

EFFECT OF SELF-REGULATED LEARNING INTERVENTION ON SELF-EFFICACY AND ACADEMIC PERFORMANCE IN CELLULAR RESPIRATION AMONG SECONDARY SCHOOL STUDENTS

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Abstract

This study investigated the effect of Self-Regulated Learning Intervention on students' Self-efficacy and academic performance in cellular respiration. Four research questions and hypotheses were formulated. A quasi-experimental design was adopted to determine the causal relationship between the intervention and students' Self-efficacy and academic performance in cellular respiration. From a population of 5,378 SSII students, 85 students were selected using a multi-stage sampling technique. Data were collected using the Self-efficacy Scale (SES) and a Cellular Respiration Performance Test (CRPT), which were validated by three experts and have reliability coefficients of 0.864 and 0.816, respectively. Data were analysed using descriptive statistics and Analysis of Covariance. Results showed that the SRLI group had significantly higher post-test scores in Self-efficacy (MD = 12.18) and academic performance (MD = 3.03) than the control group. ANCOVA indicated a significant main effect of the intervention on self-efficacy, $F(1, 80) = 51.44, p < .05$; and academic performance, $F(1, 80) = 25.67, p < .05$. No significant gender differences were found across outcomes ($p > .05$), indicating that the intervention was gender friendly. The study concludes that SRLI is a highly effective, gender-inclusive strategy for teaching cellular respiration and recommends its systematic integration into classroom practice.

Keywords: Self-Regulated Learning Intervention (SRLI), Self-efficacy, Academic Performance.

Introduction

The shift from teacher-centred to learner-centred models in 21st-century education reflects growing recognition that students must become active constructors of knowledge. International frameworks and Nigeria's National Policy on Education emphasise competencies such as critical thinking, metacognition, and self-directed learning (Federal Republic of Nigeria, (FRN, 2013); Organisation for Economic Co-operation and Development (OECD, 2018)]. These skills are especially critical in biology, which underpins responses to public health, agriculture, and environmental sustainability. Yet despite the subject's importance, learning outcomes remain poor across Nigeria, particularly in northern states like Katsina. West African Examinations Council (WAEC) reports consistently document weaknesses in conceptual understanding and problem-solving, with cellular respiration and genetics identified as persistently challenging topics (WAEC, 2022). In Katsina State, the Biology pass rate in the 2022 WASSCE was approximately 48%, below the national average [Katsina State Ministry of Basic and Secondary Education (KSMBSE, 2023)].

In response, researchers have turned to Self-Regulated Learning (SRL) as a promising framework. SRL is a proactive, cyclical process in which learners set goals, deploy strategies, monitor progress, and regulate cognition, motivation, and behaviour (Zimmerman, 2002). Unlike traditional views, SRL positions learners as agents of their own learning. Theoretical models such as Zimmerman's three-phase cycle (forethought, performance, self-reflection) and Pintrich's framework converge on the idea that SRL can be taught and scaffolded (Panadero, 2017; Dignath & Veenman, 2021). A key component is self-efficacy: beliefs in one's capability to execute actions needed to achieve goals. Self-efficacy enhances goal-setting, strategic flexibility, and accurate self-evaluation (Caprara et al., 2018; Hayat et al., 2020). Conversely, students may possess self-regulatory knowledge but fail to apply it without sufficient self-efficacy.

Although extensive research links SRL to academic achievement, few studies have experimentally examined the causal effects of structured SRL interventions on both self-efficacy and performance simultaneously. Most existing work is correlational or laboratory-based, lacking ecological validity (Theobald, 2021; de Boer et al., 2018). This gap is particularly pronounced in Nigeria and especially northern Nigeria, where studies have largely explored correlations rather than causal mechanisms (Garba & Abubakar, 2020; Stern et al., 2021). Furthermore, the role of gender in SRL and Science, Technology, Engineering, and Mathematics (STEM) achievement has yielded mixed findings. While some studies report female students using more metacognitive strategies and others find minimal gender differences, few Nigerian studies have examined whether SRL interventions benefit male and female students equally in secondary school biology.

Given the persistently low achievement in Katsina State, the strong theoretical support for SRL, and the scarcity of quasi-experimental evidence from authentic classrooms, there is a clear need for locally grounded intervention research. The present study, therefore, implemented an SRL intervention integrated into the teaching of cellular respiration and examined its effects on students' self-efficacy and academic performance, including potential gender differences.

Objectives

The specific objectives of the study are to:

1. Determine the effect of the Self-Regulated Learning Intervention (SRLI) combined with conventional teaching on students' self-efficacy towards learning cellular respiration.
2. Examine the influence of gender on the self-efficacy of students taught cellular respiration using the Self-Regulated Learning Intervention (SRLI) combined with conventional teaching
3. Determine the effect of the Self-Regulated Learning Intervention (SRLI) combined with conventional teaching on students' academic performance in cellular respiration.
4. Examine the influence of gender on the academic performance of students taught cellular respiration using the Self-Regulated Learning Intervention (SRLI) combined with conventional teaching

Research Questions

The following research questions have been raised:

1. What is the mean difference in self-efficacy towards learning cellular respiration between students taught using the Self-Regulated Learning Intervention (SRLI) and conventional method and those taught using the conventional method only?
2. What is the mean difference in self-efficacy towards learning cellular respiration between male and female students taught using SRLI and the conventional method only?
3. What is the mean difference in academic performance scores between students taught cellular respiration using SRLI and the conventional method and those taught using the conventional method only?
4. What is the mean difference in academic performance scores between male and female students taught cellular respiration using SRLI and the conventional method only?

Hypotheses

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

- H0₁: There is no significant difference in self-efficacy towards learning cellular respiration between students taught with SRLI and the conventional method and those taught using the conventional method only.
- H0₂: There is no significant difference in self-efficacy toward learning cellular respiration between male and female students taught using SRLI and the conventional method.
- H0₃: There is no significant difference in academic performance scores in cellular respiration between students taught using SRLI and the conventional method and those taught using the conventional method only.
- H0₄: There is no significant difference in academic performance scores in cellular respiration between male and female students taught using SRLI and the conventional method.

Methodology

This study employed a quasi-experimental, pre-test-post-test control group design. A true experimental design was logistically impractical and ethically problematic in authentic educational settings, as random assignment of individuals disrupts intact classroom structures (Shadish et al., 2002). To approximate experimental rigor, intact classes were randomly assigned to either the experimental or control condition. The pre-test-post-test design allows for comparison of changes over time while controlling for pre-existing differences. Moreover, the inclusion of a pre-test enables Analysis of Covariance (ANCOVA), which adjusts for baseline scores, increasing analytic precision and the validity of conclusions regarding intervention effects (Field, 2018; Creswell & Creswell, 2018).

The target population comprised all 5,378 Senior Secondary School II students in the 2022/2023 academic session offering Biology in public schools within Dutsin-Ma Zonal Education Quality Assurance, Katsina State, Nigeria. A multi-stage sampling technique enhanced representativeness and

practicality. First, two co-educational public secondary schools with comparable academic profiles, teacher qualifications, and laboratory access were purposively selected. Second, two intact SSII classes from each school were selected via simple random sampling (balloting). Finally, one class per school was randomly assigned to the experimental (n = 48) and control (n = 37) groups, yielding a total sample of 85 students. This strategy maximized equivalence between groups before the intervention, strengthening internal validity, while preserving ecological validity relevant to typical classroom practice.

Data were collected using two instruments. The Self-Efficacy Scale (SES), adapted from Abdul-Gafoor and Muhammed (2007) and grounded in Bandura's (1977) social cognitive theory, comprised 20 items on a four-point modified Likert scale from Strongly Agree to Strongly Disagree, with positive and negative statements scored accordingly. The Cellular Respiration Performance Test (CRPT), a researcher-developed 30-item achievement test, included 25 multiple-choice and five short-answer questions aligned with the SSII national curriculum, assessing knowledge, comprehension, application, and analysis. Both instruments underwent expert review by three specialists in science education, educational psychology, and test measurement. A pilot study with 30 non-participating SSII students yielded Cronbach's alpha coefficients of .864 for the SES and .816 for the CRPT, indicating good to excellent internal consistency (DeVellis, 2017).

Data were analyzed using means and standard deviations to address the research questions regarding mean differences. ANCOVA was used to test the hypotheses, which determined post-test differences between groups while statistically controlling for pre-test scores. This approach reduces error variance, increases test sensitivity, and provides a more accurate assessment of the intervention's true effect on self-efficacy and academic performance after accounting for initial ability levels (Pallant, 2020), aligning with best practices for pre-test-post-test control group designs in educational research.

Findings

Answering Research Questions

Research Question One: What is the mean difference in self-efficacy towards learning cellular respiration between students taught using SRLI and the conventional method and those taught using the conventional method only?

Table 1: Means and Standard Deviations of Self-efficacy Levels of Students toward Cellular Respiration in Experimental and Control Groups

Groups	N	M	SD	MD
SRLI (EG)	48	69.85	6.10	
Conventional Method (CG)	37	57.68	9.61	12.18

M = Mean, SD = Standard Deviation, MD=Mean Difference

Table 1 shows that students taught using SRLI recorded a higher mean self-efficacy score ($M = 69.85$, $SD = 6.10$) than those taught with the conventional method ($M = 57.68$, $SD = 9.61$), with a mean difference of 12.18 in favour of the experimental group. This suggests that the SRLI substantially enhanced students' self-efficacy toward learning cellular respiration compared with the conventional approach alone.

Research Question Two: What is the mean difference in self-efficacy towards learning cellular respiration between male and female students taught using SRLI and the conventional method only?

Table 2: Means and Standard Deviations of self-efficacy Levels of Male and Female Students toward Cellular Respiration in the Experimental Group Only

Gender	N	M	SD	MD
Male	28	70.04	5.71	0.44
Female	20	69.60	6.74	

M = Mean, SD = Standard Deviation, MD=Mean Difference

Table 2 shows that male students in the experimental group had a mean self-efficacy score of 70.04 ($SD = 5.71$), while female students had a mean score of 69.60 ($SD = 6.74$), resulting in a mean difference of 0.44 in favour of females. This difference is small, indicating that SRLI produced comparable levels of self-efficacy for both male and female students.

Testing Hypotheses H_{01} & H_{02}

The two hypotheses on the difference in students' self-efficacy towards learning cellular respiration between groups and gender were tested as follows:

Table 5: Analysis of Covariance of Students' Self-efficacy Scores by Group and Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3440.983 ^a	4	860.246	14.543	.000
Intercept	2974.556	1	2974.556	50.288	.000
Pretest	178.427	1	178.427	3.016	.086
Groups	3042.697	1	3042.697	51.440	.000
Group * Gender	117.027	1	117.027	1.978	.163
Gender	77.031	1	77.031	1.302	.257
Error	4732.029	80	71.332		
Total	362375.000	85			
Corrected Total	8173.012	84			

In Table 5 the analysis revealed a statistically significant main effect for the treatment groups ($F(1, 80) = 51.44$, $p < .05$), indicating that the Self-Regulated Learning Intervention (SRLI) blended with conventional teaching significantly influenced students' self-efficacy. Thus, H_{01} was rejected. However, the main effect for gender was not significant ($F(1, 80) = 1.30$, $p > .05$), H_{02} was retained.

Therefore, it is concluded that the intervention was effective in enhancing self-efficacy, and this effect was consistent for both male and female students.

Research Question Three: What is the mean difference in academic performance scores between students taught cellular respiration using SRLI and the conventional method and those taught using the conventional method only?

Table 3: Means and Standard Deviations of Academic Performance Scores of Students in Cellular Respiration in Experimental and Control Groups

Groups	N	M	SD	MD
SRLI (EG)	48	14.35	2.03	
Conventional Method (CG)	37	11.32	3.30	3.03

M = Mean, SD = Standard Deviation, MD=Mean Difference

Table 3 indicates that students exposed to SRLI achieved a higher mean academic performance score (M = 14.35, SD = 2.03) than those taught using the conventional method (M = 11.32, SD = 3.30), with a mean difference of 3.03. This demonstrates that SRLI is more effective than the conventional method in improving students' academic performance in cellular respiration.

Research Question Four: What is the mean difference in academic performance scores between male and female students taught cellular respiration using SRLI and conventional method only?

Table 4: Means and Standard Deviations of Academic Performance Scores of Male and Female Students in Cellular Respiration in Experimental Group Only

Gender	N	M	SD	MD
Male	28	14.25	2.34	0.22
Female	20	14.43	1.81	

M = Mean, SD = Standard Deviation, MD=Mean Difference

Table 4 indicates that male students had a mean score of 14.25 (SD = 2.34), while female students had a mean score of 14.43 (SD = 1.81), yielding a mean difference of 0.22 in favour of females. The very small difference suggests that SRLI supports similar levels of academic performance for both male and female students.

Testing Hypotheses (H₀₃ & H₀₄)

The two hypotheses on the difference in students' Performance in cellular respiration between groups and gender were tested as follows:

Table 6: Analysis of Covariance for Academic Performance Scores by Group and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	198.387a	4	49.597	6.882	.000
Intercept	885.074	1	885.074	122.819	.000
Pretest	1.629	1	1.629	0.226	.636
Groups	184.995	1	184.995	25.671	.000
Group * Gender	3.407	1	3.407	0.473	.494
Gender	0.761	1	0.761	0.106	.746
Error	576.507	80	7.206		
Total	15218.000	85			
Corrected Total	774.894	84			

An ANCOVA on post-test academic performance scores, with pre-test scores as the covariate, revealed a significant main effect of instructional group after controlling for pre-test differences, $F(1,80)=25.67, p<.001$). Students in the SRLI group achieved higher post-test scores than those in the conventional group, leading to rejection of H_0 . However, the Group \times Gender interaction was not significant, $F(1, 80) = 0.47, p =.494$).

Discussion

The present findings demonstrate that the Self-Regulated Learning Intervention (SRLI) significantly strengthened students' academic self-efficacy in cellular respiration. This result aligns with a broad body of international evidence, including studies by Affuso et al. (2025) in Italy, Sexton et al. (2026) in China and Onongha et al. (2025) in Nigeria, all of which identify self-regulation as a robust predictor of academic self-efficacy. Nevertheless, the effectiveness of such interventions is not universal; contrasting evidence from Atherton (2015), Granello et al. (2025), and Mohamed et al. (2025) suggests that success depends critically on subject matter, contextual factors, and intervention design, with some studies reporting no significant improvements or even negative performance outcomes.

Regarding gender, male students in the present study showed slightly higher mean self-efficacy scores than their female counterparts. This pattern is consistent with prior research documenting male advantages in domain-specific self-efficacy, particularly in mathematics, computer science, and social sciences (Huang, 2013; Keller et al., 2024; Wang & Yu, 2023). However, other studies have found no significant gender differences in e-learning outcomes or self-efficacy (Yu & Deng, 2022), indicating that gender effects may be context-dependent.

The SRLI also yielded significantly higher academic performance in cellular respiration compared to conventional methods. This finding supports Ekuri and Offiah (2018) and Suhandoko and Hsu (2020), who reported positive links between self-regulatory attributes and achievement. By promoting strategic, reflective learning over rote memorisation, the SRLI appears to foster deeper conceptual understanding that translates into improved test scores. The positive performance effect diverges partly from Younes et al. (2015), who observed gains in achievement motivation but not in science test scores, suggesting that the present intervention was particularly effective in converting motivational gains into measurable academic outcomes.

Importantly, no significant gender differences were observed in self-efficacy or performance. This contrasts with Saghir and Batool (2019) but aligns with Ejelue (2017), who reported similarly low gender disparities in self-regulation and achievement. In the context of Katsina State secondary schools, the SRLI thus functioned as a gender-neutral pedagogical tool that supported male and female learners equitably.

Conclusion

The empirical evidence supports the SRLI as a highly effective, inclusive strategy for teaching complex biology topics such as cellular respiration. By moving students from passive recipients of information to active, self-directed learners, the intervention significantly strengthened self-efficacy and improved academic performance compared to conventional methods. Its equivalent benefits for male and female students underscore its potential as a gender-friendly approach for improving science learning outcomes in Katsina State and similar contexts.

Recommendations

Based on the findings, the following recommendations are proposed:

1. Biology secondary school teachers should systematically incorporate SRLI strategies (e.g., goal setting, self-monitoring, Self-evaluation) into their lesson plans for complex topics such as cellular respiration and genetics.
2. Ministries of education and professional bodies, such as the Science Teachers Association of Nigeria (STAN), should organize regular workshops and in-service training to build teachers' capacity to design and implement SRL-based instruction.
3. Educational policymakers in Katsina State and beyond should provide curricular and assessment guidelines that explicitly encourage SRL practices and allocate resources to scale up evidence-based interventions such as SRLI across schools.

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