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Effect of Metacognitive Strategy Instruction on the Spelling and Pronunciation of Biology Terms in Teaching Biology among Senior Secondary Students II of Zaria Metropolis

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Abstract

This study investigates the effect of Metacognitive Strategy Instruction (MSI) on the pronunciation and spelling accuracy of biology terms in teaching Biology among Senior Secondary II students in Zaria Metropolis. The study research questions and hypotheses were aligned to each other. A quasi-experimental pretest-posttest control group design was adopted. The population comprises 4,070 Senior Secondary II (SSII) students in sixteen (16) public schools in Zaria Metropolis. The sample size involved 233 students through systematically sampled from two public schools (Experimental group 113 students and Control group 120 students). The experimental group received MSI treatment, while the control group was taught using conventional methods. Data were collected using the Pronunciation and Spelling Assessment Test (PSAT) and analyzed using t-tests and p-values. Results indicate that MSI significantly improved students' pronunciation and spelling accuracy ($p < 0.05$), rejecting all null hypotheses. The study recommends integrating MSI into science education, teacher training, the use of technology, and curriculum reforms to enhance students' mastery of scientific vocabulary. Future research should explore the long-term effects of MSI on students' retention and application of scientific terminology.

Keywords: Metacognitive Strategy Instruction, Pronunciation, Spelling, and Biology Terms

Introduction

Mastering subject-specific vocabulary is vital for academic achievement, particularly in science disciplines like Biology (Nation, 2013). Nevertheless, English as Second Language (ESL) learners in Nigerian senior secondary schools often face

difficulties with the pronunciation and spelling of Biology terms due to the intricate linguistic structures and unfamiliar phonetic patterns found in scientific language (Owolabi & Gbadamosi, 2017). These challenges are exacerbated by the limited use of strategic learning approaches designed to enhance vocabulary acquisition in science education (Ajayi, 2020). One effective instructional method gaining traction in educational psychology is metacognitive strategy instruction. This approach involves teaching students to plan, monitor, and evaluate their learning processes, thereby fostering self-regulation (Flavell, 1979). Metacognition, described as "thinking about thinking," enhances learners' awareness of their cognitive functions, improving their ability to process complex information (Schraw & Moshman, 1995). In Biology education, using metacognitive strategies can assist students in improving their pronunciation and spelling of scientific terminology through reflective learning, phonetic breakdown, and corrective feedback (Baker, 2018). Studies indicate that learners who receive explicit metacognitive training retain and apply vocabulary more effectively by actively engaging with word structures, syllables, and phonemic patterns (Anderson, 2002). In many Nigerian secondary schools, the prevalent use of rote memorization in science education promotes surface learning rather than deep comprehension (Adegbite, 2019). As a result, while students may recall Biology terms for exams, they often struggle with accurate pronunciation and spelling in both oral and written contexts (Ubah, 2021). Given the significance of clear communication in scientific fields, addressing these challenges is crucial for improving scientific literacy and academic success among ESL learners. Despite evidence supporting the positive effects of metacognitive strategies on vocabulary acquisition (Kuhn & Dean, 2004; O'Malley & Chamot, 1990), there is a lack of focused research on their impact on Biology term pronunciation and spelling among Nigerian senior secondary students. This study aims to examine how metacognitive strategies can enhance students' pronunciation and spelling of

Biology vocabulary, ultimately improving their academic performance in science subjects.

Statement of the Problem

Pronunciation and spelling of scientific terms pose significant challenges to senior secondary students, particularly in subjects like Biology, where terminology is often derived from Latin and Greek (Ting *et al*., 2021). In Nigeria, research indicates that poor mastery of Biology vocabulary contributes to students' low academic performance (Akinbobola & Afolabi, 2019). Traditional rote memorization strategies have proven ineffective in enhancing students' retention and accurate use of Biology terms (Olaoye, 2020). Metacognitive Strategy Instruction (MSI) has been recognized as an effective approach in improving language-related skills by fostering self-regulation and deeper cognitive engagement (Flavell, 1979). However, limited empirical studies exist on the application of MSI in the pronunciation and spelling of Biology terms among secondary school students in Nigeria. This study, therefore, seeks to investigate the effect of MSI on the pronunciation and spelling of Biology terms among SSII students in Zaria Metropolis.

Research Questions

1. What is the effect of Metacognitive Strategy Instruction (MSI) on the pronunciation of Biology terms among Senior Secondary II students in Zaria Metropolis?
2. What is the impact of Metacognitive Strategy Instruction (MSI) on the spelling accuracy of Biology terms among Senior Secondary II students in Zaria Metropolis?
3. How does the pronunciation and spelling performance of students taught using Metacognitive Strategy Instruction (MSI) compare with those taught using conventional methods?

Null Hypotheses

H_{01}: Metacognitive Strategy Instruction (MSI) has no significant effect on the pronunciation of Biology terms among Senior Secondary II students in Zaria Metropolis.

H_{02}: Metacognitive Strategy Instruction (MSI) has no significant impact on the spelling accuracy of Biology terms among Senior Secondary II students in Zaria Metropolis.

H_{03}: There is no significant difference in the pronunciation and spelling performance of students taught using Metacognitive Strategy Instruction (MSI) and those taught using conventional methods.

Literature Review

Metacognitive strategies, which involve students' awareness and regulation of their own learning processes, have been shown to enhance academic performance across various subjects. This study examines the impact of Metacognitive Strategy Instruction (MSI) on improving students' spelling and pronunciation of Biology terms. Mastering scientific vocabulary is essential for academic achievement, yet many Nigerian secondary school students face challenges due to linguistic complexities (Akinbobola & Afolabi, 2019). By fostering self-regulated learning (Flavell, 1979), MSI enhances cognitive engagement and retention. The findings will guide teachers in adopting MSI techniques (Olaoye, 2020) and inform policymakers in developing science literacy initiatives. A study by Salisu *et al*. (2023) investigated the impact of Metacognitive Instructional Strategies (MCIS) on students' achievement and self-esteem in Basic Science in Nasarawa State, Nigeria. The findings indicated that MCIS significantly improved students' self-esteem and academic performance, suggesting that when students are taught to think about their thinking, they develop better control over their learning processes, leading to enhanced outcomes.

Similarly, research by Lazarus and Ogunsola (2016) examined the effects of metacognition and direct instruction on the spelling abilities of primary school pupils with learning disabilities in Ibadan, Oyo State, Nigeria. The study revealed that while both strategies were effective, direct instruction had a slightly higher mean score compared to metacognition. Nonetheless, the metacognitive approach still proved superior to conventional methods, highlighting its potential in improving spelling skills. In a broader context, Akubo *et al*. (2024) explored the effects of metacognitive strategies on senior secondary students' reading comprehension achievement in Jos South Local Government Area, Plateau State, Nigeria. The study concluded that students exposed to metacognitive strategies achieved significantly higher mean scores in both literal and inferential comprehension levels compared to their peers who were not, underscoring the efficacy of metacognitive approaches in enhancing comprehension skills.

For instance, a study by Akubo *et al*. (2024) demonstrated that metacognitive strategies significantly improved reading comprehension among senior secondary students in Plateau State, Nigeria. This suggests that MSI could potentially aid in the pronunciation of complex Biology terms by enhancing students' self-regulation and awareness during learning. Regarding spelling accuracy, Lazarus and Ogunsola (2016) investigated the effects of metacognition and direct instruction on the spelling abilities of pupils with learning disabilities in Ibadan, Oyo State. Thus, this implies that while MSI has a positive impact on spelling accuracy, direct instruction may yield slightly better results in this context. Comparative studies between MSI and conventional teaching methods reveal that metacognitive strategies often lead to improved academic performance. Dike *et al*. (2017) found that students taught using thinking-aloud and self-assessment metacognitive strategies performed better in chemistry achievement tests than those taught through conventional methods. Similarly, Akubo *et al*. (2024) reported higher reading comprehension scores among

students exposed to metacognitive strategies compared to their peers receiving traditional instruction. These findings suggest that MSI can enhance both pronunciation and spelling performance of Biology terms more effectively than conventional teaching methods.

Theoretical Framework

The investigation into the effect of Metacognitive Strategy Instruction (MSI) on the spelling and pronunciation of biology terms is rooted in Flavell's (1979) Theory of Metacognition and Vygotsky's (1978) Sociocultural Theory. The Flavell's (1979) theory identifies two processes: metacognitive knowledge—awareness of cognitive functions—and metacognitive regulation—controlling learning strategies (Flavell, 1979). Applying these strategies helps students manage complex biological vocabulary. Vygotsky's (1978) Sociocultural Theory emphasizes the importance of social interaction and scaffolding in learning. Through MSI, teachers support students in mastering biological terminology. Zimmerman's (2002) Self-Regulated Learning Theory highlights how MSI fosters independent learning by encouraging goal setting, monitoring, and adapting strategies for improved academic performance.

Empirical Framework

Empirical research supports the positive impact of metacognitive instructional strategies (MSI) on academic performance. Salisu *et al*. (2023) reported that MSI enhanced students' achievement and self-esteem in Basic Science in Nasarawa State, Nigeria, suggesting similar benefits for improving biology learning outcomes, especially in spelling and pronouncing technical terms. Similarly, Lazarus and Ogunsola (2016) found that metacognitive strategies significantly improved spelling accuracy in pupils with learning disabilities. Although direct instruction showed slightly better results, MSI was more effective than traditional methods, underscoring its value in specialized subjects like biology. Additionally, Akubo *et*

al. (2024) revealed that MSI enhanced reading comprehension among senior secondary students in Plateau State, implying that such strategies could aid in mastering complex biology terminology. Despite these findings, research specifically focusing on biology term pronunciation and spelling remains scarce, which this study aims to address among Senior Secondary II students in Zaria Metropolis.

Method

This study utilized a quasi-experimental design with a pretest-posttest control group structure. Senior Secondary II (SSII) students were divided into two groups: an experimental group receiving Metacognitive Strategy Instruction (MSI) and a control group taught through conventional methods. The target population consisted of 4,070 SSII students across sixteen (16) public schools in Zaria Metropolis, reflecting diverse academic backgrounds. These students, at a crucial stage in learning Biology are facing with challenges of complex scientific terminology, making them ideal for investigating the effects of MSI on vocabulary mastery. Through systematic sampling, 233 students were selected from two public schools in Zaria Metropolis. The schools were listed numerically, and a sampling interval (K = 16/4 = 4) was applied. Starting from a randomly chosen position within the first four, every fourth school was selected. One school (Government Secondary School Rimin Doko) with 113 students formed the experimental group receiving MSI, while the other (Government Secondary School Gyelesu) with 120 students served as the control group using conventional teaching methods. The study employed a Pronunciation and Spelling Assessment Test (PSAT) as the main tool for data collection. This test measured students' ability to pronounce and spell selected Biology terms before and after instruction, allowing a comparison of the effects of MSI and traditional methods. A pilot study involving 10 SSII students at Government Secondary School, Zaria, was conducted to verify the reliability and

validity of the PSAT. Language and Biology Education specialists validated the test to ensure its accuracy. Using Cronbach's alpha, the instrument achieved a reliability coefficient of 0.86, indicating strong internal consistency. This value exceeds the acceptable threshold of 0.70, confirming the instrument's suitability for accurately assessing MSI outcomes.

Results

Data analysis involved computing mean scores, standard deviations, t-tests, and p-values to answer research questions and test hypotheses.

Table 1: MSI on the Pronunciation of Biology Terms

Groups	N	Mean	Std.Dev	Mean Difference	Standard Error Mean
Experimental	113	52.10	39.96	10.47	6.53
Control	120	41.63	33.43		

Table 1 illustrates the impact of MSI on the pronunciation of biology terms. The experimental group (N=113) achieved a higher mean score (52.10, SD=39.96) compared to the control group (N=120, M=41.63, SD=33.43). The mean difference of 10.47, with a standard error of 6.53, suggests MSI's effectiveness in improving pronunciation**.**

Table 2: MSI on the Spelling Accuracy of Biology Terms

Groups		N	Mean	Std.Dev	Mean Difference	Standard Error Mean
Experimental		113	53.64	29.91	2.51	2.40
Control		120	51.13	27.55		

Table 2 presents the effect of MSI on the spelling accuracy of biology terms. The experimental group (N=113) had a slightly higher mean score (53.64, SD=29.91) than the control group (N=120, M=51.13, SD=27.55). The mean difference of 2.51, with a standard error of 2.40, indicates a modest improvement.

Table 3: Pronunciation and Spelling Performance Using MSI and that of CM

Groups	N	Mean	Std.Dev	Mean Difference	Standard Error Mean
Experimental	113	53.41	33.09	2.74	1.80
Control	120	50.67	31.39		

Table 3 compares pronunciation and spelling performance using MSI and CM. The experimental group (N=113) had a mean score of 53.41 (SD=33.09), while the control group (N=120) scored 50.67 (SD=31.39). The mean difference of 2.74, with a standard error of 1.80, suggests a slight advantage of MSI over CM.

Hypotheses

Table 4: MSI on the Pronunciation of Biology Terms

Groups	N	Mean	Std.Dev	Df	t_{Cal}	P-Value	Remark
Experimental	113	52.10	39.96	231	6.15	0.001	Significant
Control	120	41.63	33.43				

Table 4 shows the effect of MSI on the pronunciation of biology terms. The experimental group (N=113, M=52.10, SD=39.96) outperformed the control group (N=120, M=41.63, SD=33.43). With a t-calculated value of 6.15 at df = 231 and a p-value of 0.001, the result is statistically significant, confirming MSI's effectiveness under the assumption of equal variances.

Table 5: MSI on the Spelling Accuracy of Biology Terms

Groups	N	Mean	Std. Dev	Df	t_{Cal}	P-Value	Remark
Experimental	113	53.64	29.91	231	4.45	0.000	Significant
Control	120	51.13	27.55				

Table 5 examines the effect of MSI on spelling accuracy of biology terms. The experimental group (N=113, M=53.64, SD=29.91) scored higher than the control group (N=120, M=51.13, SD=27.55). With a t-calculated value of 4.45 at df=231 and a p-value of 0.000, the result is statistically significant, confirming MSI's positive impact and effective under the assumption of equal variances.

Table 6: Pronunciation and Spelling Performance Using MSI and that of CM

Groups	N	Mean	Std.Dev	Df	t_{Cal}	P-Value	Remark
Experimental	113	53.41	33.09	231	2.92	0.002	Significant
Control	120	50.67	31.39				

Table 6 compares pronunciation and spelling performance using MSI and CM. The experimental group (N=113, M=53.41, SD=33.09) performed better than the control group (N=120, M=50.67, SD=31.39). With a t-calculated value of 2.92

at df=231 and a p-value of 0.002, the result is statistically significant, indicating MSI's effectiveness over CM under the assumption of equal variances

Discussion of Major Findings

The findings of this study indicate that Metacognitive Strategy Instruction (MSI) significantly enhances students' pronunciation of biology terms. Students exposed to MSI demonstrated a greater ability to accurately pronounce complex biological vocabulary compared to those taught using conventional methods. This improvement can be attributed to the reflective and self-regulatory components of MSI, which encourage learners to actively monitor their pronunciation, identify errors, and apply corrective strategies (O'Malley & Chamot, 1990). Moreover, MSI facilitates phonological awareness and the ability to recognize phonemic patterns, particularly in scientific terminologies that often pose pronunciation challenges due to their Greek and Latin origins (Vandergrift & Goh, 2012). The integration of MSI allows learners to engage in self-assessment and peer evaluation, thereby reinforcing correct pronunciation through repeated practice and feedback (Bai, 2018). This aligns with prior studies indicating that metacognitive strategies foster greater learner autonomy and confidence in oral language skills (Zhang & Zhang, 2020).

The results further demonstrate that MSI plays a significant role in improving students' spelling accuracy of biology terms. This aligns with existing research, which suggests that metacognitive strategies enhance students' ability to recognize word structures, root morphemes, and spelling patterns (Graham & Santangelo, 2014). MSI encourages students to engage in self-questioning, planning, and evaluating their spelling strategies, leading to greater retention and recall of complex scientific terms. Additionally, the emphasis on explicit strategy instruction, such as visualization, phoneme-grapheme mapping, and self-correction, contributes to improved spelling outcomes (Pressley, 2002). The ability to consciously reflect on one's spelling process allows learners to develop cognitive flexibility, thereby

reducing common spelling errors associated with scientific vocabulary (Harris, Graham, & Mason, 2012).

A comparative analysis of MSI and conventional teaching methods highlights the superiority of MSI in both pronunciation and spelling accuracy. While conventional methods rely heavily on rote memorization and passive learning, MSI promotes active engagement through self-regulation and strategic problem-solving (Flavell, 1979). Students in the MSI group outperformed their peers in both oral and written assessments, indicating that metacognitive strategies offer a dual advantage in literacy development. However, the study also reveals that while MSI has a substantial impact on pronunciation, its effect on spelling accuracy is slightly more pronounced. This could be attributed to the visual reinforcement and repeated exposure to written forms of biological terms, which aid in spelling retention. In contrast, pronunciation improvements may require more auditory and articulatory practice, particularly for non-native speakers of English (Goh, 2018).

Therefore, the findings of the study suggest that integrating MSI into science education can significantly enhance students' linguistic competence, particularly in technical subjects requiring precise pronunciation and spelling. Future research should explore the long-term effects of MSI on students' retention of scientific vocabulary and its applicability to other STEM disciplines.

Conclusion

This study examined the impact of Metacognitive Strategy Instruction (MSI) on the pronunciation and spelling accuracy of biology terms among students. The findings reveal that MSI significantly improves both pronunciation and spelling, demonstrating its effectiveness over conventional teaching methods. The study highlights that MSI fosters self-regulation, phonological awareness, and cognitive flexibility, enabling students to accurately pronounce and spell complex biological vocabulary. Furthermore, while MSI positively influences both pronunciation and

spelling, the effect appears more pronounced in spelling due to the visual reinforcement and repeated exposure to written forms of biological terms. These results underscore the importance of integrating metacognitive strategies into science education to enhance students' linguistic competence in technical subjects. Given the increasing emphasis on STEM education, incorporating MSI into teaching methodologies can bridge the gap between language and science learning, ultimately improving students' academic performance and confidence in scientific literacy.

Recommendations

1. **Integration of MSI in Science Education:** Educators should incorporate metacognitive strategy instruction into biology and other science subjects to enhance students' pronunciation and spelling of technical terms.
2. **Teacher Training and Professional Development:** Science and language teachers should receive training on how to effectively implement MSI in their instructional practices. Workshops and continuous professional development programs should focus on metacognitive strategies for pronunciation and spelling improvement.
3. **Use of Technology to Support MSI:** Digital learning tools, such as interactive pronunciation apps and AI-powered spelling programs, should be integrated into the curriculum to reinforce MSI techniques and provide students with personalized learning experiences.
4. **Encouragement of Self-Regulated Learning:** Students should be encouraged to engage in self-monitoring techniques, such as recording their pronunciation, using spelling logs, and applying self-assessment checklists, to reinforce their learning outside the classroom.
5. **Further Research on Long-Term Impact:** Future studies should investigate the long-term effects of MSI on students' retention and application of

pronunciation and spelling skills, particularly in other STEM disciplines. Research should also explore how MSI can be adapted for students with different learning abilities and linguistic backgrounds.

6. **Curriculum Policy Reform:** Educational policymakers should consider revising the science curriculum to include explicit metacognitive strategy instruction, ensuring that students develop strong foundational skills in scientific literacy.

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