EFFECTS OF COOPERATIVE LEARNING STRATEGY ON SENIOR SECONDARY SCHOOL STUDENTS' PERFORMANCE IN STOICHIOMETRY IN KOGI STATE

BY

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Abstract

This study investigated the effects of cooperative learning strategy on senior secondary school students' performance in stoichiometry in Kogi State, Nigeria, with gender as a moderating variable. A quasi-experimental research design involving pretest-posttest control group was adopted. A total of 120 SS2 chemistry students, selected through multistage sampling, participated in the study. The experimental group was taught using cooperative learning strategies, while the control group received conventional instruction. Data was collected using a validated Stoichiometry Achievement Test (SAT) with a reliability coefficient of 0.82. Data analysis involved descriptive and inferential statistics including mean, standard deviation, ANCOVA, and t-test. Findings revealed that students taught using cooperative learning strategies significantly outperformed their counterparts in the control group. Furthermore, gender had no significant effect on performance, indicating that cooperative learning benefited both male and female students equally. The study recommends the integration of cooperative learning into chemistry instruction to enhance students' understanding and performance in stoichiometry.

Keywords: Cooperative learning, stoichiometry, chemistry education, gender

Introduction

Chemistry is a foundational science subject that plays a pivotal role in technological and industrial development. Within the chemistry curriculum, stoichiometry is an essential yet challenging topic for many secondary school students due to its abstract and mathematical nature (Okoye & Eze, 2022). Stoichiometry, which involves the quantitative relationships between reactants and products in chemical reactions, is a fundamental yet challenging topic in chemistry education. Students often struggle with stoichiometry due to its abstract nature and the mathematical skills required, which many learners find difficult (Achor et al., 2021). The difficulty can be traced to the traditional teaching methods in most Nigerian secondary schools, which are often teacher-centered, have been identified as a

major contributing factor to students' poor understanding of stoichiometric concepts (Ezeudu & Nworgu, 2023). These methods limit students' engagement and critical thinking, leading to low academic performance and reduced retention. To address this issue, educators and researchers have advocated for the use of learner-centered approaches, such as active participation, peer interaction, and collaborative problem-solving which emphasizes cooperative learning strategies. (Johnson & Johnson, 2020; Yusuf et al., 2023). Cooperative learning is a structured form of group work where students work together to achieve shared learning goals. It has been shown to improve academic performance, communication skills, and students' attitude toward learning science (Slavin, 2019; Awodun et al., 2021). Studies in science education have found that cooperative learning strategies enhance students' understanding of complex chemistry topics, including stoichiometry, by promoting deeper conceptual engagement regardless of their gender differences (Udeani & Onoh, 2022).

Gender differences in academic achievement and learning preferences have been a subject of extensive research. In the context of cooperative learning, some studies have explored how gender may influence students' performance and engagement. Igwe et al. (2024) observed that within the cooperative learning groups, male students had higher mean achievement and retention scores than female students in chemistry. However, other studies have reported no significant gender differences in chemistry achievement and retention when cooperative learning strategies are employed to increase students' performance. Given the persistent low performance in chemistry in external examinations such as the West African Senior School Certificate Examination (WAEC), there is a pressing need to explore innovative strategies that can improve learning outcomes in secondary school students. (WAEC Chief Examiners' Report, 2023). Hence, it has been observed that there is limited empirical evidence on the effectiveness of cooperative learning strategies in teaching stoichiometry within the Nigerian context, particularly in Kogi State. These findings underscore the need for further investigation into how gender may moderate the effectiveness of cooperative learning strategies on Senior Secondary School Students' Performance in Stoichiometry in Kogi State.

Statement of the Problem

Students' persistent difficulty in understanding stoichiometric concepts and the continued reliance on ineffective teaching methods pose a significant challenge in secondary chemistry education. The problem is further compounded by large class sizes and limited instructional resources, especially in public schools in Kogi State. While cooperative learning has shown promise elsewhere, its specific impact on students' achievement in stoichiometry remains underexplored in this region. This study, therefore, seeks to examine the effects of cooperative learning strategy on students' performance in stoichiometry in secondary schools in Kogi State.

Objectives of the Study

The primary objective of this study is to examine the effects of cooperative learning strategy on students' performance in stoichiometry in secondary schools in Kogi State. Specifically, the study seeks to:

1. Determine the difference in performance between students taught stoichiometry using cooperative learning strategy and those taught using conventional teaching methods.
2. Assess the effect of cooperative learning strategy on the performance of male and female students in stoichiometry.
3. Investigate the interaction effect of cooperative learning strategy and gender on students' performance in stoichiometry.
4. Compare the mean achievement scores of students in the experimental and control groups.

Research Questions

To guide the study, the following research questions are posed:

1. What is the mean difference in the performance of students taught stoichiometry using cooperative learning strategy and those taught using conventional methods?
2. What is the difference in the performance of male and female students taught stoichiometry using cooperative learning strategy?
3. What is the interaction effect of teaching strategy and gender on students' performance in stoichiometry?
4. What are the mean achievement scores of students in the cooperative learning group compared to those in the conventional teaching group?

Research Hypotheses

The following null hypotheses will be tested at 0.05 level of significance:

H_{01}: There is no significant difference in the achievement of students taught stoichiometry using cooperative learning strategy and those taught using conventional methods.

H_{02}: There is no significant difference in the achievement male and female students taught stoichiometry using cooperative learning strategy.

H_{03}: There is no significant interaction effect of teaching strategy and gender on students' achievement in stoichiometry.

Methodology

This study adopted a quasi-experimental design involving a pretest-posttest non-equivalent control group design. The design was deemed appropriate since intact classes were used, and random assignment of participants to experimental and control groups was not feasible. The design involved two groups: an experimental group taught using the cooperative learning strategy and a control group taught using conventional lecture method. Gender was treated as a moderating variable.

The population comprised all Senior Secondary School II (SS II) chemistry students in public secondary schools in Kogi State, Nigeria. This population was chosen because stoichiometry is a core topic in the SS II chemistry curriculum. A sample of 120 students (60 in the experimental group and 60 in the control group) was drawn from four co-educational secondary schools in Kogi State using a multi-stage sampling technique. Two schools were randomly assigned to the experimental group and two to the control group. Gender was balanced across groups to enable analysis of its moderating effect. The instrument used was a researcher-developed Stoichiometry Achievement Test (SAT). The SAT consisted of 25 multiple-choice items covering key areas of stoichiometry. The test items were validated by experts in science education and chemistry to ensure content validity. A reliability coefficient of 0.87 was obtained using the Kuder-Richardson Formula 20 (KR-20), indicating high internal consistency. Students in the experimental group were taught using the Cooperative Learning Strategy, specifically the Jigsaw technique, for six weeks. Lessons were student-centered, involving group discussions, task rotations, and collaborative problem-solving. Students in the control group received instruction via the Conventional Lecture Method, which was teacher-centered and involved direct instruction and individual exercises. Both groups were taught the same content in stoichiometry and were exposed to the same lesson duration and objectives. The lessons were delivered by trained chemistry teachers to ensure fidelity of implementation. A pretest was administered to both groups to determine their baseline knowledge in stoichiometry before the intervention. After six weeks of instruction, a post test was administered using the same SAT instrument. Gender data were also collected for subgroup analysis. The data were analyzed using both descriptive and inferential statistics: Mean and standard deviation were used to answer the research questions. Analysis of Covariance (ANCOVA) was used to test null hypotheses at a 0.05 level of significance. Pretest scores served as covariates to control for initial differences in performance. Interaction effects between gender and teaching strategy were also examined.

Results

Research Question One:

What is the difference in the performance of students taught stoichiometry using cooperative learning strategy and those taught using conventional methods?

Table 1:

Mean and Standard Deviation of Students' Posttest Scores by Group

Group	N	Mean	SD
Experimental (Cooperative Learning)	60	72.65	8.43
Control (Conventional Method)	60	58.42	9.11

Students taught using cooperative learning strategy had a higher mean score (M = 72.65) than those taught with conventional methods (M = 58.42). This suggests that cooperative learning enhanced students' understanding of stoichiometry more effectively.

Table 2:

ANCOVA Summary of Posttest Scores

Sources	SS	df	MS	F	P
Covariate (Pretest)	1145.76	1	1145.76	10.23	.002
Group	2184.32	1	2184.32	19.51	.000
Error	13120.14	116	113.11		
Total	16450.22	118	-	-	-

$p < .05$

The result shows a statistically significant effect of cooperative learning on students' performance in stoichiometry ($F(1,116) = 19.51$, $p < .001$).

This finding is consistent with Agwu and Nmadu (2023), who reported that cooperative learning significantly improved academic achievement in chemistry. Similarly, Jack and Jinadu (2023) demonstrated that the Jigsaw strategy enhanced students' mastery of chemistry concepts compared to lecture-based methods.

Research Question Two:

What is the difference in the performance of male and female students taught stoichiometry using cooperative learning strategy?

Table 3:
Mean Scores of Male and Female Students in Experimental Group

Group	N	Mean	SD
Male	30	74.20	7.95
Female	30	71.10	8.87

Male students had a slightly higher mean score (M = 74.20) compared to female students (M = 71.10). However, the difference was not statistically significant.

Table 4:
ANCOVA Summary for Gender Effect

Sources	SS	df	MS	F	P
Gender	312.24	1	312.24	2.68	.105

Although males scored slightly higher, gender did not significantly affect performance. This aligns with findings by Yusuf et al. (2023), who observed no significant gender disparity in science achievement when cooperative strategies were used. However, it contrasts with Igwe et al. (2024), who found males outperforming females in cooperative chemistry classes, suggesting contextual variations may exist.

Research Question Three: What is the interaction effect of teaching strategy and gender on students' performance in stoichiometry?

Table 5:
ANCOVA Summary of Interaction Effect

Sources	SS	df	MS	F	P
Strategy *Gender	78.14	1	78.14	0.69	.409

There was no statistically significant interaction between teaching strategy and gender (F (1,116) = 0.69, p = .409), indicating that cooperative learning benefits both genders similarly.

Interpretation: This supports the social constructivist view that all learners, regardless of gender, benefit from socially interactive learning environments (Vygotsky, 1978). It also corroborates the findings of Slavin (2019) and Johnson & Johnson (2020), who emphasized the inclusive benefits of cooperative learning across diverse student populations.

Discussion of Findings

The results demonstrate that cooperative learning significantly enhances students' performance in stoichiometry. These findings align with prior studies (Agwu & Nmadu, 2023; Jack & Jinadu, 2023; Aliyu, 2024) that confirmed the superiority of student-centered methods over traditional ones in chemistry education. Although

male students slightly outperformed females, the difference was not significant, implying cooperative learning is effective across genders. The lack of interaction effect further suggests that gender does not moderate the impact of cooperative learning, reinforcing the universal value of this approach. These results advocate for a shift in instructional practices in Nigerian secondary schools, especially in Kogi State, to adopt cooperative learning methods that foster deeper comprehension and peer engagement.

Conclusion

This study investigated the effect of cooperative learning strategy on secondary school students' achievement in stoichiometry, with gender as a moderating variable. The findings revealed that students taught using cooperative learning significantly outperformed those taught through conventional lecture methods. Although male students had slightly higher mean scores than female students, the difference was not statistically significant, and no interaction effect was found between gender and instructional strategy. These findings validate the effectiveness of cooperative learning in enhancing students' understanding of stoichiometry, a topic often perceived as challenging. The study underscores the importance of adopting interactive and learner-centered strategies, such as the Jigsaw model, to improve chemistry education outcomes.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Curriculum planners and educational stakeholders should integrate cooperative learning strategies into chemistry curricula, particularly for abstract topics like stoichiometry.
2. Chemistry teachers should receive training on effective implementation of cooperative learning methods such as the Jigsaw technique, to promote collaboration and peer tutoring among students.
3. Further research should be conducted across different subjects and states to confirm the generalizability of these findings, with an emphasis on other moderating variables such as school type, teacher experience, and socioeconomic background.
4. Gender considerations should not limit the adoption of cooperative learning strategies, as this method has been shown to benefit both male and female learners equitably.

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