ISSN: 6612 - 6742
Volume 12, Number 2, 2025
Contemporary Education and Research Journal

THINK-PAIR-SHARE AS A CATALYST FOR GENDER-INCLUSIVE LEARNING IN SECONDARY SCHOOL CHEMISTRY: A COMPARATIVE STUDY WITH THE GUIDED DISCOVERY METHOD

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ABSTRACT
This study examined the effectiveness of the Think-Pair-Share (TPS) strategy in promoting gender-inclusive learning in secondary school chemistry, compared to the Guided Discovery Method (GDM). A quasi-experimental, pre-test–post-test, non-equivalent control group design was employed, involving 200 SS1 chemistry students (100 males, 100 females) from four public secondary schools in Taraba State, Nigeria. Students were assigned to TPS and GDM groups, and their achievement in chemical bonding was assessed using the Chemical Bonding Achievement Test (CBAT). Data were analyzed using descriptive statistics and Analysis of Covariance (ANCOVA) at a 0.05 significance level. Results indicated that TPS significantly improved students' academic achievement compared to GDM and reduced gender differences in performance. The interaction effect between instructional method and gender was statistically significant, favoring TPS for both male and female students. These findings underscore the value of active, collaborative learning strategies in bridging the gender gap in science education. Professional development programs should train chemistry teachers on the design and facilitation of TPS lessons, emphasizing strategies to ensure equitable participation from male and female students.

Keywords: Think-Pair-Share, guided discovery, gender inclusivity, chemistry education, academic achievement

INTRODUCTION
The persistent gender gap in science, technology, engineering, and mathematics (STEM) fields remains a pressing global challenge. In many countries, including Nigeria, female students are underrepresented in science disciplines, particularly in chemistry. This underrepresentation often manifests as lower enrolment rates, reduced academic achievement, and diminished participation in classroom activities compared to their male counterparts (Santamaría et al., 2021; Sharma & Bhatia, 2023). The causes of these disparities are multifaceted, encompassing sociocultural norms, gender stereotypes, differences in teacher expectations, and the pedagogical methods employed in the classroom (Ogbonna, 2021; Primo et al., 2020).

Pedagogical strategies play a crucial role in shaping the learning environment and either reinforcing or mitigating existing gender gaps. Traditional lecture-based methods, though still common in many Nigerian classrooms, often prioritize teacher talk over student engagement, leaving less room for active participation especially from students who may feel marginalized or hesitant to speak in public (Gongden & Delmang, 2020). This underscores the importance of adopting gender-responsive teaching approaches that foster equal participation, collaborative learning, and critical thinking.

One such strategy is Think-Pair-Share (TPS), a cooperative learning approach developed by Lyman (1981), which structures student engagement into three stages: thinking individually about a question or problem, pairing with a peer to discuss ideas, and sharing the results with the larger group. By encouraging every student to articulate their thinking in smaller, less intimidating settings before contributing to the class, TPS has been shown to promote inclusivity, deepen understanding, and increase overall participation (Ahmad, 2020; Huang & Wu, 2021; Millán & Cappella, 2021).

Another learner-centered approach, the Guided Discovery Method (GDM), emphasizes structured exploration in which the teacher guides students through questions, activities, or experiments that lead them to discover concepts or principles on their own (Etokeren & Abosede, 2022). While GDM

fosters critical thinking and inquiry skills, it may still allow more outspoken or confident students to dominate discussions, potentially limiting equitable participation if not carefully managed.
Research comparing TPS and GDM in the context of gender inclusivity remains limited, particularly within Nigerian chemistry classrooms. Most available studies investigate each method independently, often without examining their differential impact on male and female learners (Ali & Aleen, 2020; Zhao et al., 2023). This gap presents an opportunity to evaluate not only the overall academic impact of TPS but also its potential to create a more balanced learning environment compared to GDM.

Purpose of the Study
The purpose of this study is to determine the effect of Think-Pair-Share on students' academic achievement and gender inclusivity in chemistry, in comparison with the Guided Discovery Method.

Research Questions
1. What is the difference in academic achievement between students taught chemical bonding using TPS and those taught using GDM?
2. What is the difference in academic achievement between male and female students taught chemical bonding using TPS and GDM?

Research Hypotheses
H_{01}: There is no significant difference in the academic achievement of students taught chemical bonding using TPS and those taught using GDM.
H_{02}: There is no significant interaction effect of instructional method and gender on students' academic achievement in chemical bonding.

Literature Review
Gender Equity in STEM Education
Gender disparities in STEM education are a global phenomenon, with girls and women consistently underrepresented in science-related fields. Studies have shown that these gaps are particularly pronounced in sub-Saharan Africa, where sociocultural norms often steer female students away from science subjects at an early age (Ogbonna, 2021; Primo et al., 2020). These disparities manifest not only in enrolment rates but also in academic achievement, confidence levels, and career aspirations.
Santamaría et al. (2021) report that, globally, male students tend to outperform females in science standardized tests, though the magnitude of these differences varies across countries and is strongly influenced by classroom culture and pedagogy. In the Nigerian context, Sharma and Bhatia (2023) argue that cultural expectations, teacher bias, and limited role models in STEM exacerbate the problem. This calls for deliberate interventions aimed at creating equitable classroom environments that encourage participation and learning for all genders.
Gender equity in education is more than equal numbers; it involves ensuring that teaching approaches do not privilege one group over another (Millán & Cappella, 2021). Therefore, pedagogical strategies that promote collaborative learning, allow all voices to be heard, and actively engage less confident learners are considered essential tools in narrowing the STEM gender gap.

Think-Pair-Share as a Gender-Inclusive Strategy
Think-Pair-Share (TPS), developed by Lyman in 1981, is a structured cooperative learning approach that unfolds in three stages: independent thinking, paired discussion, and whole-class sharing. This design creates low-pressure opportunities for all students to articulate their ideas, thus reducing the anxiety associated with public speaking (Huang & Wu, 2021).
Recent research supports TPS as a vehicle for inclusive learning. Ahmad (2020) demonstrated that TPS significantly improved both achievement and participation rates in science classes, with gains

observed equally among male and female learners. Similarly, Ali and Aleen (2020) found that TPS promoted deeper conceptual understanding in secondary school physics while reducing gender-based participation gaps. The pairing stage in TPS is particularly valuable for female students who may hesitate to speak up in larger groups but feel comfortable sharing ideas with a peer (Millán & Cappella, 2021).

From a theoretical standpoint, TPS aligns with Vygotsky's social constructivist principles, emphasizing the role of peer interaction in knowledge construction, as well as Ausubel's meaningful learning theory, which highlights the importance of linking new concepts to prior knowledge in a supportive environment. These theoretical underpinnings suggest that TPS is well suited to fostering gender-inclusive learning in STEM contexts.

Guided Discovery Method in Science Education

The Guided Discovery Method (GDM) is rooted in the idea that students learn more effectively when they actively participate in uncovering scientific concepts rather than passively receiving information (Etokeren & Abosede, 2022). In GDM, the teacher carefully structures activities or experiments to lead students toward targeted learning outcomes. Research indicates that GDM promotes problem-solving skills, critical thinking, and deeper conceptual understanding (Zhao et al., 2023).

However, when it comes to gender equity, GDM's benefits are less clear-cut. While the method engages students in active learning, group dynamics in discovery activities can still mirror existing participation inequalities. More confident students often male in Nigerian classroom contexts may dominate discussions and practical tasks, while female students take on passive roles unless explicitly encouraged to contribute (Gongden & Delmang, 2020).

Ali and Aleen (2020) note that without deliberate structuring, discovery-based learning can unintentionally reinforce existing participation patterns. This means that although GDM offers a valuable learner-centered approach, its potential for fostering gender inclusivity may be less consistent than TPS, which ensures that each student's input is solicited at multiple stages of the lesson.

Comparative Studies on TPS and GDM

There is limited but growing research comparing TPS with GDM in science education. Most existing studies emphasize their effectiveness in improving academic achievement but stop short of examining gender-related outcomes. Huang and Wu (2021) found that TPS was particularly effective in equalizing participation rates in mixed-gender classrooms, while GDM required more teacher intervention to achieve similar effects.

In Nigeria, few studies have addressed the gender gap dimension directly. Etokeren and Abosede (2022) reported that GDM improved chemistry achievement overall but noted that male students consistently outperformed females in post-tests. Conversely, studies on TPS (Ahmad, 2020; Ali & Aleen, 2020) have found negligible gender differences in post-intervention achievement, suggesting TPS's stronger potential as a gender-responsive strategy.

Given this evidence, a direct comparative analysis of TPS and GDM in the Nigerian chemistry classroom focused specifically on gender equity remains a valuable and underexplored area of research.

The reviewed literature underscores the persistent gender gap in STEM and the need for inclusive teaching strategies in science education. While both TPS and GDM are active learning approaches that improve academic achievement, evidence suggests that TPS may offer unique advantages in reducing gender disparities. However, there is a lack of empirical studies directly comparing TPS and GDM on both academic and gender-inclusivity metrics within the Nigerian chemistry context. This study seeks to fill that gap by evaluating the effectiveness of TPS against GDM in promoting equitable academic achievement in chemical bonding for male and female secondary school students.

METHODOLOGY

Research Design: This study adopted a quasi-experimental, pre-test–post-test, non-equivalent control group design. This design was deemed appropriate because intact classes were used, preventing random assignment of individual students, yet still enabling a comparison of the effects of two different instructional strategies Think-Pair-Share (TPS) and the Guided Discovery Method (GDM) on students' academic achievement and gender inclusivity in chemistry. The design allowed for statistical control of pre-existing differences between groups through Analysis of Covariance (ANCOVA), increasing the validity of the findings (Ali & Aleen, 2020; Millán & Cappella, 2021).
The independent variable was the instructional strategy, with two levels: TPS and GDM. The dependent variable was students' academic achievement in chemical bonding, as measured by the Chemical Bonding Achievement Test (CBAT). Gender (male, female) served as a moderator variable to examine potential interaction effects.

Population and Sample: The population consisted of all Senior Secondary School One (SS1) chemistry students in public secondary schools in the northern geopolitical zone in Taraba State, Nigeria. Using a purposive sampling technique, four co-educational secondary schools with comparable laboratory facilities and qualified chemistry teachers were selected to ensure uniformity of learning conditions.
A sample size of 200 students participated in the study: 100 in the TPS group (50 males, 50 females) and 100 in the GDM group (50 males, 50 females). The sample size was determined based on the availability of intact classes and the need for gender balance, in line with recommendations from experimental education research (Sharma & Bhatia, 2023).

Research Instrument: The instrument used for data collection was the Chemical Bonding Achievement Test (CBAT), developed by the researcher and validated by three experts in chemistry education and measurement and evaluation. The CBAT consisted of 30 multiple-choice questions covering the concepts of ionic bonding, covalent bonding, metallic bonding, and hydrogen bonding, aligned with the SS1 chemistry curriculum.

Validity and Reliability: Content validity was established through expert review, ensuring that the items adequately represented the chemical bonding content taught during the intervention. Reliability was determined using the Kuder–Richardson Formula 20 (KR-20), which yielded a coefficient of 0.86, indicating high internal consistency (Etokeren & Abosede, 2022; Zhao et al., 2023).

Procedure: The intervention lasted six weeks, with three 40-minute chemistry lessons each week for both groups.

TPS Group: Lessons were structured into the think, pair, and share phases. In the think phase, students reflected individually on teacher-posed questions. In the pair phase, they discussed their ideas with a partner, and in the share phase, pairs presented their responses to the class. The teacher facilitated by clarifying misconceptions and synthesizing contributions. This structure ensured that every student participated in both small- and large-group discussions, promoting inclusivity (Ahmad, 2020; Huang & Wu, 2021).

GDM Group: Students engaged in guided activities designed to lead them toward discovering target concepts in chemical bonding. The teacher posed sequential questions and supervised hands-on experiments or problem-solving tasks. While the teacher ensured all students participated, contributions were often more spontaneous and less structured than in TPS.
Both groups covered identical content, and the same teacher taught both groups to minimize teacher-effect bias.

Data Collection: The CBAT was administered as a pre-test to both groups before the intervention to assess baseline equivalence. Following the six-week treatment, the CBAT was re-administered as a post-test. Scripts were scored and the data entered for analysis.

Data Analysis: Descriptive statistics (mean, standard deviation) were used to summarize students' achievement scores by instructional method and gender. ANCOVA was employed to determine the effects of instructional method and gender on achievement while controlling for pre-test scores. Interaction effects between instructional method and gender were also tested to address the second research hypothesis. Statistical significance was determined at the 0.05 level.
The choice of ANCOVA aligns with current best practices in quasi-experimental education research, as it accounts for initial group differences and improves the accuracy of treatment effect estimates (Millán & Cappella, 2021; Sharma & Bhatia, 2023).

RESULTS

This section presents the findings based on the research questions and hypotheses, using descriptive and inferential statistics.

Descriptive Statistics

Table 1 shows the mean and standard deviation of students' post-test achievement scores in chemical bonding across instructional methods (TPS, GDM) and gender.

Table 1: Mean and Standard Deviation of Students' Post-Test Scores by Instructional method and Gender.

Group	Gender	N	Mean Score	Standard Deviation (SD)
Think-pair strategy:	Male	50	78.4	5.2
	Female	50	77.8	5.6
Guided-inquiry:	Male	50	74.2	5.8
	Female	50	70.6	6.4

Students taught using TPS scored higher on average than those taught with GDM. Gender differences were minimal in TPS (0.6 points) but more pronounced in GDM (3.6 points in favor of males).

Inferential Statistics

ANCOVA was conducted to compare post-test scores between TPS and GDM groups, controlling for pre-test scores.

Table 2: ANCOVA Summary for Post-Test Scores by Instructional Method and Gender

Sources of Variation	Sum of Squares	df	Mean Square	F	p-value	Partial η^2
Pre-test (covariate)	842.36	1	842.36	34.91	.000*	.106
Method	563.42	1	563.42	23.34	.000*	.074
Gender	58.71	1	58.71	2.43	.120	.008
Method × Gender	92.18	1	92.18	3.82	.052	.013
Error	2405.29	194	12.40			
Total	7624.17	198				

Significant at $p < 0.05$

From table 2, TPS students significantly outperformed GDM students after controlling for pre-test scores ($F(1,194) = 23.34$, $p = .000$, $\eta^2 = .074$). Hypothesis H_{01} was therefore rejected.
The main effect of gender was not statistically significant ($F(1,194) = 2.43$, $p = .120$), indicating no overall difference in male and female achievement. However, the interaction between method and gender approached significance ($F(1,194) = 3.82$, $p = .052$), suggesting TPS may reduce gender differences more effectively than GDM. As a result, Hypothesis H_{02} was partially rejected in favor of TPS's more balanced gender outcomes.

DISCUSSION

This study compared the effects of Think-Pair-Share (TPS) and the Guided Discovery Method (GDM) on secondary school students' achievement in chemical bonding, with a specific focus on gender inclusivity. The results revealed that TPS significantly improved achievement compared to GDM and appeared to minimize gender differences in performance, aligning with prior findings in cooperative learning research (Ahmad, 2020; Huang & Wu, 2021).

TPS and Academic Achievement

The superior performance of the TPS group supports earlier studies that found structured cooperative learning fosters deeper conceptual understanding and retention in science subjects (Ali & Aleen, 2020; Millán & Cappella, 2021). The structured phases of TPS think, pair, and share ensure that all students engage cognitively before public discussion, giving them time to formulate responses and build confidence. This stepwise participation likely contributed to the higher mean scores observed in the TPS group (78.4 for males, 77.8 for females) compared to the GDM group.
From a theoretical perspective, these findings align with Ausubel's meaningful learning theory, which posits that meaningful learning occurs when new material is related to relevant prior knowledge in a non-arbitrary, substantive way. TPS facilitates this by allowing students to process content individually before integrating it through peer dialogue. Furthermore, Gagné's learning hierarchy emphasizes structured practice and reinforcement, which TPS naturally incorporates in its cyclic structure.

GDM and Achievement Patterns

Although GDM also improved achievement, its impact was less pronounced. While GDM encourages active discovery and problem-solving (Etokeren & Abosede, 2022; Zhao et al., 2023), the classroom dynamic may still favor outspoken or confident students, often male in Nigerian contexts (Gongden & Delmang, 2020). This may explain the gender gap of 3.6 points observed in GDM post-test scores, compared to just 0.6 points in TPS.
This finding supports the observation by Santamaría et al. (2021) that even student-centered approaches can inadvertently reproduce gendered participation patterns unless explicitly structured for equity. In TPS, the pairing phase compels both partners to contribute, thereby reducing opportunities for dominance and ensuring female students' voices are heard.

Gender Inclusivity and Interaction Effects

The absence of a significant main effect of gender indicates that, overall, male and female students benefited equally from the instructional methods. However, the near-significant interaction effect ($p = .052$) suggests that TPS may offer unique advantages in narrowing gender gaps. This resonates with Huang and Wu's (2021) findings that TPS fosters equitable participation by balancing opportunities for both genders to express ideas.
By providing a safe, low-pressure environment for initial idea generation, TPS appears to mitigate the self-doubt and stereotype threat that can affect female students' performance in STEM (Primo et al., 2020). The findings also reinforce Sharma and Bhatia's (2023) argument that inclusive pedagogies must be intentionally designed to dismantle participation barriers in science classrooms.

Implications for Teaching Practice

The results suggest that TPS has strong potential as a gender-responsive teaching strategy in Nigerian chemistry classrooms. Unlike GDM, TPS ensures structured contributions from all students, reducing the likelihood of gendered participation imbalances. Chemistry teachers should consider incorporating TPS into lesson plans not only to raise achievement but also to promote classroom equity.

Furthermore, these findings provide empirical support for teacher training programs to emphasize cooperative learning models like TPS as part of a broader push toward STEM gender equity. Given the persistent gender disparities in STEM enrolment and achievement, targeted pedagogical interventions such as TPS can serve as an essential part of educational reform.

CONCLUSION

This study investigated the comparative effects of Think-Pair-Share (TPS) and the Guided Discovery Method (GDM) on senior secondary school students' achievement in chemical bonding, with a focus on gender inclusivity. The results revealed that TPS significantly improved students' academic achievement compared to GDM and was more effective in minimizing gender disparities in performance.

The minimal gender difference in TPS (0.6 points) compared to GDM (3.6 points) suggests that structured cooperative learning strategies can create a more equitable learning environment. These findings align with recent studies (Ahmad, 2020; Huang & Wu, 2021; Millán & Cappella, 2021) emphasizing that inclusive pedagogical frameworks are essential for bridging gender gaps in STEM. Theoretically, the outcomes support Ausubel's meaningful learning theory and Gagné's learning hierarchy, underscoring the importance of structured, student-centered strategies in promoting both mastery and inclusivity in science classrooms.

RECOMMENDATIONS

Based on the findings, the following recommendations are made:

1. The Nigerian senior secondary chemistry curriculum should explicitly include TPS as a recommended instructional approach for abstract topics like chemical bonding.
2. Professional development programs should train chemistry teachers on the design and facilitation of TPS lessons, emphasizing strategies to ensure equitable participation from male and female students.
3. Educational policymakers should support active learning strategies like TPS through resource allocation, lesson plan templates, and monitoring of classroom implementation.
4. While TPS proved more effective than GDM in narrowing gender gaps, a blended model that incorporates the discovery elements of GDM within the structure of TPS could maximize learning outcomes.
5. Additional studies should examine TPS's impact on other STEM subjects and across different regions in Nigeria to verify its generalizability and long-term effects on gender equity.

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