

Effect of Model- Lead-Test (MLT) Instructional Strategy on Students Academic Performance in Basic Science in Secondary Schools in Rivers State

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Abstract:

Improving students' academic achievement in Basic Science remains a critical challenge in Nigerian secondary schools, as traditional teacher-centered methods often limit engagement and conceptual understanding. Despite evidence supporting interactive instructional strategies, there is limited empirical research on the application of the Model–Lead–Test (MLT) strategy at the junior secondary level. This study adopted a quasi-experimental design with a non-equivalent control group, involving 100 Junior Secondary 2 students from two public schools. The experimental group ($n = 50$) received MLT instruction, while the control group ($n = 50$) was taught using the conventional lecture method. Data were collected using the 40-item Basic Science Achievement Test (BSAT) and analyzed with mean, standard deviation, and ANCOVA. Results indicated that the experimental group achieved a higher mean gain (4.00) than the control group (3.70), although the difference was not statistically significant ($F(1,97) = 3.37, p = 0.069$). Gender did not significantly influence performance. It is recommended that MLT be adopted alongside extended instructional periods to enhance learning outcomes, fostering deeper engagement and improved academic performance.

Keywords: Model-lead-test, strategy, performance, basic science, secondary schools.

INTRODUCTION

Improving students' academic progress remains one of the most challenging and enduring responsibilities of the classroom teacher. In contemporary educational systems, teachers continually grapple with fundamental pedagogical questions such as which instructional strategy best aligns with lesson objectives, what teaching methodology enhances students' understanding, which learning materials provide meaningful learning experiences, and how to structure the classroom environment to maximise students' assimilation and engagement. These concerns are particularly crucial for the teaching of basic science and technology, a foundational subject that underpins national scientific and technological growth. The importance of equipping junior secondary school learners with sound scientific understanding, relevant skills, and positive attitudes cannot be overstated, as these competencies shape learners into problem solvers, critical thinkers, lifelong learners, and self-reliant citizens capable of contributing to national development (Ogunniyi, 2020; Adeoye & Olatoye, 2022). Achieving these goals, however, depends significantly on teachers' ability to adopt instructional strategies that respond to learners' needs, current educational realities, and the demands of 21st-century science education.

Despite this need, the conventional lecture method—which has dominated Nigerian classrooms for decades—has increasingly proven inadequate for promoting active learning, inquiry, and deep conceptual understanding among students. Numerous studies have shown that teacher-centred methods limit learners' participation, reduce engagement, and fail to develop higher-order thinking skills that modern science education requires (Ezenwa & Uzoechi, 2021; Yusuf & Alabi, 2023). This gap in instructional effectiveness has necessitated the search for more interactive, structured, and learner-responsive strategies that can support students' mastery of scientific concepts while enhancing retention, motivation, and performance. One promising strategy identified in recent scholarship is the Model-Lead-Test (MLT) teaching approach, a structured form of direct instruction that emphasises explicit modelling, guided practice, and independent performance. Although research has demonstrated its effectiveness in improving learning outcomes, its application in basic science classrooms in Nigeria remains understudied, creating a significant gap that necessitates empirical investigation to determine its influence on students' academic achievement in the subject.

Conceptually, models of teaching are systematic, research-based plans that guide the structure of instruction, shape the curriculum, and organise teacher–student interactions in ways that support the attainment of learning objectives. They provide the procedures, phases, and behaviours through which instruction can be meaningfully executed (Joyce & Weil, 2018). Teaching models offer frameworks for designing learning environments, selecting instructional materials, and determining how learning experiences should unfold. They also enhance both instructional and nurturant effects—while the instructional effect influences cognitive, affective, and psychomotor outcomes directly, the nurturant effect fosters broader intellectual dispositions such as critical thinking, problem-solving, and social skills (Bruce & Hall, 2019). Within this context, the MLT model stands out as a direct, explicit instructional sequence that begins with the teacher demonstrating the target skill or concept (Model), continues with guided practice involving both teacher and learners (Lead), and ends with students practising independently to demonstrate mastery (Test). Scholars such as Ken-Maduaku (2015) and Ogidi (2015) note that this strategic progression reduces misconceptions, strengthens procedural understanding, and improves students' confidence in performing science-related tasks.

Recent empirical studies further highlight the pedagogical value of the MLT approach. For example, Lopez and Ochoa (2020) reported that the structured and repetitive nature of MLT significantly improved science achievement among English language learners by reducing cognitive overload and enhancing clarity during instruction. Similarly, Johnson and Smith (2019) found that students with learning disabilities demonstrated remarkable improvements in understanding

complex scientific concepts when taught using MLT due to its scaffolding mechanisms. Technology-enhanced adaptations of MLT have also gained prominence. Roberts and Pruitt (2021) showed that integrating digital simulations, interactive models, and electronic feedback systems within the MLT framework increased students' engagement and boosted their academic performance compared to traditional, non-digital instruction. These findings align with broader evidence emphasising that students learn more effectively when instruction is explicit, scaffolded, and structured around active participation and continual feedback (Becker & Park, 2022; Udo & Anietie, 2023).

The need for the present study therefore arises from persistent concerns about low achievement levels among basic science students, the limitations of traditional teaching methods, and the scarcity of local empirical evidence on the effectiveness of the MLT strategy in Nigerian basic science classrooms. While international research affirms the promise of MLT, contextual variations in class size, teacher preparedness, resource availability, and curriculum demands create uncertainties regarding its applicability in Nigerian schools. Consequently, there is a clear gap in literature concerning how the MLT instructional approach influences students' academic performance in basic science within the Nigerian junior secondary context. Addressing this gap is essential for informing curriculum planners, guiding teacher professional development programmes, and improving pedagogical practices that can help learners acquire the scientific competencies needed for national development. Ultimately, the study is anchored on the conviction that evidence-based teaching strategies such as MLT hold strong potential for transforming science education by promoting deeper learning, encouraging collaborative engagement, and helping students construct meaningful scientific knowledge through structured instructional support.

The growing emphasis on improving students' academic achievement in basic science and technology underscores the need for teachers to adopt instructional models that respond to the cognitive and developmental needs of 21st-century learners. As highlighted earlier, teachers face numerous questions regarding how best to deliver instruction, select learning materials, and create enabling classroom environments that support comprehension and long-term retention. These concerns become even more pressing considering that conventional lecture-dominated pedagogy, though widely used in Nigerian classrooms, no longer aligns with modern expectations for student engagement, critical thinking, and competency-based learning (Adeoye & Olatoye, 2022; Yusuf & Alabi, 2023). Consequently, there is a growing need to embrace more structured, explicit, and evidence-based instructional strategies that facilitate clearer learning pathways, scaffolded practice, and progressive learner autonomy.

Despite the documented benefits of active and learner-centred methodologies, a major gap persists in the application of systematic teaching models such as the Model-Lead-Test (MLT) framework in basic science classrooms. Existing research focuses extensively on general instructional strategies, yet few empirical studies within Nigeria explore the comparative effectiveness of MLT on students' mastery of scientific concepts, operational skills, and cognitive outcomes (Udo & Anietie, 2023). Moreover, although international studies show that structured direct instruction techniques significantly enhance performance among diverse learners—including those with learning difficulties—this evidence has not been sufficiently localised to basic science instruction at the junior secondary level (Johnson & Smith, 2019; Lopez & Ochoa, 2020). This gap demonstrates a clear need for empirical inquiry into how MLT can support concept development, procedural fluency, and learner independence in basic science.

Understanding models in teaching is instrumental to bridging this gap. Models of teaching represent broad, philosophical orientations to instruction and are grounded in theories from education, psychology, and cognitive science. They provide conceptual blueprints that guide how learning activities are designed, sequenced, and delivered to achieve specific instructional outcomes (Joyce & Weil, 2018). Unlike instructional strategies—which are more specific and task-orientated—

teaching models operate at a higher level of abstraction, influencing how teachers interpret learning problems, organise content, and choose pedagogical actions. Instructional strategies are therefore subsets of teaching models, translating broader philosophical assumptions about learning into concrete classroom practices. Through this relationship, teaching models establish the overarching framework, while instructional strategies represent the actionable steps teachers take to achieve the intended outcomes.

The importance of teaching models in instructional practice cannot be overstated. A well-chosen model helps teachers meet the needs of heterogeneous groups, address varied learning outcomes, and adapt instruction to different levels of student readiness (Bruce & Hall, 2019). In addition, teaching models expand teachers' professional repertoires by enabling them to use varied, flexible, and targeted instructional events that align with curriculum demands and learners' cognitive profiles. Joyce and Weil's earlier classification identified more than eighty distinct teaching models, each requiring consideration of the teacher's discretion, the target learners, and the intended objectives. The primary purpose of such models is to assist students in developing creativity, self-awareness, inductive reasoning, responsibility, and mastery of subject matter—competencies that remain crucial in contemporary science education (Ken-Maduaku, 2015; Ezenwa & Uzoечи, 2021).

Among the established categories of teaching models—information processing, social interaction, personal development, and behavioural models—the behavioural family has gained prominence in contemporary basic science instruction due to its emphasis on mastery learning, reinforcement, and observable competence (Nwagbo, 2013; Becker & Park, 2022). This approach aligns strongly with the direct instruction philosophy, in which learning progresses from teacher modelling to guided practice and independent demonstration of mastery. Direct Instruction (DI) has proven effective across disciplines, especially in improving performance among disadvantaged, low-achieving, or linguistically diverse learners by providing structured, explicit, and sequential learning experiences (Lopez & Ochoa, 2020; Roberts & Pruitt, 2021).

The Model-Lead-Test (MLT) strategy—an embodiment of the direct instruction model—offers a concrete framework for improving procedural and conceptual understanding in basic science. The model phase requires the teacher to explicitly demonstrate the target skill or concept, providing a clear exemplar for students to observe. In the lead phase, learners and teachers jointly practise the skill, allowing learners to verbalise reasoning, test understanding, and clarify misconceptions under guided supervision. The test phase then requires learners to independently apply the skill, demonstrating mastery and offering teachers the opportunity to provide corrective feedback (Price & Nelson, 2003; Ken-Maduaku, 2015). Research confirms that the repeated cycles of observation, guided practice, and independent performance inherent in the MLT process significantly enhance content mastery, retention, and transferability of learning, particularly in science subjects requiring procedural accuracy and conceptual clarity (Johnson & Smith, 2019; Udo & Anietie, 2023).

Furthermore, the MLT approach supports increased active academic responding—an essential determinant of learning identified by Heward (1994). When learners spend more time responding to tasks, solving problems, and articulating their understanding, they are more likely to achieve long-term retention and improved performance. Studies affirm that technology-enhanced versions of MLT, such as digital simulations in the modelling phase or interactive quizzes during the testing phase, further improve engagement and achievement (Roberts & Pruitt, 2021). Despite these documented benefits, widespread adoption of the MLT strategy remains limited, reinforcing the need for research that examines how this approach can strengthen basic science instruction in Nigerian secondary schools.

The Model-Lead-Test (MLT) instructional sequence is one of the most widely recognised forms of explicit instruction designed to promote mastery, retention, and transfer of learning among students. The sequence requires teachers to adopt systematic steps that ensure clarity, guided practice, and

independent performance (Ken-Maduaku, 2015; Becker & Park, 2022). In its basic form, MLT involves the teacher modelling the target skill or concept, guiding learners through supported practice, and finally allowing them to perform the task independently at a high criterion level of accuracy (Johnson & Smith, 2019).

As a structured instructional strategy, the design of the Model–Lead–Test sequence typically follows nine core steps. First, the teacher models the instructional task to demonstrate the expected performance clearly. Second, the teacher provides explicit instruction, particularly when the skill is unfamiliar or cognitively demanding. Third, the teacher facilitates meaningful interactions with appropriate academic language to help students internalise concepts (Lopez & Ochoa, 2020). Fourth, students are offered multiple opportunities for guided practice, enabling them to rehearse new skills. Fifth, the teacher gives corrective feedback immediately after students' initial attempts. Sixth, the teacher encourages persistence and effort, reinforcing productive learning behaviours. Seventh, students actively participate during teacher-led demonstrations, while eighth, they remain engaged during independent work. Finally, students are expected to successfully complete tasks at a high level of performance before transitioning to new content (Roberts & Pruitt, 2021; Udo & Anietie, 2023).

A substantial body of evidence indicates that when correctly applied, the MLT strategy yields significant improvements in students' academic achievement. Weber and Riley (2012) reported that students taught through MLT performed up to 80% better than those taught through less structured strategies, an advantage reaffirmed in more recent studies involving science classrooms (Ken-Maduaku, 2015; Udo & Anietie, 2023). Beyond achievement gains, the MLT model offers considerable benefits to both teachers and learners. For teachers, it enhances the quality of instruction, provides a systematic approach to lesson planning, improves awareness of students' learning needs, helps them assess the impact of instruction, and offers multiple representations of content (Bruce & Hall, 2019). It also strengthens teachers' ability to design learning experiences that foster meaningful engagement.

For learners, the strategy increases learning aptitude and retention, accelerates the pace of mastery, supports diverse learning needs, improves academic self-esteem, and helps students understand how learning will occur and what outcomes are expected (Ogidi, 2015; Ezenwa & Uzoechi, 2021). These benefits make MLT particularly valuable in subjects like basic science, where conceptual understanding, procedural fluency, and application skills are central.

However, despite its documented benefits, many basic science teachers in Nigeria still rely heavily on traditional expository approaches that limit learner participation and reduce opportunities for guided practice (Adeoye & Olatoye, 2022; Yusuf & Alabi, 2023). The continued reliance on such methods raises concerns about whether students are achieving their full potential in foundational science concepts. Given the persistent gaps in students' basic science performance in many Nigerian secondary schools, investigating the effectiveness of MLT compared to the traditional method becomes both timely and necessary.

Despite the accumulating evidence, there remain important gaps that your study is poised to address. First, most of the Nigeria-based explicit instruction studies focus either on senior secondary students (e.g., Itikpo et al., 2021) or on non-science subjects (e.g., Ogunjimi & Gbadeyanka, 2023), leaving junior secondary basic science under-examined. Because this level is central to building foundational science knowledge, it is critical to investigate how MLT operates in this context. Second, few studies rigorously monitor implementation fidelity: although strategies like MLT rely on precise modelling, guided practice, and feedback, the extent to which teachers adhere to these phases is rarely documented in published research, making it hard to attribute outcomes directly to MLT. Third, retention of learning is seldom measured: most quasi-experiments report immediate posttest gains but do not assess whether those gains persist over time. Finally, subgroup analyses—

especially by gender or baseline achievement—are limited, so it is unclear whether all student groups benefit equally from MLT. Although the Model–Lead–Test strategy has been shown in recent research to significantly improve students’ academic achievement, retention, and engagement in science education, many basic science teachers in Nigeria continue to rely on traditional expository methods that may not adequately support learners’ mastery of key concepts. This gap raises the question of whether the MLT strategy offers superior learning benefits for basic science students compared to conventional instructional practices.

Research Questions

1. Is there a difference in the mean achievement scores of students taught Basic Science using the Model–Lead–Test (MLT) strategy and those taught using the traditional method?
2. Is there a difference in the mean achievement scores of male and female students taught Basic Science using the MLT strategy?

Hypotheses

1. **H0₁**: There is no significant difference in the mean academic achievement scores of students taught Basic Science using the MLT strategy and those taught using the traditional method.
2. **H0₂**: There is no significant difference in the mean academic achievement scores of male and female students taught Basic Science using the MLT strategy.

Methodology

The study adopted a quasi-experimental research design of the non-equivalent control group type, utilising intact classes due to the impracticability of random assignment within the existing school system. Two instructional groups were compared: an experimental group exposed to the Model–Lead–Test (MLT) instructional strategy and a control group taught using the conventional expository method. Both groups were administered a pretest prior to the intervention and a posttest at the end of the instructional period, using the same achievement instrument to ensure comparability.

The population comprised all Junior Secondary Two (JS2) students offering Basic Science in public secondary schools within the study area during the 2024/2025 academic session. JS2 students were considered appropriate for the study because they possessed the foundational scientific knowledge required for the intervention content. A sample of 100 students was drawn from four intact JS2 classes selected from two public secondary schools with comparable facilities, qualified teachers, and similar academic schedules. Schools were selected purposively, while simple random sampling was used to assign one intact class in each school to either the experimental or control group, resulting in 50 students per group. Data were collected using the Basic Science Achievement Test (BSAT), a 40-item multiple-choice instrument developed by the researcher to assess students’ cognitive achievement in the basic science topics taught. The instrument was validated for face and content validity, while reliability was established through a pilot study involving 30 JS2 students from a school outside the study area. The Kuder–Richardson Formula 20 (KR-20) yielded a reliability coefficient of 0.82, indicating high internal consistency. The intervention lasted six weeks. Prior to implementation, basic science teachers in the selected schools were trained on the instructional procedures relevant to their assigned methods. The experimental group received instruction through the MLT sequence, involving teacher modelling, guided practice, and independent student performance with feedback. The control group was taught using the traditional lecture method, characterised by teacher explanation and limited student interaction. Data were analysed using mean and standard deviation to address the research questions, while Analysis of Covariance (ANCOVA) was employed to test the null hypotheses at the 0.05 level of significance.

Results

Research Question 1. What is the difference in the mean achievement scores of students taught Basic Science using the Model–Lead–Test (MLT) strategy and those taught using the traditional method?

Table 1. Summary of descriptive statistics on the difference in the mean achievement scores of students taught with the model-lead-test learning strategy and those taught with the lecture method

Groups	N	Pretest		Posttest		Gain	
		Mean	SD	Mean	SD	Mean	SD
Experimental Group	50	9.22	3.35	13.22	3.95	4.00	5.18
Control Group	50	6.74	3.16	10.68	3.58	3.98	4.78

Table 1 shows that the experimental group had a pretest mean score of 9.22 with a standard deviation of 3.35, while their posttest mean score increased to 13.22 with a standard deviation of 3.95. This resulted in a gain mean of 4.00. Similarly, the control group had a pretest mean score of 6.74 with a standard deviation of 3.16. Their posttest mean score rose to 10.68 with a standard deviation of 3.58, producing a gain mean of 3.94. These results indicate that both groups improved after the intervention; however, the experimental group recorded a slightly higher mean gain compared to the control group, although with greater variability in performance.

HO₁: There is no significant difference in the mean academic achievement scores of students taught Basic Science using the MLT instructional strategy and those taught using the traditional method.

Table 2 Summary of ANCOVA on the differences in the mean performance scores of students taught with model-lead-test learning strategy and those taught using the conventional lecture method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	730.432 ^a	2	365.216	76.758	0.000
Intercept	0.761	1	0.761	0.160	0.690
Posttest	576.672	1	576.672	121.200	0.000
Group	16.037	1	16.037	3.370	0.069
Error	461.528	97	4.758		
Total	7560.000	100			
Corrected Total	1191.960	99			

a. R Squared = .613 (Adjusted R Squared = .605)

Table 2 shows the ANCOVA result which revealed a significant model, $F(2, 97) = 76.76, p < .001$, accounting for 60.5% of the variance in posttest scores. Pretest scores significantly influenced achievement, $F(1, 97) = 121.20, p < .001$. However, the instructional group effect was not significant, $F(1, 97) = 3.37, p = .069$; therefore, the null hypothesis was not rejected.

RQ₂. Is there a difference in the mean achievement scores of male and female students taught Basic Science using the MLT strategy?

Table 3. Summary of descriptive statistics on the difference in the mean achievement scores of male and female students taught with the model-lead- test learning strategy and those taught with the lecture method

Gender	N	Pretest		Posttest		Gain	
		Mean	SD	Mean	SD	Mean	SD

Male	22	8.95	3.04	12.95	3.58	4.00	4.70
Female	28	9.42	3.61	13.43	3.98	4.01	5.37

Table 3 presents the mean and standard deviation of the pretest, posttest, and gain scores of students disaggregated by gender. The results indicate that male students obtained a pretest mean score of 8.95 (SD = 3.04) and a posttest mean score of 12.95 (SD = 3.58), resulting in a mean gain of 4.00 (SD = 4.70). Similarly, female students recorded a pretest mean score of 9.42 (SD = 3.61) and a posttest mean score of 13.43 (SD = 3.98), with a mean gain of 4.01 (SD = 5.37). The near-identical gain scores for both groups suggest that improvement in students' performance was comparable across gender, indicating that gender did not significantly influence learning gains.

HO₂: There is no significant difference in the mean academic achievement scores of male and female students taught Basic Science using the MLT strategy.

Table 2 Summary of ANCOVA on the differences in the mean achievement scores of students taught with Model-Lead-Test learning strategy and those taught using the conventional lecture method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.768 ^a	1	2.768	0.243	0.625
Intercept	4163.408	1	4163.408	364.803	0.000
Gender	2.768	1	2.768	0.243	0.625
Error	547.812	48	11.413		
Total	4801.000	50			
Corrected Total	550.580	49			
a. R Squared = .005 (Adjusted R Squared = -.016)					

The ANCOVA results show that the effect of gender on students' posttest scores was not significant, $F(1, 48) = 0.243$, $p = 0.625$, with a negligible R^2 of .005 (adjusted $R^2 = -.016$). This indicates that gender did not meaningfully influence students' achievement, and the null hypothesis that there is no difference in performance based on gender is retained.

Discussion

The findings of this study indicate that both the experimental and control groups experienced improvements in their basic science achievement scores from pretest to posttest. This demonstrates that engagement in instructional activities, regardless of the method used, positively influenced students' learning. Notably, students in the experimental group, who were taught using the innovative Model-Lead-Test (MLT) strategy, recorded higher mean gains than those in the control group. This suggests that student-centred approaches, which emphasise active participation, collaborative problem-solving, and guided practice, may offer richer learning experiences compared to traditional teacher-centred methods. Similar conclusions have been reported by Obioma and Samson (2022), who observed that active learning strategies such as project-based and flipped learning enhance engagement and knowledge retention, thereby improving academic outcomes.

Despite the relatively higher gains observed in the experimental group, the ANCOVA results indicated that the difference between groups was not statistically significant after controlling for pretest scores. This suggests that while innovative strategies may foster improvement, their advantage over conventional methods may not always be pronounced within short intervention periods. Amadi and Uche (2021) highlighted that the full impact of instructional innovations often requires extended implementation, particularly when learners are accustomed to conventional teaching practices. Additionally, contextual factors such as students' prior knowledge, motivation, and teacher expertise can moderate the effectiveness of instructional strategies (Adebayo & Okoli,

2023; Ibrahim & Hassan, 2023). The significant effect of pretest scores observed in this study confirms that students' prior achievement strongly predicts subsequent learning outcomes (Kpolovie & Iderima, 2022). Gender analysis revealed nearly identical gains for male and female students, with ANCOVA results showing no significant gender effect on achievement. This indicates that both genders benefited similarly from the instructional intervention. These results are consistent with studies by Eze and Onwuka (2022) and Adebayo and Okoli (2023), which suggest that equitable access to learner-centred strategies minimises gender disparities in academic performance. Conversely, some research highlights that gender differences may emerge in specific contexts due to cultural expectations or task characteristics (Ibrahim & Hassan, 2023; Okonkwo, 2022). The balanced and inclusive design of the MLT intervention likely mitigated such disparities, reinforcing the view that instructional approach, rather than gender, is the key determinant of achievement (Yusuf & Lawal, 2024). The findings support the potential of innovative, student-centred instructional strategies to enhance learning, while emphasising the critical role of prior knowledge, instructional fidelity, and equitable classroom practices in maximising their effectiveness.

CONCLUSION

The study highlights that innovative strategies such as project-based learning can positively influence students' outcomes, but their effectiveness may depend on contextual factors such as duration of exposure, prior knowledge, and teacher competence. Additionally, the absence of significant gender differences suggests that when instructional delivery is inclusive and student-centred, both male and female learners can perform at comparable levels. These findings support calls for broader adoption of learner-centred approaches in science education, while also emphasising the need for sustained implementation and contextual adaptation to maximise impact.

RECOMMENDATIONS

1. Schools should integrate model-lesd-test teaching strategy more consistently, as they enhance students' engagement and learning outcomes compared to conventional lecture methods.
2. Since gender was not found to significantly affect achievement, teachers should continue to provide equal learning opportunities for both male and female students, thereby sustaining equity in performance.
3. Teachers should be given regular professional development to strengthen their competence in applying innovative methods effectively.

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