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Self-Regulated Learning, Non-Cognitive Factors, and Biology Achievement: Evidence from Some Nigerian Secondary Schools

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Abstract

Biology remains one of the most challenging subjects for Nigerian secondary school students, with persistent underachievement despite ongoing curricular reforms. This study examined the extent to which self-regulated learning (SRL) strategies and non-cognitive factors predict biology achievement. A descriptive correlational design was employed with a sample of 633 SS2 students drawn through multi-stage cluster sampling. Data were collected using three validated instruments: the Factors Affecting Learning of Biological Concepts Questionnaire ($\alpha = .71$), an adapted Motivated Strategies for Learning Questionnaire ($\alpha = .91$), and a Biology Achievement Test ($\alpha = .72$). Multiple regression analyses revealed that metacognitive regulation and rehearsal strategies significantly predicted achievement, while interest and teaching quality emerged as the strongest non-cognitive predictors. When combined, cognitive, metacognitive, and non-cognitive variables explained substantial variance in biology performance. The findings highlight the need for pedagogy that integrates SRL support with motivational and contextual interventions. Implications are discussed for theory development, instructional design, and educational policy in under-resourced contexts.

Keywords: Self-Regulated Learning; Metacognition; Non-Cognitive Factors; Interest; Biology Achievement; Nigeria

1. Introduction

Persistent underachievement in secondary school biology is a global concern, but it is particularly acute in Nigeria, where national examinations consistently report low mean scores (Waeonline.org, 2016–2023). This threatens the development of a scientifically literate population as envisioned in Nigeria's education policy (Federal Ministry of Education, 2009). Despite curricular reforms, biology continues to be one of the most challenging science subjects for Nigerian students.

Prior research has attributed poor performance to difficult concepts (Etobro & Fabinu, 2017), inadequate resources, and negative attitudes (Agboghroma & Oyovwi, 2015; Cimer, 2012). However, such explanations focus on what students find difficult, with less attention to how they attempt to learn biology or the role of motivational and contextual factors in shaping achievement. This gap is critical, as improving learning outcomes requires insight into both the strategies students employ and the conditions that support or constrain effective learning.

This study is anchored in Self-Regulated Learning (SRL) theory (Zimmerman, 2000; Pintrich et al., 1991), which frames learning as an interactive cycle of forethought, performance, and reflection. Recent reviews emphasise that SRL processes are not universal but shaped by cultural and contextual conditions (Panadero, 2017; Panadero & Alonso-Tapia, 2022; Koenka, Linnenbrink-Garcia, & Anderman, 2021). Yet, African contexts remain under-represented in SRL

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research, despite systemic pressures such as exam-oriented pedagogy and limited classroom resources that likely constrain strategic engagement (Okebukola & Jegede, 2019).

This study addresses this gap by examining the combined influence of cognitive and metacognitive strategies, along with non-cognitive factors such as student interest, teacher pedagogical content knowledge (PCK), and prior knowledge, on biology achievement in Nigeria. Specifically, it explores:

- Which cognitive and metacognitive strategies Nigerian biology students employ in learning challenging concepts.
- The influence of non-cognitive factors, including interest and teaching methods, on achievement.
- How cognitive and non-cognitive factors collectively predict biology achievement.

By answering these questions, the study contributes to extending SRL theory into under-researched contexts, highlights the compensatory role of motivational factors, and offers evidence-based recommendations for pedagogy, curriculum, and policy reform in Nigerian science education.

2. Literature Review

2.1. Self-Regulated Learning (SRL)

SRL describes how students set goals, select strategies, monitor progress, and adapt learning behaviours to achieve desired outcomes (Zimmerman, 2000). It is cyclical, encompassing forethought, performance, and reflection phases (Panadero, 2017). Meta-analyses confirm a robust association between SRL and academic achievement (Dent & Koenka, 2016; Sitzmann & Ely, 2019). However, SRL is not context-free; cultural and systemic factors moderate its use (Panadero & Alonso-Tapia, 2022; Koenka et al., 2021). Understanding how SRL manifests in Nigerian classrooms is thus vital for both theory and practice.

2.2. Cognitive and Metacognitive Strategies

Cognitive strategies such as rehearsal, elaboration, organisation, and critical thinking form the core of SRL (Pintrich et al., 1991). Rehearsal supports memorisation, while elaboration and organisation promote deeper processing. Critical thinking enables students to evaluate and apply knowledge. Metacognitive regulation, meanwhile, allows learners to monitor and adapt their cognitive processes (Azevedo, Greene, & Moos, 2013). Evidence suggests that effective use of metacognition enhances performance (Yang, Chen, & Chen, 2018), though students often rely on surface-level approaches (Hadiprayitno, Muhlis, & Kusmiyati, 2019). Recent critiques caution that the dichotomy between surface and deep learning is overly simplistic, as strategy use is context-dependent (Dinsmore & Loughlin, 2020).

2.3. Non-Cognitive Factors

Motivational and contextual influences—such as interest, perseverance, and self-efficacy—are equally critical to learning (Heckman, 2008; DiPerna & Elliott, 1999). Student interest, in particular, has been shown to increase engagement and sustain strategy use (Ainley & Ainley, 2020; Harackiewicz & Priniski, 2018). In African contexts, additional non-cognitive variables such as nutrition, teaching quality, and language of instruction significantly shape achievement (Chinyoka, 2014; Omwirhiren & Ibrahim, 2016). Yet, studies rarely integrate these alongside SRL constructs, limiting holistic understanding of how cognitive and non-cognitive factors interact.

2.4. Prior Knowledge

Prior knowledge is essential for integrating new learning into existing schemas. Students with strong prior knowledge are more likely to use elaboration and monitoring effectively (Yang et al., 2018; Friedrich & Mandl, 2020). Conversely, weak prior knowledge constrains the adoption of higher-order strategies and perpetuates underachievement. In Nigeria, gaps in foundational knowledge remain a barrier to biology learning (Etobro & Fabinu, 2017), but little research has explored how this interacts with SRL processes.

2.5. Identified Gap

Most Nigerian studies highlight difficult concepts and inadequate resources but do not model the combined predictive power of cognitive, metacognitive, and non-cognitive factors. Furthermore, little is known about how SRL processes are moderated by exam-driven pedagogies and systemic constraints. This study fills these gaps by applying an integrated SRL framework to Nigerian biology learning, thereby extending theory, strengthening cross-cultural perspectives, and informing contextually grounded educational reform.

2.6. Research Design and Framework

This study adopted a descriptive correlational survey design to investigate the relationships among cognitive strategies, metacognitive regulation, non-cognitive factors, and achievement in biology. While this design identifies associations between variables, it does not permit causal inferences. Nevertheless, it is appropriate for exploring patterns of influence across a large student population and for generating evidence to inform pedagogical interventions.

The research was guided by a Self-Regulated Learning (SRL) framework (Zimmerman, 2000; Pintrich, 2004), which conceptualises learning as an interactive cycle involving forethought, performance, and reflection. Within this framework, students' academic outcomes are influenced by their ability to select and apply effective strategies, monitor their understanding, and sustain motivation. The framework for this study positions three clusters of variables:

- Cognitive strategies (rehearsal, elaboration, organisation, and critical thinking) and metacognitive regulation, which represent students' active engagement with content and monitoring of their learning processes.
- Non-cognitive factors (student interest, motivation, teacher pedagogical content knowledge, teaching methods, age, nutrition, and language of instruction), which serve as contextual and motivational drivers that can either reinforce or undermine SRL.
- Biology achievement, operationalised through performance on a standardised Biology Achievement Test (BAT), representing the outcome of the interaction between strategies and motivational/contextual influences.

By situating both cognitive/metacognitive and non-cognitive variables within a unified SRL framework, the study aims to provide a holistic understanding of how Nigerian students regulate their biology learning, and to identify which factors most powerfully predict achievement.

2.7. Sample and Sampling Technique

The target population for this study comprised all Senior Secondary Two (SS2) biology students in Ogun State, Nigeria. A multi-stage cluster sampling technique was employed to enhance representativeness while maintaining feasibility. First, six Local Government Areas (LGAs) were randomly selected from the twenty LGAs in the state, ensuring coverage of both urban and semi-urban contexts. Second, within each selected LGA, one public co-educational secondary school was randomly chosen. Finally, all SS2 science students in intact classes from these schools were invited to participate, yielding a total sample of 633 students (344 males, 289 females).

This sampling strategy has several advantages. The use of intact classes preserved the natural learning environment, thereby capturing authentic variations in student experiences. The inclusion of schools from multiple LGAs increased the diversity of the sample in terms of socio-economic background, religious affiliation, and school resources. Importantly, all sampled schools had more than a decade of experience presenting candidates for WAEC biology examinations, which strengthens the reliability of the achievement measure and enhances comparability with national performance patterns.

Nevertheless, the sample is not fully representative of all Nigerian secondary schools, as it excluded private schools and schools in other states. While the findings are likely reflective of broader trends in public secondary education in South-West Nigeria, future studies employing larger, nationally representative samples are needed to generalise more confidently to the entire country.

2.8. Research Instruments and Variables

Three instruments were employed to capture cognitive, metacognitive, and non-cognitive predictors of biology achievement.

2.8.1. Factors Affecting Learning of Biological Concepts Questionnaire (FALBCQ).

This 27-item self-report scale measured non-cognitive factors such as prior knowledge, nutrition, student interest, and teaching methods. The instrument demonstrated acceptable internal consistency (Cronbach's $\alpha = 0.71$), aligning with previous studies in the Nigerian context.

2.8.2. Adapted Motivated Strategies for Learning Questionnaire (MSLQ).

The Motivated Strategies for Learning Questionnaire (Pintrich et al., 1991), widely used in educational psychology, was adapted for Nigerian senior secondary students. The original 7-point Likert scale proved cognitively demanding during a pilot test (N = 30), with students struggling to distinguish between fine-grained response categories (e.g., "a little true

of me” vs. “somewhat true of me”). To reduce cognitive load and improve response accuracy, the scale was simplified to a 5-point Likert format (1 = Strongly Disagree to 5 = Strongly Agree).

The final 31-item adapted version yielded excellent reliability (Cronbach's $\alpha = 0.91$). Content validity was established through expert review by three experienced biology teachers, who confirmed the instrument's clarity, cultural relevance, and alignment with the Nigerian curriculum. This adaptation constitutes a methodological contribution of the study, demonstrating how a widely used SRL measure can be meaningfully modified for younger learners in non-Western contexts.

2.8.3. Biology Achievement Test (BAT).

A 25-item multiple-choice test was designed to measure achievement in biology concepts previously identified as difficult. Items were drawn from past WAEC and UTME examinations to ensure curricular alignment and ecological validity. Reliability analysis indicated acceptable internal consistency (Cronbach's $\alpha = 0.72$).

2.8.4. Dependent Variable.

The primary outcome measure was students' achievement score, defined as the percentage of correct responses on the BAT (0–100).

2.9. Data Analysis

Data were analysed using SPSS version 25. Descriptive statistics (means, standard deviations, and frequency distributions) were first computed to summarise student performance on the Biology Achievement Test (BAT) and to profile the demographic characteristics of the sample.

To address the research questions, inferential analyses were conducted in three stages:

- Cognitive and metacognitive strategies. Multiple linear regression analyses were employed to examine the predictive power of rehearsal, elaboration, organisation, critical thinking, and metacognitive regulation on biology achievement. This choice was guided by the Self-Regulated Learning (SRL) framework, which emphasises the interaction of multiple strategies rather than single-variable effects.
- Non-cognitive factors. A second set of regressions tested the predictive contributions of student interest, teaching methods, teacher pedagogical content knowledge (PCK), nutrition, language of instruction, and age. These variables were modelled together to assess their collective explanatory power, in line with motivation and expectancy-value perspectives.
- Integrated model. Finally, a combined regression model incorporated both cognitive/metacognitive strategies and non-cognitive factors to capture the holistic interplay of predictors. This step aligns with the study's conceptual framework, which positions achievement as the outcome of interactions between strategic, motivational, and contextual influences.

In all analyses, assumptions of linear regression (normality, independence, multicollinearity, and homoscedasticity) were tested and met. Standardised beta coefficients (β), significance values (p), 95% confidence intervals, and effect sizes (R^2 , Adjusted R^2) were reported to enable meaningful interpretation of both statistical and practical significance.

This analytic approach ensures that the findings do more than identify significant predictors; they illuminate the relative weight of cognitive versus non-cognitive factors within an SRL framework, thereby contributing both to theory development and to pedagogical practice.

3. Results

Students' performance on the Biology Achievement Test (BAT) was generally low, with a mean score of 29.6% ($SD = 9.5$). This confirms persistent underachievement reported in national examinations. Performance did not differ significantly by gender or parental education, but small effects were observed for religion ($p = .018$).

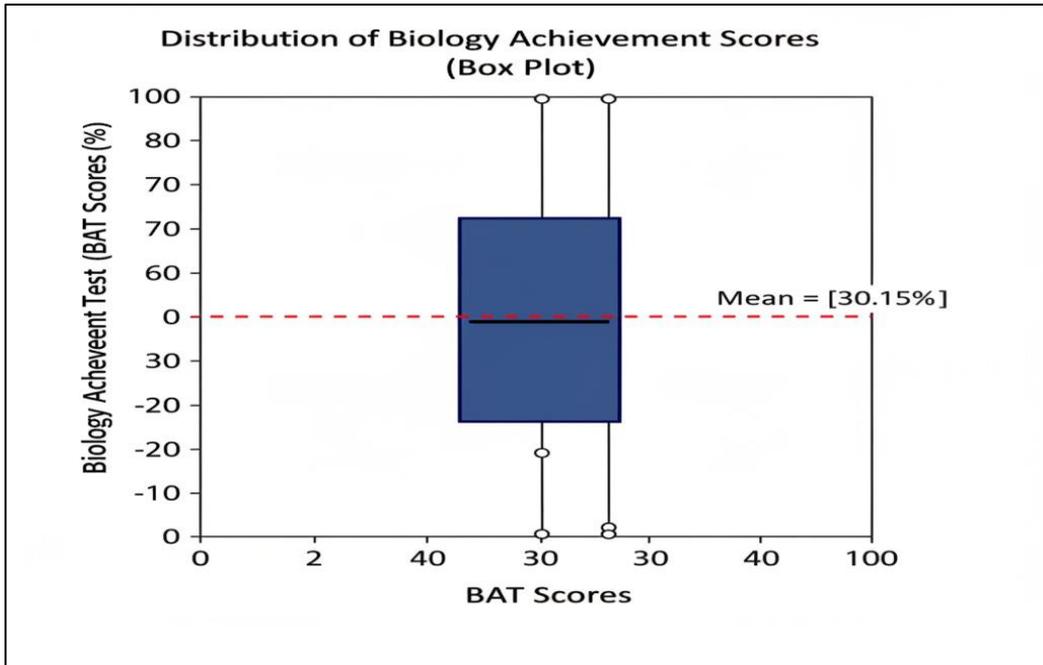


Figure 1 Distribution of Biology Achievement Test (BAT) scores among senior secondary students (N = 633). The mean score (29.6%) is indicated by the red dashed line.”

3.1. Distribution of Biology Achievement Scores

A boxplot showing the concentration of low scores around 30%.

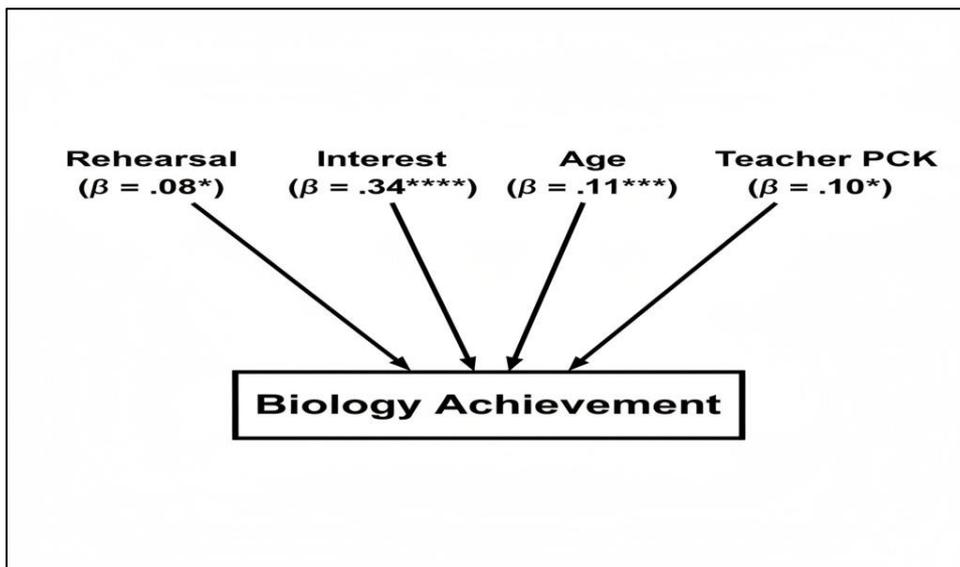


Figure 2 Path Model of Predictors of Biology Achievement

The arrows show predictors leading into Biology Achievement, with standardised β coefficients labeled.

Cognitive strategies. Among the five strategies measured, only rehearsal significantly predicted achievement ($\beta = .083$, $p = .036$, 95% CI [.05, 1.44]). The overall contribution of cognitive strategies to variance explained was minimal ($R^2 = .02$), indicating that surface-level repetition is the dominant approach, while elaboration, organisation, critical thinking, and metacognitive regulation showed no predictive power.

Non-cognitive factors. In contrast, non-cognitive variables accounted for a substantially larger proportion of variance ($R^2 = .115$, $p < .001$). Student interest was the strongest predictor ($\beta = .338$, $p < .001$), followed by age ($\beta = .112$, $p =$

.004) and teachers' pedagogical content knowledge (PCK) ($\beta = .097$, $p = .021$). Nutrition and language of instruction were not significant predictors.

Table 1 Regression Coefficients for Cognitive and Non-Cognitive Predictors of Biology Achievement

| Predictor | β (Beta) | p-value | 95% CI (Lower) | 95% CI (Upper) |
|-------------|----------------|---------|----------------|----------------|
| Rehearsal | 0.083 | 0.036 | 0.05 | 1.44 |
| Interest | 0.338 | 0.000 | 0.25 | 0.43 |
| Age | 0.112 | 0.004 | 0.04 | 0.18 |
| Teacher PCK | 0.097 | 0.021 | 0.02 | 0.17 |

Table 2 Model Summary for joint contribution of all the independent variables to the explanation of variants in students' score

| Dependent Variables | Predictors | R | R ² | Adjusted R ² | Std Error | F(17, 633)= | Sig |
|---------------------|--|-------------------|----------------|-------------------------|-----------|-------------|------|
| Score | M. EDU, RHE, GENDER, PCK, FAMILY, AGE, RELIGION, POR, MTD, CRT, INT, LAG, NTR, ORG, F. EDU, MCG, ELB | .368 ^a | .135 | .111 | .884 | 5.661 | .000 |

*POR – prior knowledge *MTD – method of teaching *CRT – critical thinking ; M.EDU-mother's education * PCK- pedagogical content knowledge of teachers *INT- interest *LAG- language of instructions *NTR- nutritional status *F.EDU- father's education *RHE – rehearsal *ORG- organisation *ELB- elaboration *MCG- metacognition

Combined model. When cognitive and non-cognitive variables were entered together, the model significantly predicted achievement ($F(17, 633) = 5.66$, $p < .001$), explaining 13.5% of the variance (Adjusted $R^2 = .111$). Interest remained the strongest predictor, followed by age, while rehearsal contributed modestly. This pattern suggests that motivational factors compensate for weak engagement with deep cognitive strategies.

4. Discussion

This study provides new insights into the persistent challenge of low achievement in Nigerian secondary school biology by unpacking the relative contributions of cognitive and non-cognitive factors. Consistent with global SRL research, cognitive strategies were expected to explain achievement variance; however, only rehearsal emerged as a significant predictor. This reliance on rote memorization suggests a truncated SRL cycle, in which students engage in low-level forethought and performance processes but rarely in reflective or strategic adaptation. This finding challenges the assumption of SRL universality by illustrating how exam-driven pedagogies and systemic pressures shape strategy use in African contexts.

The strong predictive power of student interest aligns with motivational perspectives from Self-Determination Theory and Expectancy-Value Theory, which emphasise the role of intrinsic motivation in sustaining engagement and persistence. In this study, interest acted as a compensatory mechanism, enabling students to achieve despite weak strategy use. This reinforces calls for pedagogy that prioritises relevance, inquiry, and contextualisation to spark curiosity and sustain long-term engagement.

Unexpectedly, prior knowledge was not a significant predictor. This may reflect a recursive deficit cycle: limited elaboration and organisational strategies prevent the consolidation of schemas, leaving students ill-equipped to integrate new concepts. The absence of strong prior knowledge then undermines the application of higher-order strategies, perpetuating underachievement.

Together, these findings highlight that achievement is not merely a product of strategy use but of the dynamic interaction between strategies, motivation, and context. Theoretically, the study extends SRL models by underscoring the importance of contextual moderators in shaping how students engage with learning. Practically, it points to the urgency of explicit SRL instruction in teacher education, curriculum sequencing to strengthen foundational knowledge, and pedagogical designs that cultivate interest and intrinsic motivation.

5. Conclusion

This study provides evidence that Nigerian secondary school students' achievement in biology is shaped less by sophisticated cognitive strategies and more by motivational and contextual influences. Rehearsal emerged as the only significant cognitive predictor, reflecting a narrow reliance on rote memorisation, while student interest proved to be the strongest predictor overall. These findings extend self-regulated learning (SRL) theory by demonstrating how cultural and systemic factors—such as exam-driven instruction and limited prior knowledge—constrain students' strategic engagement, leading to an overdependence on surface-level approaches.

Practically, the study underscores the need for explicit instruction in SRL strategies, especially elaboration, organisation, and critical thinking, to enable students to move beyond rehearsal. Teachers should adopt pedagogical designs that spark curiosity and link biology concepts to students' lived experiences, thereby leveraging interest as a motivational driver. Furthermore, curriculum planners should sequence content to build robust prior knowledge early, ensuring students can apply higher-order strategies to advanced topics.

At the policy level, the findings call for teacher professional development programmes that integrate SRL-based pedagogy, as well as reforms in assessment practices to reward deep learning rather than rote recall. By aligning instructional strategies, curriculum scaffolding, and policy support, Nigerian education can move towards producing scientifically literate learners equipped with the skills for higher-order thinking and lifelong learning.

Compliance with ethical standards

Formal authorisation and ethical clearance to conduct the study in the schools were obtained from the Ministry of Education in Ogun State, Nigeria. The study was conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent and Assent

Participation in the study was entirely voluntary. Since the participants were senior secondary school students (minors), written Informed Consent was obtained from their parents or legal guardians prior to their involvement. This consent process included a thorough explanation of the study's purpose, procedures, potential risks, and benefits.

Additionally, Assent was obtained from each student participant, ensuring their personal willingness to take part. Participants were explicitly informed of their right to refuse to answer any question or to withdraw from the study at any time without suffering any penalty or prejudice.

Confidentiality and Data Security

All ethical measures were taken to ensure the privacy, anonymity, and confidentiality of the participants and their data.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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