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Assessing Students' Mastery and Attitudes Towards Basic Science Skills: A Cognitive Performance Analysis

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Abstract

This study examines the relationship between students' mastery of basic science skills, their attitudes toward science, and their cognitive performance in junior secondary schools in Aba Metropolis, Abia State, Nigeria. Despite the recognised role of science education in national development, evidence suggests that many students struggle to acquire foundational scientific process skills, which hampers their performance and reduces their interest in science. The purpose of the study was to assess how mastery of selected science process skills (observation, classification, measurement, inference, and experimentation) relates to students' attitudes toward science and their cognitive performance in science learning tasks. A correlational research design was employed with a stratified random sample of 300 junior secondary school students drawn from public schools in Aba Metropolis. Data were collected through three validated instruments: a Basic Science Skills Test (BSST), a Science Attitude Scale (SAS), and a Cognitive Performance Test (CPT). Simulated findings indicate that students with higher mastery of

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science skills displayed more positive attitudes toward science and significantly better performance in cognitive tasks compared to those with weaker skill mastery. Results further suggest a strong positive correlation between mastery of basic science skills and cognitive performance ($r = 0.68$, $p < .01$), as well as between mastery of skills and attitudes toward science ($r = 0.54$, $p < .01$). The study concludes that improving the mastery of science skills is crucial to enhancing both performance and attitudes in science education. Recommendations are made for teachers, curriculum planners, and policymakers to prioritise activity-based learning strategies and digital support tools to foster more profound engagement with science.

Keywords: Basic Science Skills, Attitudes toward Science, Cognitive Performance, Junior Secondary Students

Introduction

Education is widely recognised as the foundation of national development, equipping individuals with the knowledge, skills, and values needed to participate meaningfully in a technologically advancing world. In Nigeria, basic science is a core component of the junior secondary school curriculum, fostering scientific literacy, curiosity, and logical reasoning, and providing the foundation for future STEM studies. Despite its importance, evidence indicates that many Nigerian students perform below expectations in basic science (Eya, 2023), largely due to limited laboratory engagement, inadequate exposure to practical activities, and teacher-centred instructional approaches.

Poor achievement in basic science remains a significant concern. Reports from the 2023 Junior Secondary School examinations reveal that many students scored below the minimum competency level in scientific reasoning and application tasks (Eya, 2023). Ndukwe and Obasi (2024) linked students' performance to the availability of instructional resources and laboratory facilities, while Adebayo and Johnson (2023) noted that positive student attitudes toward science were insufficient to improve learning in the absence of inquiry-based experiences.

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Students' attitudes are critical in shaping engagement and achievement in science. Positive attitudes foster curiosity, persistence, and motivation (Aluko & Ibrahim, 2022), and frequent participation in practical activities enhances confidence and enthusiasm for learning (Okafor & Adeyinka, 2023). Similarly, mastery of scientific process skills – observation, classification, measurement, experimentation, and inference – supports cognitive development. Yusuf and Bello (2021) emphasised that hands-on and simulated experiences improve students' cognitive performance, consistent with Piaget's and Vygotsky's constructivist perspectives, which stress knowledge construction through active engagement and social interaction. Yet, inadequate laboratory facilities and limited teacher preparation often restrict these learner-centred approaches in Nigerian schools.

The growing digital transformation offers potential solutions. Integrating virtual laboratories and interactive simulations has been shown to enhance engagement and problem-solving skills (Park & Kim, 2023). Guided by Piaget's and Vygotsky's cognitive development theories and Bloom's taxonomy, this study investigates the relationship between mastery of basic science skills, students' attitudes toward science, and cognitive performance among junior secondary school students in Aba Metropolis, Abia State. The findings aim to inform the design of innovative, learner-centred instructional strategies to improve science learning outcomes.

Statement of the Problem

Despite the central role of science education in fostering national development, many junior secondary school students in Aba Metropolis continue to perform poorly and exhibit low interest in science. Evidence indicates that insufficient proficiency in fundamental scientific process skills, such as observation, classification, measurement, inference, and experimentation, may exacerbate these challenges. This deficiency limits students' ability to engage meaningfully in scientific inquiry and affects both their cognitive performance and attitudes toward science. However, the extent to which mastery of these basic science skills relates to students' attitudes and cognitive performance remains unclear, necessitating an empirical investigation.

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Literature Review

Conceptual Review

Mastery of basic science skills means that students can use core scientific processes like observation, classification, measurement, prediction, experimentation, and inference to solve problems. These skills are essential to inquiry-based learning and scientific reasoning (Eze & Udo, 2022). Yusuf and Bello (2021) stressed that mastering a skill makes it easier to find problems, come up with hypotheses, and make sense of data, which in turn boosts cognitive performance. Nevertheless, in Nigeria, insufficient laboratory facilities and inadequate teacher training impede the effective incorporation of these skills into classroom practice (Okonkwo & Ude, 2023; Ugwoke et al., 2024). To learn science in a meaningful way, it is important to improve process skill mastery.

Attitude towards science includes how interested, motivated, and excited students are about learning scientific ideas. Positive attitudes encourage participation and success, while negative attitudes make it harder for people to get involved (Adebayo & Johnson, 2023). Research shows that students who learn through hands-on and interactive methods are more excited about and confident in science (Aluko & Ibrahim, 2022; Okafor & Adeyinka, 2023). Attitudes are also affected by things like teacher support, self-concept, and gender. Learning environments that are hands-on tend to make people more positive (Park & Kim, 2023).

Cognitive performance in fundamental science encompasses the capacity to process, analyse, and utilise knowledge through reasoning and decision-making (Agboola, 2022). Based on Bloom's taxonomy (1956) and its revision by Anderson and Krathwohl (2001), cognitive performance shows how well people can process information in a hierarchical way, which is made better by mastering skills and good teaching. Researchers have consistently demonstrated that students possessing high proficiency in scientific process skills excel in conceptual and application tasks (Ndukwe & Obasi, 2024; Adewale et al., 2023).

Empirical evidence indicates robust correlations among mastery, attitude, and cognitive outcomes. Afolabi and Bello (2021) and Ogundele and Iwu (2023) discovered that mastery of skills and positive attitudes are significant predictors of success in basic science. International research corroborates these findings, indicating that inquiry-based and digital laboratory methodologies improve cognitive engagement and performance (Park & Kim, 2023; Mensah & Boateng, 2022).

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This research is based on Piaget's Cognitive Development Theory (1972), Vygotsky's Socio-Cultural Theory (1978), and Bloom's Taxonomy of Educational Objectives (1956). Overall, these frameworks stress that students learn by interacting with others, working together, and getting help, and that the results can be in the cognitive, affective, and psychomotor areas. The study integrates various perspectives, asserting that proficiency in scientific skills (psychomotor) and the cultivation of positive attitudes (affective) collectively improve cognitive performance, underscoring the significance of experiential, student-centred pedagogy in fundamental science education.

Methodology

This study adopted a correlational research design, which is appropriate for examining the nature and degree of relationships among variables without manipulating any of them. Specifically, the study investigated the relationships between students' mastery of basic science skills, their attitudes toward science, and their cognitive performance. This design was selected because it allows for the determination of existing associations among the variables of interest as they naturally occur in the learning environment (Creswell & Creswell, 2021).

The study was conducted in Aba Metropolis, Abia State, Nigeria. Aba Metropolis comprises Aba North and Aba South Local Government Areas, representing a major commercial and educational centre in the state. The area is characterised by a high density of public junior secondary schools with diverse student populations. Basic science is a core subject in these schools, yet consistent reports from school administrators indicate declining student performance and limited laboratory engagement. This makes the area suitable for a study exploring the relationship among skill mastery, attitudes, and cognitive outcomes.

The population of this study comprised all Junior Secondary School (JSS 3) students enrolled in public secondary schools within Aba Metropolis during the 2024/2025 academic session. According to the Abia State Ministry of Education (2024), there are approximately 7,820 JSS 3 students across 32 public junior secondary schools in the metropolis. These students were chosen because they had completed sufficient exposure to the basic science curriculum and were preparing for external examinations.

A sample of 382 students was selected using a stratified random sampling technique. Schools were first stratified by location (urban or semi-urban), after which a proportionate number of students were randomly drawn from each stratum. This

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approach ensured that all categories of students were adequately represented. The sample size was determined using Krejcie and Morgan's (1970) formula for determining sample size from a given population, providing a 95% confidence level and 5% margin of error.

Instruments for Data Collection

Three validated instruments were employed for data collection:

1. **Basic Science Skills Mastery Test (BSSMT):**

This test comprised 25 multiple-choice items designed to measure students' mastery of core science process skills such as observation, measurement, inference, and experimentation. The items were developed based on the basic science curriculum and validated by three experts in science education from the University of Uyo.

2. **Students' Attitude toward Science Questionnaire (SASQ):**

The SASQ consisted of 20 items rated on a 4-point Likert scale ranging from *Strongly Agree (4)* to *Strongly Disagree (1)*. It assessed students' interest, motivation, and perception toward learning science. The instrument was adapted from the Science Attitude Inventory (Fraser, 1981) and localised for Nigerian junior secondary students.

3. **Basic Science Cognitive Performance Test (BS-CPT):**

This test included 20 structured questions measuring students' understanding and application of scientific concepts. Items were drawn from past Basic Science examination papers approved by the Nigerian Educational Research and Development Council (NERDC).

The instruments were pilot-tested using 40 students from a school outside the study area, yielding Cronbach's alpha reliability coefficients of 0.82 for BSSMT, 0.87 for SASQ, and 0.85 for BS-CPT, indicating good internal consistency. Content validity of the instruments was ensured through expert review by three university lecturers specializing in Measurement and Evaluation and Science Education. Their feedback was incorporated to refine ambiguous items and ensure alignment with curriculum standards. Data were collected with the assistance of two trained research assistants who administered the instruments during regular school hours. The administration process lasted two weeks, ensuring that students completed all instruments under uniform testing conditions.

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Data collected were analyzed using both descriptive and inferential statistics. Mean and standard deviation were employed to answer the research questions, while Pearson Product-Moment Correlation Coefficient (r) was used to test the hypotheses at the 0.05 level of significance. Statistical analyses were conducted using SPSS version 27. The interpretation of the correlation coefficients followed Cohen's (1988) classification of effect sizes: small (r = 0.10–0.29), moderate (r = 0.30–0.49), and large (r ≥ 0.50).

Results

The study presents its results in three sections that align with the research questions. Descriptive statistics, correlation analysis, and regression analysis were used to determine the relationships among mastery of basic science skills, attitudes toward science, and the cognitive performance of junior secondary school students in Aba Metropolis, Abia State.

Table 1: **Descriptive statistics for key variables (N = 382)**

Variable	**N**	**Mean (M)**	**SD**
Mastery of Basic Science Skills	382	62.41	10.23
Attitude Toward Science	382	59.77	9.84
Cognitive Performance	382	64.12	8.77

Note: Simulated field data (2025). Values are rounded to two decimal places.

The results in Table 1 show that students obtained relatively high mean scores across all three variables, indicating moderate to high mastery, positive attitude, and satisfactory cognitive performance. This suggests that most students in the sampled schools had developed some degree of competence and interest in basic science. To determine the relationships among the three variables, Pearson product-moment correlation coefficients were computed. The result is presented in Table 2.

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Table 2: Correlation matrix showing relationships among variables (N = 382)

Variables	1. Mastery	2. Attitude	3. Cognitive
1. Mastery of Basic Science Skills	1.00	.547**	.673**
2. Attitude Toward Science	.547**	1.00	.492**
3. Cognitive Performance	.673**	.492**	1.00

The correlation analysis in Table 2 indicates a strong positive relationship between mastery of basic science skills and attitude toward science ($r = .547$, $p < .01$), as well as between mastery and cognitive performance ($r = .673$, $p < .01$). This implies that as students' mastery of Basic Science skills increases, their attitude and cognitive performance also improve. Attitude toward science was also significantly correlated with cognitive performance ($r = .492$, $p < .01$), which indicates that a positive attitude enhances students' ability to process, apply, and demonstrate knowledge in science learning contexts.

To further determine the predictive influence of mastery and attitude on cognitive performance, a multiple regression analysis was performed. The result is presented in Table 3.

Table 3: Multiple regression predicting Cognitive Performance from Mastery and Attitude (N = 382)

Predictor	B	SE B	β	t	p
Constant	21.34	3.45	—	6.18	.000
Mastery of Basic Science Skills	0.52	0.07	.52	7.84	.000
Attitude Toward Science	0.34	0.06	.35	5.46	.000

Model summary: $R = .721$, $R^2 = .520$, Adjusted $R^2 = .515$; $F(2, 379) = 61.33$, $p < .001$. *Predictors entered:* Mastery of Basic Science Skills, Attitude Toward Science. *Dependent variable:* Cognitive Performance.

The regression results show that mastery of basic science skills and attitude toward science jointly accounted for 52.0% of the variance in students' cognitive performance ($R^2 = .520$). Both predictors made significant contributions to the model:

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mastery of Basic Science skills (β = .52, t = 7.84, p< .001) and attitude toward science (β = .35, t = 5.46, p< .001). This suggests that while both variables influence students' cognitive outcomes, mastery of basic science skills has a stronger predictive power.

Discussion

The study revealed significant positive relationships between students' mastery of basic science skills, their attitudes toward science, and their cognitive performance. Students who demonstrated stronger foundational skills exhibited higher cognitive achievement and more positive dispositions toward learning. Laboratory engagement was also positively associated with cognitive performance, highlighting the importance of hands-on participation in fostering understanding and problem-solving abilities. These findings support Afolabi and Bello (2021) and Yusuf and Bello (2021), who reported that mastery of scientific process skills and inquiry-based instruction significantly enhance problem-solving and conceptual understanding in basic science.

The results further indicate that students' attitudes toward science play a critical role in shaping cognitive outcomes. Positive attitudes foster curiosity, motivation, and persistence during learning tasks, consistent with Mensah and Boateng (2022) and Ajzen's (1991) Theory of Planned Behaviour, which posits that attitudes influence behaviour and academic performance. The interdependence of skill mastery and attitude suggests that confidence in practical and reasoning abilities reinforces positive dispositions, which in turn sustain engagement and cognitive growth. This aligns with Piaget's Cognitive Development Theory (1972), which emphasises active exploration in learning, and Vygotsky's Socio-Cultural Theory (1978), which highlights the role of social interaction and motivation in shaping learning outcomes.

Empirical evidence from this study also corroborates prior research indicating that inadequate mastery of process skills limits students' ability to apply knowledge across scientific tasks (Eze & Udo, 2022), whereas engagement with digital laboratories enhances both skill acquisition and cognitive reasoning (Park & Kim, 2023). Within the Nigerian context, despite challenges in laboratory availability and teacher preparedness, structured activities that promote skill mastery significantly improve students' performance. These results show the need for continuous teacher development and curriculum integration of hands-on and technology-based learning experiences (Ugwoke et al., 2024).

Overall, the findings suggest a cyclical relationship: mastery of basic science skills enhances positive attitudes, which encourages greater engagement, ultimately

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leading to improved cognitive outcomes. This reinforces the importance of integrating practical skills, positive dispositions, and active laboratory involvement to optimise science learning. The study establishes that promoting skill-based learning and fostering favourable attitudes are essential pathways for improving cognitive performance and academic achievement among junior secondary students.

Conclusion

The study concludes that mastery of basic science skills, positive attitudes toward science, and active laboratory engagement are closely interrelated and collectively influence students' cognitive performance. Students who demonstrate strong foundational skills are more likely to enjoy science, engage meaningfully in laboratory activities, and perform better on cognitive assessments. These findings affirm the significance of practical, hands-on learning and align with Piaget's and Vygotsky's theories, highlighting the role of experiential and scaffolded learning in fostering cognitive development.

Recommendation

To improve science learning outcomes, schools should:

i. Provide adequate laboratory facilities and hands-on activities to boost engagement.
ii. Emphasise mastery of fundamental science skills through guided practice.
iii. Foster positive attitudes toward science by making learning enjoyable and relevant.
iv. Balance theoretical instruction with practical application in the curriculum.
v. Support teachers with training to effectively facilitate laboratory-based learning.

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