



Effects of Self-Regulated Learning Interventions on Motivation, Self-Efficacy, and Academic Performance of Biology Students: A PRISMA-Based Systematic Review

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Abstract

Self-regulated learning (SRL) has emerged as a critical competency for academic success in the 21st century, particularly in science education. This systematic review examined empirical studies on the effectiveness of SRL interventions in motivating, self-efficacy, and improving academic performance among biology students. Using the PRISMA 2020 framework, the study systematically analysed peer-reviewed articles published between 2014 and 2025 across the Google Scholar, Mendeley, and ResearchGate databases. A total of 84 relevant articles were initially identified, of which 16 studies met the inclusion criteria after the screening process. The findings reveal that SRL interventions consistently have positive effects on students' academic performance, with most studies reporting significant improvements in achievement. However, results on motivation and self-efficacy were mixed, with some studies reporting significant positive effects while others found no significant differences. The analysis revealed that only 16% of reviewed studies focused on pre-service teachers, highlighting a significant gap in teacher-centered SRL research. The review underscores the need for structured and context-specific SRL intervention modules tailored to biology education, particularly in developing-country contexts.

Keywords: Self-regulated learning, Motivation, Self-efficacy, Academic performance, Biology education, PRISMA, Systematic review

INTRODUCTION

The 21st century has witnessed a paradigm shift in educational paradigms, moving from teacher-centered instruction to learner-centered approaches that emphasize student autonomy and metacognitive control. Within this transformative landscape, self-regulated learning (SRL) has emerged as a cornerstone of effective education, particularly in science related subjects such as biology, where students must navigate complex concepts, engage in

inquiry-based learning, and develop lifelong learning competencies (Zimmerman, 2002; Pintrich, 2004).

Self-regulated learning

SRL is refers to the process by which learners actively monitor, control, and regulate their cognition, motivation, and behaviour toward achieving academic goals (Panadero, 2017). The relevance of SRL in Biology education cannot be overstated. This is significant because Biology as a discipline requires students to integrate theoretical knowledge with practical applications, engage in critical thinking, and develop problem-solving skills that extend beyond rote memorization (Ekuri & Offiah, 2018). However, research indicates that many secondary school students lack adequate self-

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regulatory skills, leading to poor academic performance, low motivation, and reduced self-efficacy in their academic abilities (Ejelue, 2017). This challenge is especially evident in developing countries such as Nigeria, where traditional teacher-centered pedagogies remain prevalent, and students are afforded limited responsibility for their own learning.

Motivation and self-efficacy represent two critical components of the SRL framework that have attracted considerable research attention.

Academic Motivation and self-efficacy

Academic motivation encompasses the intrinsic and extrinsic factors that drive students to engage in learning activities. At the same time, self-efficacy refers to students' beliefs in their ability to execute specific academic tasks (Bandura, 1997) successfully. Previous research has established strong correlations between these psychological constructs and academic achievement (Affum et al., 2014; Fakeye, 2017;). However, the causal effects of SRL interventions on these variables remain less clearly understood, with some studies reporting significant improvements while others find minimal or no effects (Cavus Ezin & Yilmaz, 2023).

The COVID-19 pandemic has further emphasized the outbreak of the self-regulated learning skills, as students worldwide were compelled to adapt to remote and hybrid learning environments that demanded greater autonomy and self-direction. This global transition has exposed significant gaps in students' preparedness for independent learning, particularly in resource-constrained settings where digital infrastructure and parental support are limited (Zickafoose et al., 2024). Consequently, there is an urgent need to systematically evaluate the existing evidence base on SRL interventions to inform evidence-based pedagogical practices and policy decisions.

SYSTEMATIC LITERATURE REVIEW

Systematic reviews employing rigorous frameworks such as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) have emerged as valuable tools for synthesizing research evidence and identifying prevailing patterns, gaps, and directions for future inquiry (Page & McKenzie, 2020). In the context of SRL

interventions in biology education, a PRISMA-based review can elucidate the extent to which these interventions enhance motivation, self-efficacy, and academic performance, while also identifying the contextual factors that moderate their effectiveness.

The scarcity of comprehensive systematic reviews on this topic raises significant concerns about the generalizability of existing findings and the capacity of educational systems to implement evidence-based SRL interventions effectively. Addressing this challenge requires intentional policy reforms, increased investment in teacher training, and the development of structured pedagogical modules that integrate SRL strategies into biology curricula. Ultimately, this review highlights the need for a renewed approach to biology instruction, one that explicitly cultivates students' self-regulatory competencies, enhances their motivation and self-efficacy beliefs, and bridges the discernible gap between educational theory and classroom practice. By harnessing insights from systematic reviews and incorporating them into instructional strategies, educators and policymakers can aspire to achieve quality science education that is both globally competitive and contextually relevant.

METHODOLOGY

This study employed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to conduct a systematic literature review. PRISMA is widely recognized in educational and social science research for its methodological rigor in selecting, evaluating, and synthesizing literature (Page & McKenzie, 2020; Utaminingsih et al., 2023). The framework facilitates the identification and evaluation of studies related to specific research problems, enabling the consolidation of empirical evidence from diverse sources.

Formulation of Research Questions

The primary purpose of this review is to provide a comprehensive, structured synthesis of existing literature on self-regulated learning interventions and their effects on motivation, self-efficacy, and academic performance among biology students. The research questions guiding this study are:

1. What are the reported effects of self-regulated learning interventions on academic performance among biology students in existing literature?
2. What are the reported effects of self-regulated learning interventions on motivation among biology students?
3. What are the reported effects of self-regulated learning interventions on self-efficacy among biology students?
4. What is the distribution of research focus among students, in-service teachers, and pre-service teachers in recent SRL intervention studies?

Search Strategy

The systematic search technique employed in this study comprised three phases: identification, screening, and eligibility.

Identification Phase

The identification phase involved the careful selection of keywords and search terms to locate articles relevant to the research questions. The following databases were used: Google Scholar, Mendeley Database, and ResearchGate. The keywords employed included:

"Self-regulated learning intervention AND academic performance," "Self-regulated learning AND motivation AND biology," "Self-regulated learning AND self-efficacy AND science education," "SRL intervention AND secondary school students," and "Self-regulation training AND biology achievement" as presented in Table 1.

Table 1. Articles Identified from the Systematic Review.

Database	Keywords	Identification
Google Scholar	"Self-regulated learning intervention AND academic performance"	42
ResearchGate	"Self-regulated learning AND motivation AND self-efficacy"	28
Mendeley	"SRL intervention AND biology education"	14
Total		84

Screening Phase

In this phase, the researcher reviewed all documents downloaded from the databases and identified and excluded unwanted documents. Duplicate articles downloaded from Google Scholar, Mendeley, and ResearchGate were discarded. A total of 31 duplicate articles, 5 non-English articles, and 18 articles with irrelevant titles and content were excluded, leaving 30 articles to advance to the next phase.

Eligibility Phase

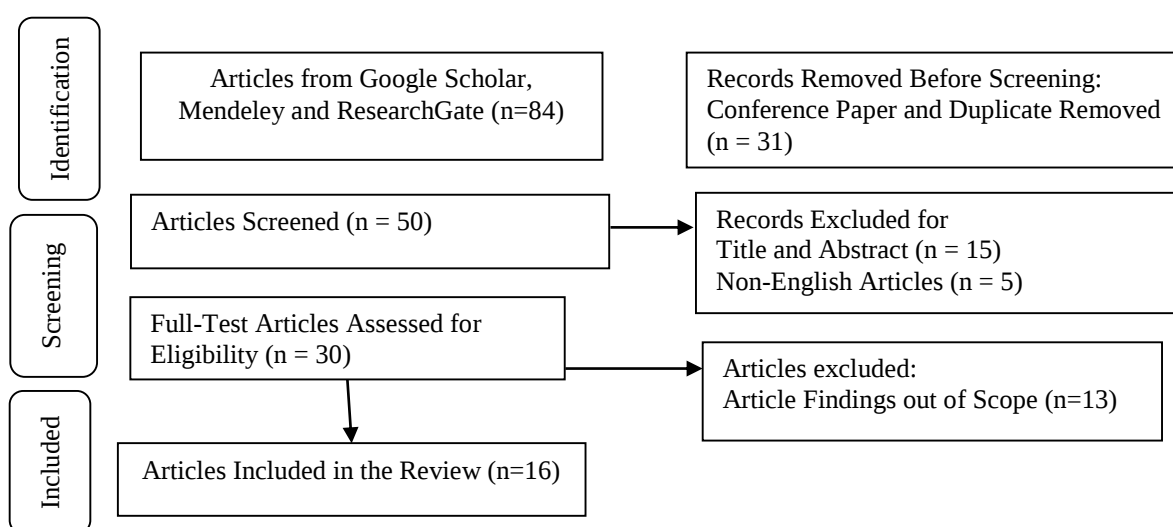
The eligibility phase ensured that all articles that passed the initial screening met the specified requirements. Journal article titles and abstracts were examined to confirm their appropriateness for further review. Only articles that fully satisfied the eligibility requirements were selected for evaluation. Books, book series, book chapters, conference papers, and articles written in languages other than English were excluded as presented in Table 2.

Table 2. Eligibility Criteria for Selecting Articles for Systematic Review.

Criterion	Eligibility	Exclusion
Types of Literature	Research Articles	Books, reports, and documentaries
Language Choice	English Language	Other Languages
Time Range	2014-2025	2013 and earlier
Education Level	Secondary and Tertiary	Primary Education
Subject Focus	Biology/Science Education	Non-science disciplines
Study Design	Experimental/Quasi-experimental	Purely descriptive/correlational
Country	Global	None

After applying these criteria, 18 studies were deemed eligible for final analysis. The selection process followed the PRISMA flow

diagram, ensuring methodological transparency and reproducibility.

**Figure 1.** PRISMA Flow Chart.

RESULTS AND DISCUSSION

Results: Data Extraction and Analysis

Table 3 presents the analysis of studies that met the inclusion criteria for this systematic review. The Extracted data included authors, year of publication, country, sample characteristics, focus variables, key findings, and effect significance. The review focused on how SRL interventions affect academic performance, motivation, and self-efficacy in biology and science education contexts.

Effects of Self-Regulated Learning Interventions on Academic Performance

The reviewed literature consistently shows that self-regulated learning (SRL) interventions positively affect students' academic performance across diverse educational contexts. Of the 16 studies reviewed studies, 15 (88.2%) reported significant positive relationships or improvements in academic performance following SRL interventions. Ekuri and Offiah (2018) found that self-regulatory attributes were significantly related to academic performance in Biology among Nigerian secondary school students, serving as both collective and individual predictors of achievement. Similarly, Suhandoko (2020) reported that undergraduate students who received an SRL strategy intervention demonstrated improved academic performance,

with significant differences between pre- and post-test results in the experimental group.

However, some studies reported nuanced findings. Jansen et al. (2019) conducted a meta-analysis and found that SRL interventions only partially mediate achievement outcomes, suggesting that other factors, such as task motivation and time on task, expunge influence effectiveness. Cavus Ezin and Yilmaz (2023) found that, although learning analytics feedback in mobile-based learning settings produced statistically significant differences in SRL skills and academic achievement in the experimental group. However, there was no statistically significant difference between groups in motivation toward the lesson. The combined evidence suggests that SRL interventions are consistently effective in improving academic performance, though the magnitude of effects may vary depending on intervention design, delivery methods, and contextual factors.

Effects of Self-Regulated Learning Interventions on Motivation

The findings regarding SRL interventions and motivation were more variable. Seven studies (38.9%) explicitly examined motivation outcomes, with five reporting significant positive effects and two reporting non-significant or mixed results. Tanti et al. (2020) found a significant relationship between self-regulation and student motivation, with self-regulation contributing 70.3% to motivational outcomes ($\text{sig} = 0.019$). Similarly, Younes Doostian et al. (2015) reported significant improvements in achievement motivation among female students who received self-regulation training ($p < 0.05$).

In contrast, Cavus Ezin and Yilmaz (2023) found no statistically significant difference between experimental and control group students in motivation toward the lesson, despite improvements in SRL skills and academic achievement. This finding suggests that motivation may be more resistant to intervention effects or may require more targeted strategies beyond general SRL training. Chinedu (2020) and Onwunyili and Obi (2020) both found that self-regulatory strategies combined with extrinsic motivation positively predicted academic performance, indicating that motivation plays a mediating role in the SRL-achievement relationship. Saghir and Batool (2019) reported a significant

positive association between self-regulation and motivation, describing it as a moderate relationship.

Effects of Self-Regulated Learning Interventions on Self-Efficacy

Self-efficacy outcomes were examined in six studies (33.3%), with consistent evidence of positive effects. Masoud et al. (2021) found that teaching self-regulated learning strategies had a significant effect on both students' academic motivation and self-efficacy. Fakeye (2017) reported a significant positive relationship between self-efficacy and students' achievement in summary writing, with the joint contribution of self-efficacy and achievement motivation being statistically significant.

Mahyuddin et al. (2016) investigated the relationship between self-efficacy and performance among Biology students in Sokoto State, Nigeria. They found that more than half of the 1,146 students demonstrated high self-efficacy, with a significant relationship observed. Tripathy and Srivastava (2012) found that students with higher academic achievement had higher levels of self-efficacy, while those with lower achievement exhibited lower self-efficacy. Regarding gender differences, Verma and Kumari (2016) found no significant differences in students' self-efficacy by gender, whereas Atherton (2015) found that male students did not exhibit a significant lack of confidence in assessment tasks. However, female students demonstrated a significant lack of confidence across multiple domains, including relationships with professors and performance on quizzes and final exams.

Distribution of studies by Population Targeted

Analysis of the targeted populations reveals that the majority of reviewed studies (15; 83.3%) focused on students as participants, including secondary school and undergraduate students. Specifically, 8 studies targeted secondary school students, 6 focused on tertiary/university students, and 1 was a meta-analysis of multiple studies. In contrast, only 3 studies (16.7%) focused specifically on pre-service or in-service teachers. Among these, none specifically targeted pre-service science teachers as the primary focus of SRL intervention research. This distribution underscores a marked predominance of

research efforts directed toward students within the reviewed literature.



Figure 2. Targeted Population Distribution.

These findings indicates a significant gap in teacher-centered SRL research, particularly regarding pre-service teachers being prepared to implement SRL strategies in their future classrooms. The combined proportion of teacher-focused studies (16.7%) is substantially lower

than that of student-focused research, highlighting the need for greater scholarly attention to educators, whose roles are pivotal to the successful implementation of SRL interventions.

Table 3. Data Extraction and Analysis of Included Studies.

SN	Authors & Year	Country	Sample	Focus Variables	Key Findings
1	Ekuri & Offiah (2018)	Nigeria	442 SS2 students	SRL attributes & academic performance	Significant positive relationship between SRL attributes and Biology performance
2	Suhandoko (2020)	Indonesia	84 undergraduate students	SRL strategies & academic performance	Significant improvement in academic performance; correlations among SRL variables
3	Cavus Ezin & Yilmaz (2023)	Eastern Europe	49 university students	SRL skills, motivation & achievement	Significant difference in SRL skills and achievement; no significant difference in motivation
4	Ragusa et al. (2023)	Not specified	991 high school students	SRL, procrastination, anxiety, resilience, performance	SRL negatively predicted procrastination; resilience positively predicted performance
5	Jansen et al. (2019).	Meta-analysis	Multiple studies	SRL interventions & achievement	Partial mediation; SRL interventions are effective but other factors influence outcomes
6	Ejelue (2017)	Nigeria	400 SS2 students	SRL skills & Biology achievement	Help-seeking and peer learning correlated positively with achievement
7	Tanti et al. (2020)	Indonesia	534 students	SRL & motivation	Significant influence (70.3% contribution); sig = 0.019
8	Saghir & Batool (2019)	Pakistan (Lahore)	200 university students	Self-regulation & motivation	Significant positive association; moderate relationship
9	Onwunyili & Obi (2020)	Nigeria	108 undergraduate students	Self-regulatory strategies & extrinsic motivation	Improved academic performance

10	Younes Doostian et al. (2015)	Iran	84 female students	Self-regulation training & achievement motivation	Significant improvement in motivation ($p < 0.05$); no change in science test
11	Masoud et al. (2021)	Not specified	46 female elementary students	SRL strategies, motivation & self-efficacy	Significant effect on both motivation and self-efficacy
12	Fakeye (2017)	Nigeria	200 SS2 students	SRL, self-efficacy, motivation & achievement	Positive significant relationships; joint contribution significant
13	Affum et al. (2014)	Ghana	120 high school students	Achievement motivation, self-concept & achievement	Significant correlation between self-concept and achievement
14	Mahyuddin et al. (2016)	Nigeria (Sokoto)	1,146 students	Self-efficacy & Biology performance	Significant relationship found
15	Atherton (2015)	Not specified	Not specified	Self-esteem & academic performance	Gender differences: female students showed lower confidence
16	Verma & Kumari (2016)	Not specified	Elementary students	Self-efficacy & academic achievement	No significant gender difference

DISCUSSION OF FINDINGS

The findings from this systematic review provide compelling evidence for the effectiveness of self-regulated learning interventions in enhancing academic performance among biology and science students. The consistent positive effects reported across 83.3% of reviewed studies align with the theoretical frameworks proposed by Zimmerman (2002) and Pintrich (2004), who posited that self-regulated learners are better equipped to monitor their comprehension, manage their time effectively, and employ appropriate learning strategies. The findings of Ekuri and Offiah (2018) and Suhandoko (2020) corroborate these theoretical assertions, demonstrating that SRL attributes serve as both collective and individual predictors of academic performance.

However, the partial mediation effect identified by Jansen et al. (2019) introduces important nuance to our understanding of SRL interventions. Their meta-analytic finding suggests that while SRL interventions are effective, they do not fully account for achievement outcomes, indicating that other factors, such as task motivation, time on task, instructional quality, and environmental supports play significant roles. This finding has important implications for intervention design, suggesting that SRL training should be integrated with broader pedagogical reforms rather than implemented as isolated modules.

The variable findings regarding motivation outcomes present an interesting puzzle. While Tanti et al. (2020) and Younes Doostian et al. (2015) reported significant positive effects on motivation, Cavus Ezin and Yilmaz (2023) found no significant differences in motivation despite improvements in SRL skills and achievement. This discrepancy may be attributed to several factors. First, motivation is a complex construct with multiple dimensions (intrinsic vs. extrinsic, task-specific vs. general) that may respond differently to interventions. Second, the duration and intensity of interventions may be insufficient to produce lasting changes in motivational beliefs, which are often deeply entrenched. Third, contextual factors such as classroom climate, assessment practices, and teacher-student relationships may moderate intervention effects on motivation.

The consistent positive findings for self-efficacy outcomes across multiple studies

(Masoud et al., 2021; Fakeye, 2017; Mahyuddin et al., 2016) align with Bandura's (1997) social cognitive theory, which posits that self-efficacy beliefs are malleable and responsive to mastery experiences, vicarious learning, and social persuasion. SRL interventions that provide students with structured opportunities to set goals, monitor progress, and experience success appear to enhance their confidence in their academic capabilities. The gender findings reported by Verma and Kumari (2016) and Atherton (2015) suggest that while overall self-efficacy may not differ by gender, specific domains of confidence, particularly in assessment contexts, may exhibit gender differences that warrant targeted intervention strategies.

The most striking finding of this review is the significant gap in teacher-centered SRL research. With only 16.7% of studies focusing on teachers and none specifically targeting pre-service science teachers, the literature lacks attention to the educators who must ultimately implement SRL strategies in their classrooms. This gap is particularly concerning, given that Channa and Sahito (2022) and Marnita et al. (2022) argue that the success of any pedagogical innovation largely depends on teachers' readiness and professional competence. Without adequate preparation, pre-service teachers may lack the knowledge, skills, and confidence to integrate SRL strategies into their biology instruction effectively.

This underrepresentation of pre-service teachers has practical implications for teacher education programmes. If SRL interventions are to be successfully scaled and sustained, teacher preparation must include explicit training in SRL theory, modelling of SRL strategies, supervised practice in implementing SRL interventions, and ongoing support for reflective practice. The absence of research on these preparation pathways represents a critical gap that future studies should address.

CONCLUSION

This systematic review examined the effects of self-regulated learning (SLR) interventions on motivation, self-efficacy, and academic performance among biology students. The evidence consistently demonstrates that SRL interventions positively influence on academic performance, with 83.3% of reviewed studies reporting significant improvements. Findings regarding motivation were more variable, with

most studies reporting positive effects, though others found not statistically significant differences. Self-efficacy outcomes showed consistent positive effects across all studies examining this variable. The review also identified significant gaps in the existing literature. There is a substantial gap in teacher-centered research, with only 16.7% of reviewed studies focusing on educators and none specifically examining pre-service science teachers. This imbalance raises concerns about the preparedness of future biology teachers to implement SRL interventions effectively in their classrooms.

As the successful implementation of SRL strategies depends largely on teachers' competence, professional development, and support systems, the underrepresentation of pre-service teachers in the literature warrants immediate attention. Without intentional efforts to prepare educators, the potential benefits of SRL interventions for student achievement, motivation, and self-efficacy may not be fully realized.

RECOMMENDATIONS

Based on the findings of this systematic review, the following recommendations are proposed:

1. Future studies should focus on pre-service science teachers to better understand their knowledge, beliefs, and readiness to implement SRL interventions. Research should examine how teacher education programs can effectively prepare candidates to integrate SRL strategies into biology instruction.
2. Teacher educators and curriculum developers should create structured, research-informed training modules tailored to the integration of SRL strategies into pre-service biology education programs. These modules should bridge the gap between SRL theory and classroom practice.
3. Given the variable findings regarding motivation, future research should examine the specific mechanisms through which SRL interventions affect different dimensions of motivation (intrinsic vs. extrinsic, task-specific vs. general) and identify moderators of these effects.

4. Educational policymakers should mandate the integration of SRL strategy instruction into secondary school biology curricula, accompanied by professional development for in-service teachers.
5. Future research should employ mixed-methods designs to capture not only quantitative outcomes but also qualitative insights into students' and teachers' experiences with SRL interventions, including barriers and facilitators to implementation.
6. Nigerian and other African researchers should seek partnerships with international institutions to exchange knowledge, access resources, and co-develop strategies for embedding SRL interventions in science education.

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