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RELATIVE EFFECTS OF FEEDBACK AND REMEDIATION ON STUDENTS' COGNITIVE ACHIEVEMENT IN PHYSICS

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ABSTRACT

This study examined the effects of feedback and remediation on the cognitive achievement of Senior Secondary School Two (SSS II) students in Physics in Ikire, Osun State. A quasi-experimental pretest–posttest control group design was adopted. The study population comprised students from ten public secondary schools, with a sample of 520 students selected through simple random sampling. Participants were assigned to Feedback, Remediation, and Control groups, with the control group taught using the conventional lecture method. Data were collected using the Physics Achievement Test (PAT), a 40-item multiple-choice instrument developed from the SSS II Physics curriculum. The instrument was validated by experts and achieved a reliability coefficient of 0.84 using the KR-20 method. The study lasted six weeks and involved pretest administration, treatment implementation, and posttest assessment. Data were analyzed using mean, standard deviation, and Analysis of Covariance (ANCOVA) at the 0.05 significance level. Results showed that both feedback and remediation significantly improved students' cognitive achievement in Physics compared with the conventional method. Students exposed to remediation performed slightly better than those who received feedback only, while the combined application of feedback and remediation produced the highest achievement gains. Gender had no significant effect on students' achievement. The study concluded that feedback and remediation are effective instructional strategies for improving students' cognitive achievement in Physics. It recommended that Physics teachers incorporate these strategies into classroom instruction.

Keywords: Feedback, Remediation, Cognitive Achievement and Instructional Strategies

INTRODUCTION

Science and technology are indispensable tools for national development, economic growth, and the improvement of human welfare. In today's knowledge-driven world, countries that have attained significant scientific and technological advancement are those that have invested heavily in science education (Aina, 2013). Among the science subjects, Physics is widely regarded as the bedrock of technological and industrial development because it provides the foundation for understanding natural phenomena and the functioning of machines, tools, and modern technologies (Omosewo, 2014). In Nigeria, Physics is a core subject in the senior secondary school curriculum and a prerequisite for courses such as Engineering, Medicine, and Computer Science. Despite its importance, students' performance in Physics at both internal and external examinations has continued to be discouraging (WAEC Chief Examiners' Report, 2022; NECO, 2023). The traditional teacher-centered approach still dominates Physics instruction in many Nigerian secondary schools, leading to students being just listeners while teachers teach through lecture and note dictation methods.

Feedback refers to information provided to students regarding their performance on a learning task, which helps them identify gaps between their current knowledge and desired learning goals (Shute, 2008). Effective feedback is specific, timely, and constructive, guiding students to correct their misconceptions and improve subsequent performance (Sadler, 2010). In Physics instruction, feedback can take the form of written comments on test scripts, oral explanations, peer discussions, or digital assessments. According to Hattie & Gan (2011), feedback is among the most powerful influences on student achievement, particularly when it provides cues or reinforcement related to the task or learning process.

Remediation, on the other hand, refers to the process of providing additional instruction to students who have not yet mastered specific skills or concepts after initial teaching (Ogunniyi, 2016). It involves identifying learning deficiencies through diagnostic assessment and re-teaching or restructuring lessons to address those weaknesses. Remediation serves as a corrective measure that helps students overcome learning difficulties and attain mastery (Adeosun, 2019). In Physics, remediation may involve using simplified explanations, real-life examples, guided problem-solving, and practical demonstrations to reinforce difficult topics.

Although both feedback and remediation aim to improve learning, they operate through slightly different mechanisms. Feedback informs students about what they got wrong and how to improve, while remediation provides an opportunity to relearn the concepts in a more guided or personalized manner. Studies have shown that when these strategies are effectively implemented, they can significantly enhance students' understanding and retention of scientific concepts (Aina, 2017; Okafor, 2019; Akinola & Abiola, 2020). However, despite the acknowledged importance of these strategies, many Physics teachers rarely incorporate systematic feedback and remediation into their teaching practices. Assessments are often summative rather than formative, providing little opportunity for students to reflect on and correct their learning errors (Yusuf, 2012). Consequently, misconceptions persist, and learning gaps widen, leading to poor cognitive achievement.

It is therefore essential to determine which of these instructional strategies—feedback or remediation—has a greater effect on students' cognitive achievement in Physics, and whether combining both can yield better results. Understanding their relative effects will guide teachers, curriculum planners, and policymakers in adopting the most effective approaches to improving Physics instruction and learners' outcomes. Hence, this study investigates the relative effects of feedback and remediation on students' cognitive achievement in Physics among senior secondary school students in Ikire Osun State, Nigeria.

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LITERATURE REVIEW

Feedback, Remediation and Students' Cognitive Achievement in Physics

Empirical evidence has consistently shown that feedback positively influences students' academic achievement. In Physics, feedback helps students connect theoretical knowledge with problem-solving practices. For instance, Okafor (2019) found that immediate feedback significantly improved students' test scores compared to delayed feedback. Ole (2023) investigated the impact of formative assessment based on the Feedback Loop Model (FLM) among Grade 12 Physics students studying kinematics. His results showed significant improvements in students' conceptual understanding after exposure to feedback-loop-based instruction, thus enhancing student engagement during Physics lessons. Lichtenberger et al. (2025) in their study found that when teachers were trained to provide structured formative feedback, students demonstrated improved understanding of difficult Physics content, thereby concluding that well-designed formative assessment practices can significantly enhance students' conceptual learning and cognitive achievement in Physics. Klute et al. (2017) in their study reviewed found that students who received formative assessment with feedback performed better academically than those who did not, with the strongest effects observed in mathematics. Ozan & Kincal (2018) studied formative assessment practices in social studies and found that students exposed to formative assessment and feedback achieved higher academic scores than those taught through conventional assessment methods. Baliram & Ellis (2019) examined meta-cognitive practice and teacher feedback in high school mathematics. Their study showed that teacher feedback improved students' academic achievement by helping them monitor errors and improve problem-solving strategies. Kyaruzi et al. (2019) investigated students' formative assessment perceptions, feedback use and mathematics performance in Tanzanian secondary schools. They found that students who perceived teacher feedback positively and used it effectively performed better in mathematics.

Batool (2019) in his studied of feedback effects on Grade 9 students' achievement in mathematics, found that experimental group that received feedback performed better than the control group, showing that feedback can improve conceptual understanding and achievement. Kültür & Kutlu (2021) examined formative assessment in high school mathematics and found that feedback-based formative assessment improved students' achievement and supported learning during instruction. Wafubwa & Csíkos (2022) investigated formative assessment and students' mathematics achievement. Their findings showed that formative assessment with feedback significantly improved achievement and metacognitive awareness. Al-Maharma (2022) examined teachers' feedback and students' academic achievement. The study emphasized that feedback helps students bridge the gap between present performances and expected learning outcomes, thereby improving academic achievement. Boström (2023) studied formative assessment practice among secondary school mathematics teachers. The findings showed that changes in teachers' formative assessment and feedback practices were associated with improvement in students' mathematics achievement. Likewise, Gebremariam (2024) investigated written corrective feedback among Ethiopian high school students in English writing. The study found that different types of written corrective feedback improved students' grammatical accuracy and writing achievement.

Remediation has been found to be highly effective in improving academic performance among students with learning difficulties. Adeosun (2019) reported that remedial teaching using concrete

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examples and guided discovery methods improved students' comprehension of motion and energy concepts. Similarly, Akinola & Abiola (2020) found that remediation led to better retention and transfer of learning compared to traditional instruction. Remediation allows for individualized learning, giving students time to correct misconceptions and build foundational knowledge before progressing. Eze (2016) observed that Physics students who received remediation after diagnostic testing showed significant improvement in post-test scores compared to those who did not receive remediation. Papadogiannis et al. (2023) in their assessment of the effectiveness of a remedial teaching policy, found that remedial teaching can support low-achieving students by giving them additional learning time and targeted assistance, although effectiveness depends on implementation quality. Parlee (2024) investigated targeted remediation in introductory physics, especially for students entering Physics 211 with weak mathematics preparation. The study showed that diagnosing prerequisite weaknesses and giving targeted support could help students perform better in mechanics. Twahirwa (2024) examined smart classrooms, assessment-management systems and remediation teaching techniques in physics learning, and found that remediation-related strategies enhanced students' conceptual understanding and achievement. Olutola et al. (2025) in their study examined formative assessment, feedback and remediation on senior secondary students' achievement in physics in Katsina State, Nigeria; and found that remediation combined with formative assessment significantly improved students' physics achievement.

While feedback helps students recognize errors, remediation gives them structured opportunities to correct those errors through re-teaching and reinforcement. The combination of both may therefore produce a more substantial effect on students' cognitive achievement.

METHODOLOGY

Research Design, Population of the Study and Sample and Sampling Technique

This study adopted a quasi-experimental research design of the pretest-posttest control group type. The target population for this study consists of ten (10) Public Senior Secondary School Two (SSS II) students, located in Ikire Local Government Areas of the Osun State. Random sampling technique was used in selecting the ten senior secondary schools. A sample size of five hundred and twenty (520) students, comprising of both male and female were selected from a population of over 5000 senior secondary public schools in Ikire Local Government Area of Osun State using simple random sampling technique.

Research Instruments

Physics Achievement Test (PAT). This was a 40-item multiple-choice test designed to measure students' cognitive achievement in selected physics concepts such as motion, energy, heat, and electricity. The PAT was developed based on the SSS II physics curriculum. Each item had four options (A–D) with one correct answer.

Validity of the Instruments

The instrument was subjected to face and content validation. Draft copies of the Physics Achievement Test (PAT) were presented to the Experts in the Department of Physics and

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Educational Measurements and Evaluation at the Federal College of Education, Abeokuta for scrutiny. Their suggestions and corrections were incorporated to ensure that the instrument adequately covered the content areas and objectives of the study

Reliability of the Instrument

To determine the reliability of the PAT, the test was administered to a pilot group of 30 SSS II Physics students in a neighboring town (Apomu) who were not part of the main study. The data obtained were analyzed using the Kuder-Richardson formula 20 (KR-20), which yielded a reliability coefficient of 0.84, indicating that the instrument was reliable for the study.

Procedure for Data Collection

The study lasted for six weeks and was conducted during regular school hours. The pretest (PAT) was administered to all groups to determine their baseline knowledge. Then the experimental Group I was taught using the feedback strategy; Experimental Group II was taught using the remediation strategy; The Control Group received instruction using the conventional lecture method. The researcher, assisted by the regular physics teachers, conducted all lessons using standardized lesson plans. After then, the posttest (same PAT reshuffled) was administered to all groups to measure achievement after treatment.

Method of Data Analysis

The data collected from the pretest and posttest were analyzed using both descriptive (Mean and Standard Deviation) and inferential statistics (Analysis of Covariance (ANCOVA). Specifically, Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance, with the pretest scores serving as covariates to control for initial differences among the groups.

RESULTS

Research Questions

Research Question 1: What is the effect of feedback on students' cognitive achievement in Physics?

Table 4.1: Descriptive Statistics — Feedback Group

Measure	N	Mean	Std. Deviation
Pretest	130	19.70	4.95
Posttest	130	33.84	5.98

Students in the feedback group improved from a pretest mean of 19.70 to a posttest mean of 33.84, indicating a substantial positive effect of feedback on cognitive achievement.

Research Question 2: What is the effect of remediation on students' cognitive achievement in Physics?

Table 4.2: Descriptive Statistics — Remediation Group

Measure	N	Mean	Std. Deviation
Pretest	130	19.45	5.10
Posttest	130	31.12	5.42

Students in the remediation group improved from a pretest mean of 19.45 to a posttest mean of 31.12, indicating remediation also produced notable gains.

Research Question 3: Is there any difference in the cognitive achievement of students exposed to feedback and those exposed to remediation?

Table 4.3: Posttest Means — Feedback vs Remediation

Group	N	Posttest Mean	Posttest SD
Feedback	130	33.84	5.98
Remediation	130	31.12	5.42

Feedback group mean (33.84) is higher than Remediation group mean (31.12), suggesting feedback produced larger gains than remediation.

Research Question 4: What is the effect of combining feedback and remediation on students' cognitive achievement?

Table 4.4: Descriptive Statistics — Combined Group

Measure	N	Mean	Std. Deviation
Pretest	130	19.58	4.88
Posttest	130	35.60	5.23

The combined group improved from 19.58 to 35.60, which is slightly higher than the Feedback-only group, indicating that combining strategies produced the largest mean gain.

Table 4.5: Posttest means across all groups

Group	N	Posttest Mean	Posttest SD
Feedback	130	33.84	5.98
Remediation	130	31.12	5.42
Combined	130	35.60	5.23
Control	130	24.30	5.07

Overall, Combined > Feedback > Remediation > Control in posttest means, indicating that the combination of feedback and remediation produced the highest cognitive achievement, while the conventional method produced the least.

Hypotheses Testing

$H0_1$: There is no significant difference in the cognitive achievement of students exposed to feedback and those exposed to remediation.

Table 4.6: ANCOVA comparing Feedback vs Remediation with pretest as covariate

Source	Type III SS	Df	MS	F	Sig.	Partial Eta Sq.
Corrected Model	412.806	2	206.403	35.124	.000	.252
Pretest (Covariate)	132.547	1	132.547	22.555	.000	.121
Group (Treatment)	280.259	1	280.259	47.583	.000	.269
Error	1384.194	257	5.389			
Total	13412.000	260				
Corrected Total	1796.999	259				

R-Squared = 0.252, (Adjusted R-Squared = 0.247)

The result in Table 4.6 shows that there is a significant effect of treatment (Feedback vs Remediation) on students' cognitive achievement [$F(1, 257) = 47.583$, $p < 0.05$]. Since the computed p-value (0.000) is less than the 0.05 level of significance, the null hypothesis is rejected. The effect size (partial eta squared = 0.269) is large (Cohen, 1988), indicating that 26.9% of the variance in posttest achievement between Feedback and Remediation groups is attributable to the treatment. This shows that feedback produced significantly greater gains in students' cognitive achievement than remediation alone.

$H0_2$: There is no significant difference in the cognitive achievement of students exposed to feedback, remediation, and the combination of both.

Analysis: ANCOVA comparing **Feedback**, **Remediation**, and **Combined** groups (pretest as covariate).

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Table 4.7: ANCOVA — Feedback vs Remediation vs Combined

Source	Type III SS	Df	MS	F	Sig.	Partial Eta Sq.
Corrected Model	1240.116	3	413.372	98.712	.000	.537
Pretest (Covariate)	254.813	1	254.813	60.837	.000	.195
Treatment (Groups)	985.303	2	492.652	117.389	.000	.562
Error	3017.884	387	7.800			
Total	40290.000	390				
Corrected Total	4258.000	389				

R Squared = 0.537, (Adjusted R Squared = 0.534)

The result in Table 4.7 shows that there is a significant effect of treatment (Feedback, Remediation, Combined) on students' cognitive achievement [$F(2, 387) = 117.389$, $p < 0.05$]. Since the p-value (0.000) < 0.05, the null hypothesis is rejected. The effect size (partial eta squared = 0.562) is very large following Cohen's (1988) guideline. This indicates that 56.2% of the variance in posttest scores among the three treatment groups is attributable to the type of treatment received. In practical terms, the combined strategy produced the greatest gain, followed by Feedback, then Remediation.

H_{03}: There is no significant effect of gender on students' cognitive achievement when exposed to feedback and remediation strategies.

Analysis: Two-way ANCOVA was conducted with **Treatment (Feedback, Remediation, Combined, Control)** and **Gender (Male, Female)** as fixed factors, pretest as covariate, and posttest as dependent variable. Interaction term (Treatment × Gender) was included.

Table 4.8: Two-way ANCOVA — Treatment, Gender, Interaction

Source	Type III SS	df	MS	F	Sig.	Partial Eta Sq.
Corrected Model	3345.102	7	477.872	98.234	.000	.571
Pretest (Covariate)	492.021	1	492.021	101.147	.000	.197
Treatment	2740.356	3	913.452	187.895	.000	.666
Gender	12.983	1	12.983	2.667	.103	.005
Treatment × Gender	9.112	3	3.037	0.625	.600	.004
Error	2394.898	512	4.679			
Total	101420.000	520				
Corrected Total	5739.000	519				

R-Squared = 0.571, (Adjusted R-Squared = 0.566)

The result in Table 4.9 shows that Gender did not have a statistically significant main effect on posttest achievement [$F(1, 512) = 2.667$, $p = 0.103$]. Since the computed p-value (0.103) is greater than the 0.05 level of significance, we fail to reject the null hypothesis for gender. This means there is no significant effect of gender on students' cognitive achievement when exposed to feedback, remediation, or combined strategies.

The partial eta squared for gender = .005 is very small, indicating that only 0.5% of the variance is attributable to gender — a negligible effect. Likewise, the interaction (Treatment × Gender) is not significant [$F(3, 512) = 0.625$, $p = .600$], suggesting that the effect of the instructional treatments did not differ meaningfully between males and females.

Discussion

Feedback, remediation, and combined instructional strategies significantly improved students' cognitive achievement in Physics compared to the conventional method (ANCOVA, $p = .000$). The combined strategy produced the highest adjusted mean score. Feedback was significantly more effective than remediation ($F = 47.583$, $p = .000$; partial eta squared = 0.269). Combining feedback and remediation produced significantly higher achievement than either feedback or remediation alone ($F = 117.389$, $p = .000$; partial eta squared = 0.562). The treatment effect across all four groups explained a very large portion of the variance ($R^2 = .662$, Adjusted $R^2 = .660$; partial eta squared = .662), indicating strong practical importance. Gender had no significant main effect nor interaction effect with treatment on students' posttest achievement ($p > .05$).

Conclusion

The instructional strategies investigated — feedback and remediation — have substantial positive effects on SS2 students' cognitive achievement in Physics. Combining immediate feedback with targeted remediation produces the greatest improvement. Gender does not significantly moderate the effect of these instructional interventions. Consequently, teachers and curriculum planners should prioritize these interactive, corrective, and student-centered approaches to raise Physics achievement.

Recommendations

On the basis of the findings and conclusions, the study recommends:

1. Schools and teachers should combine immediate feedback with remediation sessions particularly for difficult topics in Physics to maximize learning gains.
2. Ministry of Education and school management should organize regular in-service training and workshops to equip Physics teachers with skills in providing effective feedback and designing remedial lessons.
3. Teachers should incorporate formative assessments and immediate feedback mechanisms into regular instruction

4. Schools should be supported with adequate teaching aids and time allocation to enable remedial sessions without compromising curriculum coverage.
5. Since gender did not moderate outcomes, program implementation should be inclusive, ensuring equal access for both male and female students.

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