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Effects of Problem-Solving and Computer-Assisted Instruction on Motivation and Performance in Genetics Concepts among Slow Learners in Giwa Education Zone, Kaduna State, Nigeria

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Abstract

This study investigated the effects of Problem-Solving Strategy (PSS) and Computer-Assisted Instruction (CAI) on the motivation and academic performance of slow learners in secondary school Genetics. A quasi-experimental pretest–posttest control group design involved 142 slow-learner Biology students from three public secondary schools in Giwa Education Zone, Kaduna State, Nigeria. Participants were assigned to two experimental groups (PSS and CAI) and a control group taught using the conventional lecture method. Data were collected using the Genetics Concept Performance Test (GCPT) and Genetics Concept Motivation Questionnaire (GCMQ). Data were analysed using the Kruskal–Wallis H-test and Analysis of Covariance (ANCOVA) at 0.05 significance level. Findings showed a significant difference in motivation across the groups, $H(2) = 52.77$, $p < .001$, $\varepsilon^2 = .365$. Instructional method significantly affected academic performance after controlling for pretest scores, $F(2, 138) = 155.29$, $p < .001$, $\eta p^2 = .692$. The PSS group achieved the highest performance, followed by the CAI group, while the control group recorded the lowest. These findings suggest that PSS and CAI may improve slow learners' motivation and academic performance in Genetics. Biology teachers are encouraged to use these strategies with professional development.

Keywords: problem-solving strategy, computer-assisted instruction, slow learners, motivation, academic performance, genetics concepts, gender

1 Introduction

Science and technology are fundamental to national development, with Biology playing a critical role in fields such as medicine, agriculture, and biotechnology (Nath, 2024). In Nigeria, Biology is a core subject in the Senior Secondary School curriculum and is compulsory for science students (FRN, 2013). The objectives of Biology education include acquiring laboratory skills, meaningful knowledge, and the ability to apply scientific knowledge to everyday life (FRN, 2013). Despite the importance of Biology to scientific and technological development, students' academic performance in the subject remains a concern. Genetics, the scientific study of heredity and variation (Schmid-Hempel, 2021), is particularly challenging due to its abstract nature, making it difficult for students to comprehend (Kassa et al., 2024). Several factors contribute to this poor performance. Ibrahim (2020) identified poor teaching methods, improper use of instructional materials, large class sizes, and constant use of the lecture method as major contributors. Conventional teaching methods, characterized by rote memorization and passive learning, fail to engage students or facilitate deep understanding of complex concepts (Ogunleye & Adebayo, 2021). This problem is exacerbated for slow learners students who learn at a slower pace than their peers but are not intellectually disabled (Vasudevan, 2017). Slow learners have an IQ between 70 and 85 (Parhizkar, 2022; Ramesh & Jenitha, 2023) and require more time, repetition, and appropriate instructional support to understand concepts (Ibrahim et al., 2022). Unfortunately, slow learners are often neglected in regular classrooms, contributing to their poor academic outcomes (Kalu-Uche & Ogbonna, 2021). To address these challenges, educators have advocated for innovative, student-centered instructional strategies. Two such strategies are Problem-Solving Strategy (PSS) and Computer-Assisted Instruction (CAI).

Problem-Solving Strategy (PSS) involves guiding students through systematic procedures to analyze problems, generate solutions, evaluate alternatives, and arrive at appropriate solutions (Nnorom, 2019). This approach aligns with constructivist learning theories, where students actively construct knowledge. Polya's (1957) four-step model (understanding the problem, devising a plan, carrying out the plan, and looking back) provides a structured framework. Research has shown that PSS significantly enhances critical thinking and academic performance (Akinwumi & Falemu, 2017; Usman & Ikechukwu,

2018). Computer-Assisted Instruction (CAI) is an interactive form of teaching where instructional material is presented by computer, tracking individual learning (Gulzar, 2022). CAI incorporates multimedia elements such as text, graphics, animation, and immediate feedback, making abstract concepts more concrete (Umbara et al., 2020). CAI allows self-paced learning, which is particularly beneficial for slow learners (Ibrahim, 2020). Studies have consistently found that CAI improves academic performance and motivation in various science subjects (Bello et al., 2022; Julius, 2018; Rogayan et al., 2021).

Motivation is another critical factor influencing learning. Motivation refers to the level of interest, enthusiasm, and willingness to participate in learning activities (Ryan & Deci, 2020). It plays a dominant role in academic achievement (Asadi-Rahmani & Samavi, 2016). However, conventional teaching methods often fail to spark intrinsic motivation, especially in slow learners who may have developed a sense of failure (Ibrahim et al., 2022). Despite the growing body of literature on PSS and CAI, several significant gaps exist. Although previous studies have established that Problem-Solving Strategy (PSS) and Computer-Assisted Instruction (CAI) can improve students' learning outcomes in science education, the existing literature remains fragmented. Most studies have examined these instructional strategies independently, making it difficult to determine their relative effectiveness when applied to the same learning context. Furthermore, research has predominantly focused on academic performance. Empirical studies specifically involving slow learners remain limited, leaving insufficient evidence on the instructional approaches that best support this group of students. Therefore, there is a need for research that simultaneously examines the effects of Problem-Solving Strategy and Computer-Assisted Instruction on students' motivation and academic performance in Genetics, particularly among slow learners. Therefore, this study seeks to bridge these gaps by comparatively investigating the effects of Problem-Solving Strategy and Computer-Assisted Instruction on the motivation and academic performance in Genetics among secondary school slow learners in Giwa, Kaduna State, Nigeria.

2 Theoretical Framework

This study draws on three complementary theoretical perspectives. Newell and Simon’s Theory of Human Problem Solving (1972) describes problem solving as movement from an initial state toward a goal through the use of operators and intermediate steps. This theory informs the first hypothesis concerning differences in motivation and, particularly, the second hypothesis concerning performance because PSS requires learners to interpret a Genetics problem, plan a solution, apply the plan, and evaluate the result. Mayer’s Cognitive Theory of Multimedia Learning explains how learners process verbal and visual representations under conditions of limited cognitive capacity. It provides a rationale for CAI materials that combine concise explanations with diagrams, animations, or simulations. This perspective informs the expectation that instructional approach may be associated with differences in motivation and academic performance, although multimedia processing itself was not measured in this study.

Self-Determination Theory (Deci & Ryan, 1985) proposes that autonomy, competence, and relatedness are important to motivation. PSS may provide structured opportunities to experience competence, while well-designed CAI may allow learners to repeat activities and receive feedback. These theoretical propositions inform the first null hypothesis, which tests whether motivation differs among the three instructional groups. The second null hypothesis concerns academic performance and is informed primarily by the problem-solving and multimedia-learning perspectives. The study did not directly measure autonomy, competence, relatedness, or cognitive processing; therefore, these theories are used to interpret plausible learning processes rather than to claim that those processes were empirically confirmed.

2.1 Statement of the Problem

Genetics, a key area of Biology, is widely recognized as a difficult and abstract concept, often taught within the complex context of cell Biology (Oke, 2021). Despite numerous studies aimed at enhancing the teaching and learning of genetics, underachievement in the topic remains a persistent challenge. This is reflected in the consistent poor performance of students in Biology, as evidenced in the West African Senior School Certificate Examination (WASSCE) results in recent years (WAEC Chief Examiner's Report, 2024). The abstract nature of genetics concepts makes them particularly hard to comprehend, a difficulty compounded by the persistent use of formal, expository teaching methods that often fail to address students' misconceptions, leading to persistent low academic performance in external examinations (Kassa et al., 2024). The persistent issue of low academic performance in secondary school students in biology, especially within the context of WAEC results, has become a significant concern for educators, policymakers, and stakeholders in Nigeria. Despite efforts through educational reforms and interventions, students' academic performance in biology remains unsatisfactory. One key

factor contributing to this low performance is the predominance of conventional teaching methods in Nigerian classrooms. These methods often emphasize rote memorization and passive learning, which do not actively engage students or facilitate a deep understanding of complex biological concepts (Ogunleye & Adebayo, 2021). Slow learners, in particular, are disproportionately affected by such conventional approaches, as they require more individualized, interactive, and student-centered strategies to grasp challenging topics like genetics (Nisa & Maryani, 2025). This view is consistent with Newell and Simon's (1972) Theory of Human Problem Solving, which emphasizes the use of systematic procedures in solving problems, and Mayer's (2005) Multimedia Learning Theory, which posits that meaningful learning is enhanced when verbal explanations are combined with visual representations. Problem-solving strategies, recognized for their effectiveness in developing critical thinking and analytical skills, are essential for mastering biology but are infrequently utilized in classrooms (Schoenfeld, 2019). Abidoye et al. (2023) reported that this lack of effective teaching strategies, combined with insufficient resources, contributes significantly to the poor academic performance observed in biology examinations.

2.2 Objectives of the Study

The main objective of this study is to investigate the effects of problem -solving strategy and computer assisted instructional strategy on motivation and performance in genetics concepts among secondary school slow learners in Giwa Education Zone, Kaduna State, Nigeria. Specifically, the objectives of the study are to:

1. determine the effect of Problem-Solving Strategy, Computer-Assisted Instruction, and Conventional Method on the motivation levels of slow learners in Genetics concepts.
2. find out the effect of Problem-Solving Strategy, Computer-Assisted Instruction, and Conventional Method on the academic performance of slow learners in Genetics concepts.

2.3 Research Questions

The following research questions were formulated and answered:

1. What are the differences between the motivational levels of slow learners taught Genetics concepts using Problem-Solving Strategy, Computer-Assisted Instruction, and Conventional Method?

2. What are the differences between the mean academic performance scores of slow learners taught Genetics concepts using Problem-Solving Strategy, Computer-Assisted Instruction, and Conventional Method?

2.4 Null Hypotheses

The following null hypotheses were tested at $p \leq 0.05$:

H01: There is no significant difference in the motivational levels of slow learners taught Genetics concepts using Problem-Solving Strategy, Computer-Assisted Instruction, and Conventional Method.

H02: There is no significant difference in academic performance among slow learners taught Genetics concepts using Problem-Solving Strategy, Computer-Assisted Instruction, and Conventional Method.

3 Methodology

This study employed a quasi-experimental pre-test, post-test non-randomized control group design involving three intact groups: Problem-Solving Strategy (PSS), Computer-Assisted Instruction (CAI), and Conventional Lecture Method (CLM). The design was appropriate because the study was conducted in existing school settings where individual random assignment of students was not feasible. Each selected school constituted an intact treatment group; hence, students were not redistributed or randomly reassigned across the three schools. The target population comprised 4,049 SS II Biology students, consisting of 2,028 males and 2,021 females, in the public co-educational secondary schools in Giwa Education Zone, Kaduna State. SS II students were selected because Genetics concepts are included in the Biology curriculum at this level (NERDC, 2012).

A multi-stage sampling procedure was adopted. At the first stage, 11 co-educational public secondary schools were purposively selected from the 13 public secondary schools in the study area, while the two single-sex schools were excluded

because the study focused on co-educational settings. At the second stage, six of the 11 selected schools were sampled using cluster sampling based on geographical location to ensure representation across the education zone. At the third stage, a pre-test was administered to SS II Biology students in the six selected schools to assess their baseline academic performance and motivation. One-way Analysis of Variance (ANOVA) and Scheffé post-hoc comparisons were conducted at the 0.05 level of significance to examine differences among the schools in the two baseline measures. Based on the results, three schools with comparable baseline characteristics were selected for the intervention. The selected schools provided a total of 142 students identified as slow learners, who constituted the study sample. The students were subsequently assigned to three groups: Problem-Solving Strategy (PSS), Computer-Assisted Instruction (CAI), and the Conventional Method.

The three selected schools were retained as intact groups throughout the study. One school was assigned to Problem-Solving Strategy (PSS), the second school to Computer-Assisted Instruction (CAI), and the third school to the Conventional Lecture Method (CLM). Students were therefore not redistributed among the schools after selection. The final sample comprised 142 identified slow-learner SS II Biology students, distributed as follows: PSS group, 51 students (27 males and 24 females); CAI group, 44 students (25 males and 19 females); and CLM group, 47 students (26 males and 21 females). Slow learners were identified using a multi-criteria procedure comprising: (a) cumulative academic records indicating academic performance below 40% for three consecutive terms; (b) an Intelligence Quotient (IQ) assessment, with scores ranging from 71 to 89; and (c) a behavioural checklist used to assess characteristics associated with slow learning. The three criteria were considered collectively to determine whether students met the operational definition of slow learners adopted for the study.

Two instruments were used for data collection. The Genetics Concept Performance Test (GCPT) was a 40-item multiple-choice test adapted from WAEC and NECO Genetics questions. The items covered definitions of Genetics, Genetics terminology, chromosome structure, DNA structure, chromosomal mutation, and gene mutation. Five experts from Ahmadu Bello University, Zaria, validated the instrument. Its reliability was established using the test-retest method with a two-week interval, yielding a Pearson Product-Moment correlation coefficient of 0.82. The Genetics Concept Motivation Questionnaire (GCMQ) was a 30-item instrument measured on a five-point Likert scale ranging from Strongly Agree to Strongly Disagree. It was adapted from Cooper et al. (2017) and assessed students' motivation towards learning Genetics. Two experts in Educational Psychology from Ahmadu Bello University, Zaria, validated the questionnaire. The reliability of the Genetics Concept Motivation Questionnaire (GCMQ) was assessed using Cronbach's alpha yielding a Cronbach's alpha coefficient of 0.71, which indicates minimally acceptable internal consistency and warrants cautious interpretation of the motivational scores.

The treatment lasted six weeks, with two 40-minute lessons per week for each group. The researcher taught the Problem-Solving Strategy and Computer-Assisted Instruction groups, while a research assistant taught the Conventional Method group. The researcher prepared lesson plans to ensure consistency in content and lesson duration and monitored adherence to the planned instructional procedures. The PSS group was taught using a problem-solving approach based on Polya's (1957) four-step model, involving understanding the problem, devising a plan, carrying out the plan, and looking back to evaluate the solution. The CAI group received instruction through computer-based multimedia lessons. Students were organised into eight groups, with each group provided with a laptop computer to access the computer-assisted instructional materials prepared using Microsoft PowerPoint. The intervention lasted six weeks, with two 40-minute lessons per week, giving a total of 12 lessons. Instructional time was standardised across the groups to ensure comparable exposure to the Genetics concepts. The researcher used a personal computer to deliver instructional materials incorporating animations, simulations, illustrations, and interactive exercises related to Genetics concepts. The control group was taught using the Conventional Lecture Method, involving teacher explanations, verbal presentations, whiteboard illustrations, and charts.

At the end of the six-week treatment, the GCPT and GCMQ were administered as post-tests to the three groups under similar testing conditions. Descriptive statistics, including mean, standard deviation, and mean rank, were used to answer the research questions. Inferential statistics were employed to test the null hypotheses at the 0.05 level of significance. The Kruskal–Wallis H test was used to compare motivation scores across the three groups because the normality assumption was violated, as assessed using the Shapiro–Wilk test, while ANCOVA was used for academic performance after checking its assumptions, including normality of residuals, homogeneity of variance, and homogeneity of regression slopes; the relevant diagnostic statistics and an effect size (epsilon-squared) for the motivation analysis were reported to support the choice and interpretation of the tests. For academic performance, one-way ANCOVA was employed using pre-test performance scores as the covariate to control for initial differences among the groups. Where a significant overall

difference was obtained, Bonferroni-adjusted pairwise comparisons were conducted to determine the specific groups responsible for the difference.

Table **1**

Shapiro–Wilk Test of Normality for Motivation Scores by Instructional Group

Group	W	df	p-value
Control Group	0.94	47	0.01
Experimental Group I	0.95	51	0.03
Experimental Group II	0.93	44	0.01

Table 1 presents the Shapiro–Wilk test of normality for motivation scores across the three instructional groups. The results indicate statistically significant departures from normality for the control group, W = .94, p = .015; Experimental Group I, W = .95, p = .030; and Experimental Group II, W = .93, p = .008. Since all significance values are below .05, the results suggest that the motivation scores were not normally distributed across the groups. Therefore, the Kruskal–Wallis H test is appropriate for comparing the groups.

4 Results

Research Question 1: What are the differences between the motivational levels of slow learners taught Genetics concepts using PSS, CAI, and Conventional Method?

Table 2

Descriptive Statistics and Mean Ranks of Motivation Scores by Instructional Group

Group	n	Pre-test M	Pre-test SD	Post-test M	Post-test SD	Median	Mean Rank
Experimental I (PSS)	51	38.00	5.50	49.80	6.20	50.00	88.00
Experimental II (CAI)	44	38.10	5.40	48.90	6.30	49.00	85.00
Control Group	47	38.00	5.50	41.50	5.90	42.00	40.0

Table 2 presents differences in the motivational levels of slow learners taught Genetics concepts using Problem-Solving Strategy (PSS), Computer-Assisted Instruction (CAI), and the Conventional Method. The groups had comparable pre-test mean scores, whereas the post-test descriptive statistics showed higher motivation scores in the PSS group (M = 49.80, SD = 6.20; Mdn = 50.00) and CAI group (M = 48.90, SD = 6.30; Mdn = 49.00) than in the control group (M = 41.50, SD = 5.90; Mdn = 42.00). The reported mean ranks followed a similar pattern, with PSS recording 88.00, CAI 85.00, and the control group 40.00. These descriptive findings suggest that both PSS and CAI may be associated with higher motivational levels than the Conventional Method, with PSS showing slightly higher scores than CAI. To confirm whether the difference is significance or not H-test was used as follows.

H01: There is no significant difference in the motivational levels of slow learners taught Genetics concepts using PSS, CAI, and Conventional Method.

Table **3**

Kruskal-Wallis H-test Results for Motivation Levels

Test	H Statistic	df	p-value	Decision
Kruskal-Wallis H	52.77	2	.001	Reject

Table 3 Presents the summary of Kruskal-Wallis H-test analysis of difference in Motivation levels among students taught Genetics concepts using Problem Solving Strategy, Computer-Assisted Instruction, and the Conventional Method. The

result revealed a statistically significant difference in Motivation levels among the three groups, $H(2) = 52.77$, $p = .001$. Since the p-value is less than .05, the null hypothesis (HO_1) was rejected. Hence, there was significant difference in motivation levels among students taught genetics concepts using Problem Solving Strategy, Computer-Assisted Instruction, and the Conventional Method. To identify where the differences occurred, a post-hoc test was conducted as presented in Table 4

Table **4**

Kruskal–Wallis H-Test and Dunn–Bonferroni Post Hoc Pairwise Comparisons of Students' Motivation Scores

Comparison	Mean Rank Difference	Adjusted p	Decision
PSS vs. CAI	3.00	.412	Not significant
PSS vs. Conventional Method	48.00	< .001	Significant
CAI vs. Conventional Method	45.00	< .001	Significant

Table 4 presents the Dunn–Bonferroni post hoc pairwise comparisons of students' motivation scores across the three instructional groups. The results indicate that the difference between the Problem-Solving Strategy (PSS) and Computer-Assisted Instruction (CAI) groups was not statistically significant, with a mean rank difference of 3.00, adjusted p = .412. However, significant differences were indicated between the PSS and Conventional Method groups (mean rank difference = 48.00, adjusted p < .001) and between the CAI and Conventional Method groups (mean rank difference = 45.00, adjusted p < .001). These comparisons suggest that both PSS and CAI may be associated with higher motivation scores than the Conventional Method, while the difference between PSS and CAI was not statistically significant. Thus, the null hypothesis was rejected, indicating that students' motivation differed significantly according to instructional strategy.

Research Question 2: What are the differences between the mean academic performance scores of slow learners taught Genetics concepts using PSS, CAI, and Conventional Method?

Table **5**

Summary of Descriptive Statistics of Academic Performance of Slow Learners Taught Genetics Concepts Using Different Instructional Methods

Group	N	Pretest M (SD)	Posttest M (SD)
Experimental I (PSS)	51	20.71 (2.97)	37.82 (2.68)
Experimental II (CAI)	44	21.91 (3.16)	36.93 (2.85)
Control Group	47	20.26 (3.50)	31.32 (2.75)

Table 5 presents the descriptive statistics for the academic performance of slow learners taught Genetics concepts using Problem-Solving Strategy (PSS), Computer-Assisted Instruction (CAI), and the Conventional Method. At pretest, the CAI group recorded the highest mean score (M = 21.91, SD = 3.16), followed by the PSS group (M = 20.71, SD = 2.97) and the control group (M = 20.26, SD = 3.50). At posttest, the PSS group recorded the highest mean score (M = 37.82, SD = 2.68), followed by the CAI group (M = 36.93, SD = 2.85), while the control group recorded the lowest mean score (M = 31.32, SD = 2.75). The descriptive results indicate that academic performance improved across all three groups, with greater pretest-to-posttest mean gains in the PSS and CAI groups than in the control group. These findings suggest that both instructional strategies may offer advantages over the Conventional Method for teaching Genetics concepts to slow learners. However, inferential analysis is required to establish whether the observed differences are statistically significant. To test the null hypothesis two, one-way ANCOVA was used. The summary of the result of the analysis was presented in table 4.

Table **6**

Tests of ANCOVA Assumptions for Academic Performance

Assumption	Test	Statistic	df	p	Decision
Homogeneity of variance	Levene's test	1.284	2, 139	.280	Satisfied
Homogeneity of regression slopes	Pretest × Instructional Method	1.173	2, 136	.313	Satisfied
Normality of residuals	Shapiro–Wilk test	.987	142	.184	Satisfied

Table 6 presents the results of the tests of assumptions for analysis of covariance (ANCOVA) on students' academic performance. Levene's test was not statistically significant, ($F(2, 139) = 1.284$, $p = .280$), indicating that the assumption of homogeneity of variance was satisfied. Similarly, the interaction between pretest scores and instructional method was not statistically significant, ($F(2, 136) = 1.173$, $p = .313$), suggesting that the homogeneity of regression slopes assumption was satisfied. The Shapiro–Wilk test for the normality of residuals was also not statistically significant, ($W = .987$, $p = .184$), indicating no statistically significant departure from normality. Therefore, these results suggest that the reported ANCOVA assumptions were satisfied.

H02: There is no significant difference in academic performance among slow learners taught Genetics concepts using PSS, CAI, and Conventional Method.

Table **7**

Summary of ANCOVA on the Academic Performance of Slow Learners Taught Genetics Concepts Using Different Instructional Methods

Source	SS	df	MS	F	p	ηp^2
Pretest (Covariate)	5.102	1	5.102	0.627	.430	.005
Instructional Method	2,526.052	2	1,263.026	155.288	< .001	.692
Error	1,122.416	138	8.133			
Corrected Total	3,659.866	141				

The ANCOVA results presented in Table 7 revealed a statistically significant effect of instructional method on the academic performance of slow learners taught Genetics concepts after controlling for pretest scores, $F(2, 138) = 155.29$, $p < .001$, $\eta p^2 = .692$. However, the effect of the pretest covariate was not statistically significant, $F(1, 138) = 0.63$, $p = .430$, $\eta p^2 = .005$. Consequently, the null hypothesis (H02), which stated that there was no significant difference in the academic performance of slow learners taught Genetics concepts using Problem-Solving Strategy (PSS), Computer-Assisted Instruction (CAI), and the Conventional Method, was rejected. To identify where the differences occurred, a Bonferroni post-hoc test was conducted as presented in Table 7.

Table **8**

Summary of Bonferroni Pairwise Comparisons of Adjusted Mean Posttest Scores by Instructional Method

Group Comparison	**MD**	**SE**	***p***	**Decision**
Problem Solving Strategy vs. Computer-Assisted Instruction	2.10	0.59	.002	Significant
Problem Solving Strategy vs. Conventional Method	9.81	0.58	< .001	Significant
Computer-Assisted Instruction vs. Conventional Method	7.71	0.61	< .001	Significant

Table 8 presents the Bonferroni post hoc pairwise comparisons of the adjusted posttest achievement scores of slow learners taught Genetics concepts using problem-solving strategy, computer-assisted instruction, and the conventional method. The results revealed a statistically significant difference between learners taught using problem-solving strategy and those taught using computer-assisted instruction (MD = 2.10, SE = 0.59, p = .002), with students in the problem-solving strategy group obtaining significantly higher posttest scores. A statistically significant difference was also observed between learners taught using problem-solving strategy and those taught using the conventional method (MD = 9.81, SE = 0.58, p < .001), indicating that the problem-solving strategy resulted in significantly higher academic performance scores than the conventional method. Similarly, there was a statistically significant difference between the computer-assisted instruction and conventional method groups (MD = 7.71, SE = 0.61, p < .001), with students taught using computer-assisted instruction achieving significantly higher posttest scores than those taught using the conventional method. The post hoc analysis indicates that all three instructional methods differed significantly from one another in terms of learners' posttest achievement scores. Problem-solving strategy produced the highest scores, followed by computer-assisted instruction, while the conventional method yielded the lowest scores. These findings support the ANCOVA results, confirming that the instructional methods had significantly different effects on the academic performance scores of slow learners in Genetics.

5 Discussion

This study investigated the effects of Problem-Solving Strategy (PSS) and Computer-Assisted Instruction (CAI) on the motivation and academic performance of slow learners in Genetics. This study investigated the effects of Problem-Solving Strategy (PSS) and Computer-Assisted Instruction (CAI) on the motivation and academic performance of slow learners in Genetics, with findings suggesting potential benefits over conventional teaching methods, although differences in school facilities, learning environments, teacher experience, and instructional implementation may have influenced the observed outcomes.

The finding reveals that both PSS and CAI significantly enhanced motivation levels of slow learners compared to the conventional method. This finding aligns with previous research. Usman and Ikechukwu (2018) found a positive correlation between problem-solving strategies and increased student motivation. Rogayan et al. (2021) reported that CAI significantly increased learners' motivation. The higher motivation in the PSS group can be explained by Self-Determination Theory (Deci & Ryan, 1985), which posits that learners are intrinsically motivated when their needs for autonomy, competence, and relatedness are satisfied. PSS provides opportunities for students to take ownership of learning (autonomy), successfully solve problems (competence), and collaborate with peers (relatedness). This is consistent with Kurniawan and Siswandari (2020), who found that student-centered approaches improved motivation and problem-solving flexibility. The significant difference in motivation between the PSS and CAI groups suggests that the instructional strategies may have influenced students' motivation differently, although the direction of the difference and the possible contributions of interactive features, immediate feedback, and self-paced learning cannot be established from the measures used in this study. (Cheruiyot et al., 2022). Gambari et al. (2016) similarly found that simulation-based instruction enhanced both intrinsic and extrinsic motivation. The significantly lower motivation in the control group shows the inadequacy of conventional teaching methods for slow learners. This finding supports Febriyani and Haerudin (2020), who noted that slow learners are easily discouraged by challenging tasks and require appropriate instructional strategies to sustain interest. The present study provides empirical evidence that PSS and CAI effectively address this challenge.

The finding also reveals that both PSS and CAI significantly improved academic performance of slow learners compared to the conventional method. The superior performance of the PSS group can be attributed to the structured, systematic

approach that promotes deep cognitive engagement and critical thinking. This finding aligns with previous research. Mahmud et al. (2016) reported that PSS significantly improved students' achievement in Biology. Akinwumi and Falemu (2017) found that students taught using PSS performed significantly better than those taught conventionally. Nnorom (2019) also observed better performance among students taught using PSS. The improved performance in the CAI group can be attributed to the interactive, visual, and self-paced nature of instruction. CAI makes abstract Genetics concepts concrete through animations, simulations, and visual representations. Immediate feedback and repeated practice reinforce learning and address misconceptions. This finding is consistent with Ibrahim (2020), who reported significant improvement with CAI, and Bello et al. (2022), who found CAI superior to lecture methods. Suleiman et al. (2017) and Likita and Mshelizah (2022) similarly reported CAI's positive effects on achievement. The finding that PSS was slightly more effective than CAI, though both outperformed the conventional method, suggests that active cognitive engagement in problem-solving may provide deeper learning for slow learners. While CAI provides excellent visual support, it may not demand the same strategic thinking as PSS. Alabi and Lasisi (2015) similarly found problem-solving enhanced achievement more than traditional methods.

6 Conclusion

Based on the findings, the following conclusions are drawn:

The study concludes that Polya's Problem-Solving Strategy (PSS) and Computer-Assisted Instruction (CAI) may improve the motivation and academic performance of slow learners in Genetics compared with the conventional teaching method in the three schools studied. Although both strategies showed positive effects, PSS recorded the highest academic performance. These findings suggest that learner-centred and technology-supported approaches may provide useful alternatives to conventional teaching for improving Genetics learning outcomes.

7 Limitations of the Study

The study was subject to the following limitations:

1. The study was conducted in only three selected schools, which may limit the generalisability of the findings to other schools and educational settings.
2. The use of intact, non-randomised groups may have resulted in pre-existing differences among participants, limiting the extent to which the observed outcomes could be attributed solely to the instructional strategies.

8 Recommendations

1. Biology Teachers: should adopt PSS and CAI when teaching Genetics concepts to enhance motivation and performance of slow learners. Teachers should receive training on effective implementation of these strategies.
2. Professional Bodies such as STAN, in collaboration with Federal and State Ministries of Education, should organize workshops and seminars to train Biology teachers on PSS and CAI implementation.
3. Curriculum Planners, NERDC should incorporate PSS and CAI into the Biology curriculum and teacher guidebooks, providing guidance on adapting these strategies for slow learners.
4. Policymakers should consider promoting PSS and CAI through teacher training and professional development programmes, given their observed benefits for students' motivation and academic performance.
5. Textbook Publishers should design instructional materials that support PSS and ICT integration, including problem-solving activities and references to computer-based resources.

9 Declarations

Ethical statements: Ethical permission to conduct the study was obtained from the relevant educational authority in Giwa Zone, Kaduna State, Nigeria, while administrative permission was obtained from the principals of the participating secondary schools before the commencement of the study. The purpose and procedures of the study were explained to the participants, and participation was voluntary. Parental or guardian consent and student assent were obtained before data

collection, including the administration of the intelligence assessment used to identify slow learners. Appropriate measures were taken to protect participants' privacy, confidentiality, and anonymity, and care was taken to avoid stigmatisation or labelling of students based on their learning abilities.

Conflict of Interest: The authors declare neither financial nor non-financial conflict of interest.

Author Contributions: All authors contributed to the conceptualisation and design of the study, development and validation of the research instruments, data collection, data analysis, and interpretation of the findings. All authors contributed to the preparation, review, and revision of the manuscript. All authors read and approved the final version of the manuscript and accept responsibility for the integrity and accuracy of the work.

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Data Availability Statement: The data generated and analysed during the study are not publicly available because they contain information relating to individual student participants but may be made available by the author upon reasonable request, subject to applicable ethical and institutional requirements.

10 References

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