences, making them more effective in applying learned concepts. Research indicates that transitional thinking positively influences academic achievement by promoting adaptability, deeper understanding, and improved problem-solving skills (Aderemi & Abiona, 2024; Thinh, 2025). This form of thinking enables student teachers to respond to classroom challenges while simultaneously reflecting on their actions, thereby enhancing both learning outcomes and teaching effectiveness. The progression from transitional thinking naturally leads to reflective thinking, which represents a higher level of reasoning.

Reflective thinking is a higher-order cognitive process that involves careful analysis, evaluation, and logical reasoning. It is associated with the ability to think abstractly, consider hypothetical situations, and engage in systematic problem-solving (Hancock, 2023). Reflective thinkers critically evaluate their learning experiences, identify gaps in understanding, and make informed decisions. Studies have consistently shown a positive relationship between reflective thinking and academic achievement, as it promotes deeper understanding, knowledge retention, and effective application of concepts (Chamdani et al., 2022; Chen & Bergner, 2021). Reflective thinking also enhances self-awareness and self-regulation, enabling student teachers to continuously improve their academic and professional performance (Shu & Gu, 2023). Although it may require more time and effort, its contribution to meaningful learning and academic success is significant.

The need for this study is justified at multiple levels. Globally, there is increasing emphasis on developing higher-order thinking skills, including reasoning ability, as essential competencies for the twenty-first century. Educational systems are shifting from rote learning to approaches that promote critical thinking, problem-solving, and inquiry-based learning. In Nigeria, the persistent poor performance of students in biology, coupled with concerns about the quality of teacher preparation, highlights the need to investigate cognitive factors such as reasoning ability that influence academic achievement.

In North-East Nigeria, particularly in states like Adamawa, the situation is more critical due to consistent reports of low performance in biology and other science subjects. Despite various interventions aimed at improving science education, little attention has been given to the role of reasoning ability in shaping students' academic outcomes. Therefore, this study seeks to examine the correlation between reasoning ability specifically intuitive, transitional, and reflective thinking and the academic achievement of biology student teachers in Federal Universities of North-East Nigeria, with a view to providing empirical evidence that can inform teaching practices, curriculum development, and policy decisions.

STATEMENT OF THE PROBLEM

Biology is a fundamental science subject that contributes significantly to national development through its applications in health, agriculture, environmental sustainability, and technological advancement. It also serves as a foundation for training professionals and teachers

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who are expected to promote scientific literacy and innovation. However, despite its recognized importance, students' academic performance in biology has remained persistently poor in Nigeria. Reports from examination bodies such as WAEC and NECO have consistently indicated low pass rates in biology, particularly in the North-East region.

Empirical studies by Uuguo and Ubaoh (2020) revealed that states such as Adamawa, Bauchi, Gombe, and Yobe continue to record alarming levels of poor performance, while Omoseebi (2021) described the trend as a major educational concern. At the tertiary level, Ajetomobi, Sakiyo, and Okoronka (2023) further reported low and fluctuating graduation rates among biology student teachers, ranging from 27.5% to 41.9%, suggesting challenges in students' academic achievement and teacher preparation.

Several factors have been identified as contributing to this persistent poor performance. These include inadequate teaching methods, lack of instructional materials, insufficient laboratory facilities, overcrowded classrooms, and limited opportunities for practical and inquiry-based learning. Wola, Rungkat, and Harindah (2023) emphasized that practical activities are essential for enhancing understanding and improving performance in science subjects, while Ogbonnaya and Madu (2017) observed that many biology student teachers in Nigeria have limited access to such experiences. Although these external factors are significant, recent studies have increasingly highlighted the role of internal cognitive factors, particularly reasoning ability, as a critical determinant of students' academic achievement.

Reasoning ability, defined as the capacity to think logically, analyze information, and draw valid conclusions, is central to scientific learning (Mathesius et al., 2016). It enables students to interpret experimental data, evaluate evidence, and solve problems effectively in biology (Sneddon et al., 2020; Han et al., 2023). Scholars such as Kuhn (2016) and Feraco et al. (2023) have emphasized that reasoning ability forms the basis of critical thinking and is essential for meaningful learning in science. However, when students lack adequate reasoning skills, they often struggle to understand complex biological concepts, leading to poor academic performance. Reasoning ability is commonly categorized into intuitive, transitional, and reflective thinking (Dennin et al., 2022).

Intuitive thinking involves rapid, experience-based judgments, which, although useful for quick decision-making, may lead to superficial understanding and errors if not complemented by deeper analysis (Sternberg, 2013; Henriksen, Richardson, & Shack, 2020). Transitional thinking represents a balance between intuitive and analytical thinking, enabling students to connect theory with practice and make more informed decisions (Jiang, 2023; Aderemi & Abiona, 2024). Reflective thinking, on the other hand, involves deliberate and critical analysis of information, which has been shown to significantly enhance understanding, retention, and academic achievement (Chamdani et al., 2022; Chen & Bergner, 2021).

Despite the established importance of reasoning ability in science education, there is limited empirical evidence on how these dimensions of reasoning—intuitive, transitional, and reflective thinking relate to the academic achievement of biology student teachers in Federal Universities of North-East Nigeria. Most existing studies have focused on external factors affecting performance, with little attention given to cognitive variables that directly influence learning outcomes. This gap in knowledge makes it difficult to design effective instructional strategies that target students' thinking processes. Therefore, the problem of this study lies in the persistent poor academic achievement of biology student teachers in North-East Nigeria and the insufficient understanding of how reasoning ability contributes to this issue. Specifically, there is a need to investigate the relationship between intuitive, transitional, and reflective thinking and students' academic performance. Addressing this problem is crucial for improving biology education, enhancing teacher preparation, and promoting better learning outcomes in the region.

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Objectives of Study

The purpose of the study is to investigate correlation between Reasoning Ability of Biology student Teachers and academic achievement in Federal Universities of North East Nigeria. The Specific Objectives of the study are to determine:

1. correlation between intuitive thinking and Biology students' teacher's academic achievement in Federal universities of north east Nigeria
2. correlation among mean score of transitional thinking and Biology student-teachers academic achievement in Federal universities of north east Nigeria
3. correlation between reflective thinking and Biology student-teachers academic achievement in federal universities of North-East Nigeria.

Research Questions

The following research questions were drawn in line with the objectives to guide the study:

1. What is the Level of Intuitive thinking of biology student-teachers in Universities of North East Nigeria?
2. What is the Level of Transitional thinking of biology student-teachers in Federal Universities of North East Nigeria?
3. What is the Level of Reflective thinking of biology student-teachers in Federal Universities of North East Nigeria?

Hypotheses

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

H_{01} There is no significant correlation between intuitive thinking ability and academic achievement of biology student-teachers in Federal Universities of North East Nigeria.

H_{02} There is no significant correlation between transitional thinking ability and academic achievement of undergraduate biology student-teachers in Federal Universities of North East Nigeria.

H_{03}. There is no significant correlation between reflective thinking ability and biology student-teachers academic achievement in Federal Universities of North East Nigeria.

LITERATURE REVIEW

Reasoning ability is a fundamental cognitive skill that underpins learning, problem-solving, and academic achievement, particularly in science education. It involves the capacity to think logically, analyze information, evaluate evidence, and draw meaningful conclusions. Scholars describe scientific reasoning as the set of competencies required to understand how scientific knowledge is generated, making it a crucial component of critical thinking. In biology education, reasoning ability enables students to move beyond memorization to deeper understanding through hypothesis formation, data interpretation, and evidence-based conclusions. For biology student teachers, this skill is essential not only for academic success but also for effective teaching and the development of scientific literacy among learners.

Reasoning ability is commonly categorized into three levels: intuitive, transitional, and reflective thinking. Intuitive thinking is characterized by fast, experience-based decision-making. It allows student teachers to respond quickly to classroom situations, generate creative ideas, and make connections between concepts. Studies have shown that intuitive thinking can positively influence academic achievement by enhancing adaptability and engagement. However, its limitations include susceptibility to bias, lack of analytical depth, and difficulty in justifying decisions logically. Therefore, while it contributes to academic performance, it is most effective when combined with more analytical forms of thinking.

Transitional thinking represents a blend of intuitive and reflective thinking. Individuals at this level can balance quick insights with logical analysis, enabling them to approach problems more flexibly. Transitional thinkers are capable of linking theoretical knowledge with practical experiences, which enhances their understanding of subject matter and improves academic performance. This type of thinking also promotes adaptability, critical analysis, and the development

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of science process skills. Empirical studies indicate that transitional thinking has a positive relationship with academic achievement, as it helps student teachers make informed decisions and adjust effectively to dynamic learning environments.

Reflective thinking is a higher-order cognitive process involving careful analysis, evaluation, and logical reasoning. Reflective thinkers engage in deep thinking, consider multiple perspectives, and make well-informed judgments. This form of thinking is strongly associated with improved academic achievement, as it promotes deeper understanding, knowledge retention, and effective problem-solving. It also enhances self-awareness and self-regulation, enabling student teachers to evaluate their learning and teaching practices and continuously improve. Although reflective thinking may sometimes lead to slower decision-making, its role in fostering critical thinking and meaningful learning is significant.

METHODOLOGY

This study adopted a correlational research design to examine the relationship between reasoning ability and the academic achievement of biology student teachers in Federal Universities of North-East Nigeria. The design was considered appropriate because it enables the determination of the degree and direction of relationship among variables without manipulating them. The target population of the study consisted of 4,289 undergraduate biology student teachers in conventional Federal Universities located in North-East Nigeria. From this population, a sample of 619 Part III biology student teachers was selected for the study.

Data were collected using an instrument adapted from Benford, Russell, Lawson, and Anton (2001), known as the Lawson Classroom Science Reasoning Ability Test (LCSRAT). The instrument was subjected to validation by three experts, two from the Department of Environmental and Life Sciences Education, Modibbo Adama University, Yola, and one from the Department of Science Education (Biology Education), Abubakar Tafawa Balewa University, Bauchi to ensure its content and face validity.

The reliability of the instrument was determined using Cronbach's Alpha method, which yielded a reliability coefficient of 0.867, indicating a high level of internal consistency. Data collected were analyzed using mean and standard deviation to answer the research questions, while Pearson Product Moment Correlation (PPMC) was employed to test the hypotheses at a 0.05 level of significance.

RESULTS

Research Question 1.

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

Table 1: Mean and Standard Deviation of mean score of Intuitive Thinking science process skills acquisition by biology student teachers in Federal Universities of North-East Nigeria.

N=619		Mean	SD	Remark
1.	I often rely on my gut feeling when approaching new biology topics.	4.71	.68	VHL
2.	I can sense the outcome of a biology experiment before doing it.	2.69	1.41	ML
3.	I learn biology better when I follow my natural instincts.	4.65	.56	VHL
4.	I prefer understanding the big picture before details.	3.91	1.13	HL
5.	I quickly grasp new biological ideas even without full explanation.	4.43	.88	HL
6.	I come up with biological explanations without conscious reasoning.	3.91	1.17	HL
7.	I use common sense when solving biology-related problems.	2.95	1.53	ML
8.	I trust my instincts in unfamiliar science tasks.	4.65	.56	VHL
9.	I think fast in biological problem-solving situations.	3.76	1.23	HL
10.	I make good guesses in biology tests even with little information.	3.28	1.50	HL
Grand Mean		**3.89**	**1.06**	**HL**

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Presentation of the results in Table 1 shows the range of 2.69-4.71 respectively. 3.89 mean average and 1.07 standard deviation indicated that, the Intuitive Thinking science process skills of student-teachers in Federal Universities of North-East Nigeria is high.

Research Question 2.
What is the level of Transitional Thinking science process skills acquisition by biology student teachers in Federal Universities of North-East Nigeria.?

Table 2: Mean and Standard Deviation of Transitional Thinking science process skills acquisition by biology student teachers in Federal Universities of North-East Nigeria.

N=619		Mean	SD	Remark
1.	I try to balance intuition and logical thinking in biology.	3.76	1.25	HL
2.	I consider different points of view in biological discussions.	2.86	1.02	ML
3.	I build on my past knowledge when learning new biology concepts.	4.43	.88	HL
4.	I modify my ideas when I get new biological evidence.	3.76	1.23	HL
5.	I combine feelings and facts in making biology decisions.	4.08	1.09	HL
6.	I shift from vague understanding to clear knowledge during study.	3.13	1.73	ML
7.	I understand when an idea in biology needs further clarification.	3.17	.79	ML
8.	I adjust my thinking during complex biology lessons.	3.10	1.41	ML
9.	I can identify when I'm moving from guesswork to deeper reasoning.	2.73	1.58	ML
10.	I build bridges between what I know and what I don't know in biology.	4.00	1.05	HL
Grand Mean		**3.50**	**1.207**	**HL**

The descriptive statistics in Table 2 shows 619 respondents responded to the 10 items on the instrument indicating Transitional Thinking science process skills of student-teachers with the range of 2.73-4.43 whereas, 3.51 mean average and 1.21 standard deviation indicated that, the Transitional Thinking science process skills of student-teachers in Federal Universities of North-East Nigeria is high.

Research Question 3.
What is the level of Reflective Thinking science process skills acquisition by biology student teachers in Federal Universities of North-East Nigeria?

Table 3: Mean and Standard Deviation of Reflective Thinking science process skills acquisition by biology student teachers in Federal Universities of North-East Nigeria.

N=619		Mean	SD	Remark
1.	I think deeply about my biology learning after each lesson.	4.43	.88	HL
2.	I analyze my mistakes after biology tests.	3.93	1.18	HL
3.	I think about how to improve in biology.	3.10	1.53	HL
4.	I reflect on the strategies I use to solve biology problems.	3.00	1.69	ML
5.	I take time to review my biology class notes.	4.71	.68	VHL
6.	I evaluate how well I understand biology concepts.	2.69	1.41	ML
7.	I question the accuracy of my biology knowledge.	4.65	.56	VHL
8.	I rethink my answers after biology class discussions.	3.91	1.13	HL
9.	I compare my biology learning with previous experiences.	4.43	.88	HL
10.	I review what I have learned to strengthen my understanding.	3.91	1.17	HL
Grand Mean		**3.88**	**1.11**	**HL**

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The statistical analysis in Table 3 indicates the range of 2.69-4.71 respectively. 3.88 mean average and 1.12 standard deviation shows that, the Reflective Thinking science process skills of student-teachers in Federal Universities of North-East Nigeria is high.

Hypotheses:

HO_1: there is no significant relationship between intuitive science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria.

Table 4: PPMC of relationship between intuitive science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria

	n	Mean	Std. Deviation	Sig	r
Intuitive	619	3.78	1.12		
				0.00	0.51
Academic Achievement	619	3.79	.674		

The PPMC in Table 4 show significant relationship between intuitive science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria, P < 0.05. Since the computed p-value (0.00) is less than 0.05 level of significance, therefore the null hypothesis is rejected and concluded that, there is significant relationship between intuitive science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria. Furthermore, the r-value indicates that, 5.1 of biology student-teachers academic achievement in Universities of North East Nigeria. in this study moderate intuitive science process skill acquisition was accounted.

HO_2: there is no significant relationship between Transitional science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria.

Table 5. PPMC of relationship between transitional science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria

	n	Mean	Std. Deviation	Sig	r
Transitional	619	3.51	1.21		
				0.00	0.36
Academic Achievement	619	3.79	.674		

In Table 5 show significant relationship between transitional science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria, P < 0.05. Since the computed p-value (0.00) is less than 0.05 level of significance, therefore the null hypothesis is rejected and concluded that, there is significant relationship between transitional science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria. Furthermore, the r-value of 3.6 shows weak positive relationship between biology student-teachers academic achievement in Federal Universities of North East Nigeria in this study is accounted for by transitional science process skill acquisition.

HO_3: there is no significant relationship between reflective science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria.

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Table 6: PPMC of relationship between reflective science process skill acquisition and biology student-teachers academic achievement federal in Universities of North East Nigeria

	n	Mean	Std. Deviation	Sig	r
Reflective	619	3.51	1.21		
				0.00	0.61
Academic Achievement	619	3.79	.674		

The PPMC in Table 6 show significant relationship between reflective science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria, ($P < 0.05$. Since the computed p-value 0.00) is less than 0.05 level of significance, therefore the null hypothesis is rejected and concluded that, there is significant relationship between reflective science process skill acquisition and biology student-teachers academic achievement in Federal Universities of North East Nigeria. Furthermore, the r-value of 6.1 indicate strong positive relationship between reflective science process skill acquisition and biology student-teachers academic achievement in Universities of North East Nigeria.

FINDINGS OF THE STUDY

1. Mean and Standard Deviation of Intuitive Thinking science process skills acquisition by biology student teachers in Federal Universities of North-East Nigeria, 3.89 and 1.01 respectively. There is significant relationship between intuitive thinking and academic achievement of biology student-teachers in Universities of North East Nigeria ($F_{(6, 613)} = 10.64$, $p = 0.000$)
2. Mean and Standard Deviation of mean score of Intuitive Thinking science process skills acquisition by biology student teachers in Federal Universities of North-East Nigeria, 3.50 and 1.21 respectively. There is significant relationship between transitional thinking mean score and academic achievement of undergraduate biology student-teachers in Federal Universities of North- East Nigeria ($p=0.00 <0.05$).
3. Mean and Standard Deviation of Reflective Thinking science process skills acquisition by biology student teachers in Federal Universities of North-East Nigeria, 3.88 and 1.11, respectively. There is significant relationship between mean reflective thinking mean score and biology student-teachers academic achievement in federal Universities of North East Nigeria ($p=0.00 < 0.05$).

DISCUSSION OF FINDINGS

The study identified a significant relationship between intuitive thinking and academic achievement among biology student teachers. This finding suggests that students who rely on gut feelings or instinctive reasoning also demonstrate meaningful performance in academic settings, albeit at a basic level. Intuitive thinking, in the context of scientific reasoning, refers to quick, non-analytical judgments often based on prior experience. While it may lack the structured logic of formal reasoning, intuition plays a role in initial hypothesis generation, problem recognition, and early pattern detection. This finding mirrors observations by Zhou et al. (2021), who identified that intuitive thinkers, while often lacking in full logical explanations, could still demonstrate partial understanding of science concepts.

Similarly, Bhat (2016) noted that students with intuitive reasoning ability were able to perform moderately well in science, especially when questions aligned with prior knowledge or familiarity. While intuition alone is insufficient for deep scientific analysis, it acts as a scaffold toward higher-level reasoning. According to Lawson's theory of cognitive development, intuitive thinking is characteristic of learners in the concrete operational stage, from which they may transition to more formal operational thinking with experience and training. The implication here is

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that intuitive thinking should not be dismissed but rather cultivated and refined. Instructors can build on students' intuitive responses by prompting them to explain their reasoning, compare it with evidence, and shift toward formal logic. This scaffolding approach supports cognitive growth and academic improvement.

A statistically significant relationship also found between transitional thinking and academic achievement. Transitional thinking is a stage between intuitive (concrete) and formal reasoning, where students begin to apply logic, though not yet consistently or accurately. This finding supports Khoirina and Cari (2018) and Firdaus et al. (2022), who found that a majority of pre-service biology teachers operated at the transitional reasoning level. These students often performed moderately in science achievement, with room for growth through structured interventions. Zulkipli et al. (2020) further reported that transitional thinkers among Malaysian pre-service teachers showed potential in scientific reasoning but required targeted support to reach formal reasoning levels. Transitional thinkers are capable of forming hypotheses and controlling variables, though they may struggle with abstract principles or contradictory data. Educationally, this is a critical developmental stage. Students at the transitional level benefit from learning environments that promote questioning, experimentation, and structured reasoning practice.

Tools like inquiry-based labs, guided discussions, and reflective writing tasks can help consolidate their emerging logic. The correlation found in this study implies that students in the transitional stage are beginning to connect ideas logically, which reflects in their academic performance. However, without proper pedagogical support, they may plateau. Therefore, curricula should incorporate metacognitive strategies that encourage students to reflect on their thought processes and refine their logical structures.

The finding also showed a strong and significant relationship between relative/formal thinking and academic achievement. This indicates that students who reason at the formal operational level consistently perform better in biology. Formal thinking, according to Piaget's theory, is the highest level of cognitive development, characterized by abstract reasoning, hypothesis testing, and deductive logic. In biology, this manifests in understanding systems, predicting multivariable interactions, analyzing experimental errors, and applying models to unfamiliar contexts. This finding aligns with the work of Khan and Krell (2021) and Luo et al. (2020), who confirmed that students operating at the formal level were better at designing experiments, reasoning with evidence, and achieving high scores in science.

Anderson (2017) also emphasized the predictive power of formal reasoning for success in upper-level science courses. Zhou et al. (2021) identified formal thinkers as those who consistently answered both content and reasoning questions correctly on the Lawson test, mirroring the performance of high-achieving students. In this study, the correlation between formal reasoning and academic success among Nigerian biology student teachers reinforces this global pattern. This result has important implications for science education. Teaching strategies must be designed to stimulate abstract thinking and logical problem-solving. Activities such as advanced inquiry, simulations, debates on scientific ethics, and open-ended laboratory experiments can nurture formal reasoning.

CONCLUSION

The study concludes that reasoning ability is a significant determinant of academic achievement among biology student teachers in Federal Universities of North-East Nigeria. The ability of students to think intuitively, transitionally, and reflectively contributes meaningfully to their understanding of biological concepts and overall academic performance. This suggests that cognitive processes involved in reasoning are essential for effective learning in biology, which is inherently analytical and concept-driven.

The study therefore underscores the importance of integrating instructional approaches that promote higher-order thinking skills within biology teacher education programmes.

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Enhancing students' reasoning abilities will not only improve their academic achievement but also better prepare them to become effective science educators capable of fostering critical thinking and scientific literacy in their future classrooms.

RECOMMENDATIONS

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

1. Biology educators and teacher training institutions should incorporate instructional strategies such as brainstorming, simulations, and real-life problem-solving activities that harness students' intuitive thinking, while also guiding them to justify their ideas logically to enhance academic achievement.
2. Curriculum planners and lecturers should design learning experiences that integrate both practical and theoretical components, such as inquiry-based and experiential learning, to strengthen students' ability to balance intuitive insights with analytical reasoning for improved academic performance.
3. Teacher education programmes should emphasize reflective practices such as self-assessment, journaling, and peer evaluation, enabling student teachers to critically analyze their learning experiences and continuously improve their understanding and academic outcomes in biology.

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