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Cooperative Learning Strategies on the Science Blended Performance of SVNHS SHS Students

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Abstract

This study evaluated the effects of three cooperative learning strategies (Dyad, Triad, and Small Group) on the blended science performance of Grade 12 STEM students at Signal Village National High School. Performance was measured across three core competencies: Electronic Structure of Atoms, Chemical Bonding, and Organic Compounds.

A quasi-experimental design was employed to measure student performance before, during, and after the intervention. Statistical analysis utilized Paired t-tests to evaluate pretest-to-posttest gains within groups, and a One-Way ANOVA to compare effectiveness across the three grouping strategies.

Prior to the intervention, students' initial performance fell within the Did Not Meet Expectations range (Mean = 66.56). Following the cooperative learning implementation, overall posttest performance improved significantly to a Satisfactory level (Mean = 82.56). During live blended activities, students achieved an Outstanding performance level (Mean = 93.67). Paired t-tests confirmed significant pretest-to-posttest improvements for all groups ($p < 0.05$) with high effect sizes (Hedges' $g = 4.02$ to 9.56). However, the One-Way ANOVA revealed no significant difference in performance among the three grouping sizes ($F = 1.61, p = 0.220$).

Cooperative learning is a highly effective strategy for senior high school STEM chemistry, though group size does not significantly alter academic outcomes. Integrating these strategies into blended learning, standardizing grouping protocols, and implementing project-based bridging programs are recommended to maximize student performance.

Keywords: *Cooperative Learning, Blended Performance, Transformative Instructional Strategy, Science Performance, Competency*

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Background of the Study

Due to frequent natural disasters and geographical challenges in the Philippines, the Department of Education (DepEd) has increasingly adopted Alternative Delivery Modes (ADM) and blended learning to ensure educational continuity. While the integration of digital tools and online materials has created more flexible and modernized learning environments (Akbar et al., 2023; Shanaha & Doyle-Kent, 2024), this rapid transition has introduced complex new challenges to student engagement.

A significant consequence of blended learning is learner isolation. Without the immediate feedback of a teacher or the spontaneous peer interaction of a traditional classroom, abstract STEM subjects—such as atomic structure and organic chemistry—become particularly difficult to grasp. Conventional, lecture-centered training often fails to spark enthusiasm or drive success in these environments (Bernardo et al., 2021; Mathew, 2024). This struggle is highly evident among Grade 12 STEM-Wisdom students at Signal Village National High School (SVNHS) in Taguig City. In a blended setup, the absence of a social learning community often transforms the complexities of General Chemistry into a barrier rather than a stepping stone.

To address the challenges of learner isolation, this paper shifts the pedagogical focus toward cooperative learning. Grounded in social development principles, this approach emphasizes that students learn effectively through peer interaction rather than as isolated receivers of information. Therefore, this study aimed to determine the effects of different cooperative learning strategies—specifically Dyads, Triads, and Small Groups—on the blended science performance of Grade 12 STEM students. By identifying the most effective group structure for science education, this study seeks to transform students into active contributors to their intellectual development, enhancing both their academic performance and their collaborative skills.

Statement of the Problem

Specifically, it sought to answer the following questions:

1. What are the pre-intervention science performance levels of the students across the following core competencies:
    a. Electronic Structure of Atoms,
    b. Chemical Bonding (Ionic and Covalent Bonds), and
    c. Organic Compounds?
2. What are the post-intervention science performance levels of the students when grouped into:
    a. Dyads,
    b. Triads, and
    c. Small Groups?
3. What is the performance level of the students during the actual blended cooperative learning activities?
4. Is there a significant difference between the pretest and posttest science performance scores of the students after the implementation of the cooperative learning strategies?

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5. Is there a significant difference in post-intervention science performance among the students exposed to the three grouping strategies (Dyad, Triad, and Small Group)?

Hypotheses

1. H_{01}**:** There is no significant difference between the pretest and posttest science performance scores of Grade 12 students after the implementation of the cooperative learning strategies.

2. H_{02}**:** There is no significant difference in post-intervention science performance among the students exposed to the three grouping formats (Dyad, Triad, and Small Group).

Materials and Methods

Research Design: A quasi-experimental pretest-posttest design was utilized to quantify the effects of different cooperative learning grouping strategies on academic outcomes without disrupting existing class structures.

Participants: A purposive sample consisting of one intact class of 27 Grade 12 STEM-Wisdom students at Signal Village National High School (SVNHS) during the 2025–2026 school year.

Instruments: A researcher-validated 50-item multiple-choice assessment aligned with DepEd Most Essential Learning Competencies (MELCs) for Grade 12 General Chemistry, serving as both pretest and posttest.

Procedure: Administrative clearances and consent were secured, followed by a baseline pretest. Based on formative results, students were stratified by ability into Dyads, Triads, and Small Groups. An 8-week blended cooperative learning intervention was implemented, culminating in an identical 50-item posttest.

Data Analysis: Paired-samples t-tests were used to evaluate pretest-to-posttest performance gains within groups, Hedges' g was computed to determine effect sizes, and a One-Way Analysis of Variance (ANOVA) was applied to compare academic performance across the three grouping strategies.

Results

Baseline vs. Post-Intervention Science Performance

Table 1 and Table 2 present the descriptive statistics for student science performance before and after the cooperative learning intervention across three core competencies. Prior to the intervention, the baseline data (Table 1) revealed an overall mean score of 66.56, falling within the *Did Not Meet Expectations* (DNME) range across all grouping allocations and content areas. Following the implementation of cooperative learning, the overall posttest performance (Table 2) significantly improved to a *Satisfactory* (S) level ($M = 82.56$). Notable academic growth was observed in the Triad ($M = 83.67$) and Small Group ($M = 83.92$) formats, particularly within the Chemical Bonding competency, which achieved *Outstanding* (O) performance ratings.

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Table 1. *Baseline Performance Level Before Cooperative Learning Implementation*

Competencies	Dyad		Triad		Small Group		Overall	
	Mean	DR	Mean	DR	Mean	DR	Mean	DR
a. Atomic Structure of Atoms	66.67	DNME	64.33	DNME	64.00	DNME	64.70	DNME
b. Chemical Bonding (Ionic Bond, Covalent Bond)	67.17	DNME	68.89	DNME	68.50	DNME	68.33	DNME
c. Organic Compounds	67.17	DNME	68.44	DNME	63.58	DNME	66.00	DNME
Overall	**67.00**	**DNME**	**66.89**	**DNME**	**66.08**	**DNME**	**66.56**	**DNME**

Scale	Descriptive Rating
90-100	Outstanding (O)
85-89.99	Very Satisfactory (VS)
80-84.99	Satisfactory (S)
75-79.99	Fairly Satisfactory (FS)

Table 2. *Post-Intervention Performance Level After Cooperative Learning Exposure*

Competencies	Dyad		Triad		Small Group		Overall	
	Mean	DR	Mean	DR	Mean	DR	Mean	DR
a. Atomic Structure of Atoms	76.50	FS	77.11	FS	83.25	S	79.70	FS
b. Chemical Bonding (Ionic Bonds, Covalent Bonds)	79.17	FS	90.33	O	90.17	O	87.78	VS
c. Organic Compounds	87.50	VS	86.78	VS	76.92	FS	82.56	S
Overall	**78.17**	**FS**	**83.67**	**S**	**83.92**	**S**	**82.56**	**S**

Scale	Descriptive Rating
90-100	Outstanding (O)
85-89.99	Very Satisfactory (VS)
80-84.99	Satisfactory (S)
75-79.99	Fairly Satisfactory (FS)
Below 75	Did Not Meet Expectation (DNME)

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Student Performance During Blended Collaborative Activities

Table 3 tracks student performance across eight specific cooperative learning tasks executed during the blended session. The overall performance mean during active learning environments reached an *Outstanding* level ($M = 93.67$). High engagement and collective success were sustained across all configurations, with initial activities demonstrating complete mastery (100.00), while Activity 6 marked a momentary drop to a *Satisfactory* level (81.00).

Table 3. ***Performance Levels During Active Blended Cooperative Tasks***

ACTIVITIES	Dyad		Triad		Small Group		Overall	
	Mean	**DR**	**Mean**	**DR**	**Mean**	**DR**	**Mean**	**DR**
Activity 1	100.00	O	100.00	O	100.00	O	100.00	O
Activity 2	100.00	O	100.00	O	100.00	O	100.00	O
Activity 3	93.33	O	91.33	O	90.17	O	91.26	O
Activity 4	100.00	O	96.44	O	100.00	O	98.81	O
Activity 5	88.50	VS	85.78	VS	88.92	VS	87.78	VS
Activity 6	90.83	O	77.22	FS	78.92	FS	81.00	S
Activity 7	98.83	O	96.44	O	97.33	O	97.37	O
Activity 8	93.33	O	93.33	O	97.17	O	95.04	O
Overall	**95.33**	**O**	**92.33**	**O**	**93.83**	**O**	**93.67**	**O**

Scale	Descriptive Rating
90-100	Outstanding (O)
85-89.99	Very Satisfactory (VS)
80-84.99	Satisfactory (S)
75-79.99	Fairly Satisfactory (FS)
Below 75	Did Not Meet Expectation (DNME)

Inferential Analysis of Pretest-to-Posttest Gains

To evaluate academic development within groups, paired-sample t-tests were executed. Tables 4a, 4b, and 4c reveal statistically significant advancements from baseline to post-intervention scores for all cooperative models ($p < 0.05$).

Dyad Format (Table 4a): Produced a significant overall mean gain of 11.17 points, $t = 7.37, p = 0.001$, exhibiting a substantial effect size (Hedges' $g = 4.02$). Organic Compounds yielded the highest improvement within this group ($Mean\ Gain = 20.33, p = 0.010$).

Competencies	Pretest	Posttest	Mean Gain	Effects Size (Hedges' g)	T-value	T-prob value
a. Atomic Structure of Atoms	66.67	76.50	9.83	5.75	4.54	0.006
b. Chemical Bonding (Ionic Bond, Covalent Bond)	67.17	79.17	12.00	13.18	2.42	0.060
c. Organic Compounds	67.17	87.50	20.33	13.23	4.08	0.010
Overall	**67.00**	**78.17**	**11.17**	**4.02**	**7.37**	**0.001**

Triad Format (Table 4b): Demonstrated the largest overall advancement with a mean gain of 16.78 points, $t = 5.53, p = 0.001$, and a commanding effect size (Hedges' $g = 9.56$). Chemical Bonding experienced the largest growth within this configuration ($Mean\ Gain = 21.44, p = 0.002$).

Competencies	Pretest	Posttest	Mean Gain	Effects Size (Hedges' g)	T-value	T-prob value
a. Atomic Structure of Atoms	64.33	77.11	12.78	10.95	3.68	0.006
b. Chemical Bonding (Ionic Bond Covalent Bond)	68.89	90.33	21.44	15.04	4.49	0.002
c. Organic Compounds	68.44	86.78	18.34	18.56	3.11	0.014
Overall	**66.89**	**83.67**	**16.78**	**9.56**	**5.53**	**0.001**

Small Group Format (Table 4c): Generated an overall mean gain of 7.08 points, $t = 9.04, p = 0.000$, with a highly effective impact size (Hedges' $g = 9.04$).

Competencies	Pretest	Posttest	Mean Gain	Effects Size (Hedges' g)	T-value	T-prob value
a. Atomic Structure of Atoms;	13.15	5.25	0.000	13.15	5.25	0.000
b. Chemical Bonding (Ionic Bonds, Covalent Bonds); and	10.42	7.46	0.000	10.42	7.46	0.000
c. Organic Compounds	11.44	4.18	0.002	11.44	4.18	0.002
Overall	**7.08**	**9.04**	**0.000**	**7.08**	**9.04**	**0.000**

ANOVA Comparison of Posttest Achievements Across Formats

Table 5a. Comparison of the Performance of the Students when Grouped by Cooperative Learning Groupings.

Group	Atomic Structure of Atoms	Chemical Bonding (Ionic Bonds, Covalent Bonds)	Organic Compounds	Overall
Dyad	76.50	79.17	87.50	78.17
Triad	77.11	90.33	86.78	83.67
Small Group	83.25	90.17	76.92	83.92
F-value	**1.05**	**2.26**	**2.38**	**1.61**
F-Prob Value	**0.366**	**0.127**	**0.114**	**0.220**

*Not Significant

Table 5b. Comparison of the Performance of Students Exposed to the Different Cooperative Learning Strategies During their Activities

Group	Act. 1	Act. 2	Act. 3	Act. 4	Act. 5	Act. 6	Act. 7	Act. 8	Overall
Dyad	100.00	100.00	93.33	100.00	88.50	90.83[a]	98.83	93.33	95.33
Triad	100.00	100.00	91.33	96.44	85.78	77.22[b]	96.44	93.33	92.33
Small Group	100.00	100.00	90.17	100.00	88.92	78.92[b]	97.33	97.17	93.83
F-value	**0.00**	**0.00**	**0.15**	**1.62**	**0.28**	**6.41**	**0.21**	**1.83**	**1.93**
F-Prob Value	**1.000**	**1.000**	**0.859**	**0.218**	**0.761**	**0.006**	**0.814**	**0.182**	**0.167**

Discussion

Interpretation of findings

The baseline results ($M = 66.56$) highlight the conceptual barriers that Senior High School STEM students face when dealing with abstract chemistry topics via conventional delivery models. These results reflect the documented proficiency challenges observed by Bernardo et al. (2021) and Olbina (2021). Reduced hands-on laboratory exploration and isolated learning arrangements in hybrid environments leave students with significant gaps in their understanding of molecular structures (Ocampo, 2022; Rafanan et al., 2021).

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The implementation of cooperative strategies triggered a notable performance shift, moving scores to a *Satisfactory* average ($M = 82.56$). This substantial growth matches the observations of Manias and Al-Hroub (2021) and Balan et al. (2022), who linked cooperative environments with improved conceptual thinking and self-efficacy in secondary science.

A review of specific grouping formats shows that Triads and Small Groups achieved *Outstanding* results in Chemical Bonding (90.33 and 90.17). This pattern supports the work of Luberger (2023), confirming that three-to-four member group structures provide a collaborative dynamic where multiple viewpoints act as cognitive checks, helping students dissect complex molecular interactions. Conversely, Organic Compounds showed the strongest growth within Dyads ($M = 87.50$). Because Organic Chemistry requires substantial talk-time to master complex nomenclature and rules, the direct dialogue format of a pair limits social loafing and maximizes individual focus (Dela Cruz, 2021; Tan & Lim, 2025).

The comparison between active collaborative processes ($M = 93.67$, *Outstanding*) and individual post-interventions ($M = 82.56$, *Satisfactory*) underscores the value of real-time peer scaffolding. When working together, collective support helps minimize individual errors (Dawson et al., 2022; Mendoza & Cruz, 2023).

The performance dip in Activity 6 (81.00) further shows that as structural complexity rises, the coordination efforts within Triads and Small Groups can sometimes encounter issues with social loafing or mismanaged group dynamics (Villanueva, 2025). Despite this, the subsequent recovery in later tasks demonstrates collective resilience and adaptation over time.

Finally, the overall non-significant ANOVA values across Table 5a ($p = 0.220$) and Table 5b ($p = 0.167$) provide crucial insight: the act of collaboration itself, rather than the specific group size, drives academic improvement. This outcome aligns with Social Interdependence Theory, which emphasizes that positive interdependence and shared responsibility matter far more than headcount (Estacio, 2022; Johnson et al., 2021).

While group size did not statistically change the final grades, it highlights that instructional flexibility—shifting between configurations based on task demands—serves as an efficient pedagogical path for preparing STEM students for university-level science (Kumar & Patel, 2024).

Comparison to Existing Studies

The baseline drop to "Did Not Meet Expectations" ($Mean = 66.56$) confirms the findings of Bernardo et al. (2021), Olbina **(2021)**, Ocampo (2022), and Rafanan et al. **(2021)**, who documented that learner isolation and reduced hands-on lab time in the Philippines' hybrid transition created severe conceptual gaps for STEM students.

The significant posttest surge to a "Satisfactory" level ($Mean = 82.56$, Hedges' $g =$ 4.02 to 9.56) directly mirrors Manias and Al-Hroub (2021) and Balan et al. (2022), proving that peer-supported environments reliably reverse these trends by enhancing scientific conceptual thinking.

A granular look at your grouping formats reveals how group size interacts with topic complexity:

Triads and Small Groups scored "Outstanding" in Chemical Bonding (90.33 and 90.17). This supports Luberger (2023), who found that 3-to-4-member groups offer the ideal team dynamic to act as cognitive checks when unpacking abstract molecular structures.

Dyads excelled most in Organic Compounds ($Mean = 87.50$). This confirms the work of Dela Cruz (2021) and Tan and Lim (2025), showing that rule-heavy, high-dialogue topics benefit from the absolute individual accountability of a paired format, which minimizes social loafing.

The contrast between "Outstanding" live tasks ($Mean = 93.67$) and "Satisfactory" individual posttests ($Mean = 82.56$) reinforces Dawson et al. (2022) and Mendoza and Cruz **(2023)** on the power of real-time peer scaffolding to distribute cognitive load. Additionally, the temporary dip in Activity 6 ($Mean = 81.00$) highlights the coordination friction and temporary social loafing that Villanueva (2025) warns can happen as task complexity spikes.

Most importantly, the non-significant ANOVA result ($p = 0.220$) across the formats delivers a major theoretical insight: the act of collaboration itself, not the headcount, drives the growth. This strongly validates Johnson et al.'s (2021) Social Interdependence Theory and Estacio (2022), confirming that positive interdependence outweighs group size. It supports Kumar and Patel's (2024) view that instructional flexibility—shifting group sizes based on task demands—is an efficient pedagogical path for STEM classrooms.

Implications for Practice and Policy

Educational Practice (Teachers & School Administrators)

Implement Concept-Driven Grouping: Because the ANOVA proved group size does not statistically alter final performance ($p = 0.220$), educators should select formats based on topic complexity rather than a fixed rule. Use **Dyads** for rule-heavy nomenclature tasks (like Organic Chemistry) to maximize individual talk-time, and Triads/Small Groups for abstract conceptual tasks (like Chemical Bonding) to maximize cognitive viewpoints.

Build Post-Activity Accountability Checkpoints: The gap between "Outstanding" collaborative tasks ($Mean = 93.67$) and "Satisfactory" individual posttests ($Mean = 82.56$) reveals that peer scaffolding can mask individual gaps. Teachers must implement immediate independent assessments after group tasks to ensure collective knowledge successfully transfers to the individual.

Educational Policy (DepEd & Division Level)

Mandate Synchronous Peer Structures in ADMs: The Department of Education (DepEd) should update its Alternative Delivery Mode (ADM) guidelines. Instead of using

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blended learning purely for asynchronous independent modules, policies should enforce synchronous, peer-to-peer cooperative sessions to directly target the learner isolation challenges typical in local public schools.

Focus on Group Dynamics Training: Professional development should train teachers in structural grouping mechanics and positive interdependence rather than reducing or watering down complex Grade 12 STEM chemistry competencies.

Study Limitations

While this study offers clear empirical evidence for cooperative learning in hybrid setups, its boundaries must be noted:

Sample Size and Context: The research was restricted to a single intact class of 27 Grade 12 STEM students at Signal Village National High School during the 2025–2026 school year. This purposive sampling limits the immediate generalizability of the findings to non-STEM tracks or different public high school environments.

Methodological Design Constraints: To prevent school day disruptions, a quasi-experimental design was used instead of a true randomized control trial. Additionally, the study did not feature a traditional, non-cooperative control group, meaning the gains cannot be statistically isolated against standard lecture-based hybrid models.

Recommendations for Future Research: Future researchers should expand this model across multiple school divisions, include a dedicated control cohort, and track students longitudinally to measure if these chemistry performance gains persist into university-level STEM courses.

Conclusion

This study evaluated the effects of three cooperative learning strategies—Dyads, Triads, and Small Groups—on the blended chemistry performance of Grade 12 STEM students at Signal Village National High School. The baseline data revealed a stark reality: prior to the intervention, isolated hybrid learning left students within the "Did Not Meet Expectations" range ($Mean = 66.56$).

The implementation of structured cooperative learning successfully reversed this trend, elevating posttest scores to a "Satisfactory" level ($Mean = 82.56$) with high effect sizes across all formats. Furthermore, during live, active collaboration sessions, students achieved an "Outstanding" performance level ($Mean = 93.67$), showing that real-time peer scaffolding effectively distributed cognitive load and mitigated the isolation common in blended setups.

While specific content areas responded uniquely to group structures—with Triads and Small Groups excelling in abstract Chemical Bonding ($Mean = 90.33$ and 90.17, respectively) and Dyads yielding the highest gains in rule-heavy Organic Compounds ($Mean = 87.50$)—inferential analysis revealed that the variations in posttest achievements across the formats were not statistically significant ($p = 0.220$). Ultimately, these outcomes confirm that the psychological mechanism of collaborative interaction and positive interdependence itself, rather than mere physical group headcount, serves as the primary catalyst for academic recovery in senior high school STEM chemistry.

Recommendations

Adopt Flexible, Concept-Driven Grouping: Science educators should move away from rigid grouping rules and instead align group sizes with the cognitive demands of the topic. Utilize Dyads to enforce individual accountability and maximize speaking time during heavy nomenclature and rule-based tasks, and leverage Triads or Small Groups to provide multiple cognitive perspectives when solving abstract molecular structures.

Integrate Independent Checkpoints: To bridge the gap between "Outstanding" group success ($Mean = 93.67$) and "Satisfactory" individual posttests ($Mean = 82.56$), teachers must embed immediate, low-stakes independent assessments right after cooperative tasks to ensure collective knowledge successfully transfers to the individual learner.

Revitalize DepEd Blended Learning Frameworks: School administrations and policy creators should formally embed synchronous peer-to-peer cooperative modules into existing Alternative Delivery Modes (ADM) rather than treating hybrid schedules purely as independent, asynchronous digital workloads.

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