

Learning to Investigate Together: Group Investigation and the Development of Collaborative Skills in Secondary Sociology

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Abstract

This collaborative classroom action study examines the use of Group Investigation to strengthen students' collaborative skills in Grade X sociology at SMAN 9 Padang. Thirty-four students were enrolled, with 33 present during the pre-cycle observation. Collaboration was assessed through five indicators: interdependence, individual responsibility, interaction, communication, and group processing. The average observation score increased from 26% in the pre-cycle to 44% in Cycle 1 and 73% in Cycle 2, exceeding the predetermined 61% success criterion. Communication showed the largest overall improvement, while group processing remained the lowest-performing indicator in the final cycle. The classroom procedures required students to distribute responsibilities, investigate social-research topics, prepare reports, communicate findings, and reflect on group work. The findings indicate that Group Investigation can make collaborative participation more structured and visible in sociology lessons, although the classroom-action design does not establish causal effects beyond the studied class. The study highlights communication gains while showing the continuing need to scaffold reflection on group processes.

Keywords: collaboration; classroom action research; group investigation; social research; sociology education.

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Introduction

Education increasingly requires teachers to create learning environments in which students do more than receive information. In social research, this requirement is especially important because the subject matter asks learners to interpret ideas, connect concepts with experience, and communicate their reasoning. Yet the classroom problem documented in this study was low collaborative participation, unequal responsibility, limited communication, and weak group processing. Such conditions matter because observable participation is not a decorative feature of instruction; it is one of the mechanisms through which students encounter, test, revise, and communicate knowledge. A classroom may be orderly and still provide limited opportunities for intellectual participation. Conversely, a classroom that organizes meaningful tasks, clear roles, and structured interaction can create conditions in which students become more visible as learners.

Cooperative-learning research indicates that productive collaboration requires more than placing students in groups. Positive interdependence, individual responsibility, promotive interaction, and teacher guidance shape whether group work becomes academically meaningful (Johnson & Johnson, 2009; Gillies, 2016). Meta-analytic evidence also shows that cooperative structures can support achievement and peer relations, although effects vary

with task design and implementation quality (Roseth et al., 2008; Kyndt et al., 2013; Slavin, 2014). Group Investigation is therefore relevant to sociology not simply because it creates discussion, but because it can distribute responsibility for identifying questions, collecting information, comparing interpretations, and presenting a collective explanation.

Collaboration in sociology is educationally valuable only when group activity requires students to depend on one another for meaningful intellectual work. Group Investigation is particularly relevant because students do not simply divide a worksheet; they select or refine a topic, distribute investigative responsibilities, gather information, synthesize findings, and present a collective account. These processes mirror important features of social inquiry, where explanations are strengthened through comparison, evidence, and dialogue. The present study focuses on whether such a structure could improve five observable dimensions of collaboration—interdependence, individual responsibility, interaction, communication, and group processing—in a Grade X sociology classroom. The emphasis is therefore on the quality and organization of collaborative participation rather than on group work as an end in itself.

For this reason, the present article does not frame the Group Investigation cooperative-learning model as a universally effective treatment. Instead, it treats the classroom as a situated pedagogical system and asks what changed in observable learning processes when the intervention was introduced. This distinction is important. Classroom action studies, qualitative case studies, exploratory factor analyses, and one-group pretest-posttest designs can provide useful evidence, but each design supports a different level of inference. Strengthening the manuscript therefore requires aligning the research question, evidence, and claims. The objective of this study is to examine whether iterative use of Group Investigation could improve observable collaborative skills in sociology learning.

Improvement in this study refers to the development of five observable dimensions of collaboration: positive interdependence, individual responsibility, promotive interaction, communication, and group processing. The outcome is therefore not a generic impression that students 'worked well together.' It is a structured description of how collaborative behavior changed from a pre-cycle mean of 26% to 44% in Cycle 1 and 73% in Cycle 2. This indicator-based interpretation keeps the claim focused on collaborative practice rather than academic achievement.

Group Investigation was valuable here because it organized collaboration around a disciplinary task: students selected and planned a social-research topic, divided responsibilities, gathered information, prepared a report, presented findings, and reflected on group performance. The model did not simply place students in groups. It created interdependent roles and a shared inquiry product. Contemporary research reinforces the importance of regulating socio-emotional interaction and accountability in collaborative groups (Gedamu & Shewangezaw, 2022; Törmänen et al., 2023).

The classroom context matters because social research is both intellectual and social. Students must negotiate questions, distribute field or library tasks, compare evidence, and explain conclusions to others. These demands make a sociology research unit a productive setting for examining collaboration as an enacted competence. The study was conducted with 34 enrolled students in class X.E3 at SMAN 9 Padang, with 33 students present during the pre-cycle observation, and followed the class through two cycles of Group Investigation.

The article asks three closely connected questions: What weaknesses in collaborative behavior were visible before Group Investigation was implemented? How did the five collaboration indicators change across the two action cycles? Which dimensions remained comparatively weak even after the success criterion was reached? The third question is especially important because a class mean above 61% does not imply that all components of collaboration developed equally; group processing, for example, remained the lowest indicator in Cycle 2.

Cooperative-learning research consistently shows that productive group work depends on positive interdependence and individual accountability, not simply proximity among learners (Johnson & Johnson, 2009; Slavin, 2014). Gillies (2016) further emphasizes teacher structuring and dialogic support, while Kyndt et al. (2013) show that effects vary across learning conditions. Yet classroom reports often present collaboration as a single outcome and provide little information about which component improves and which remains difficult. Group Investigation offers an opportunity to examine collaboration as a multidimensional practice. By tracking five indicators across action cycles, this study contributes a more differentiated account of how investigative roles can shape communication, responsibility, and group processing in secondary sociology.

A disciplinary perspective further clarifies why the case matters. Learning about social research requires students to coordinate factual information with interpretation. In social-science and humanities classrooms, concepts are not meaningful when they remain detached from concrete situations. Students must identify relationships, classify evidence, compare explanations, and communicate a position. This means that classroom activity should be evaluated not merely by how busy students appear but by whether the activity carries intellectual work. The intervention in this study is therefore best understood as an attempt to redesign the pathway through which students encounter and use disciplinary ideas.

Collaborative participation should be distinguished from the simple frequency of student talk. A group can be noisy while remaining poorly coordinated, or quiet while members perform well-defined interdependent roles. The indicators used here capture a broader social architecture: responsibility, interaction, communication, and collective reflection. This distinction is consistent with cooperative-learning research that treats positive interdependence and accountability as conditions for productive group work rather than optional additions (Johnson & Johnson, 2009; Gillies, 2016).

The distribution of work is a central equity issue in Group Investigation. Free-riding and dominance can produce an apparently successful group product while masking unequal participation. The rise in individual responsibility to 71.5% and positive interdependence to 69% suggests that role organization improved, but the records do not provide student-by-student contribution data. The study therefore interprets the indicator gains as improved group-level functioning while recognizing that future studies should examine who speaks, who investigates, and who completes key intellectual tasks (Gedamu & Shewangezew, 2022).

The action cycles also show that collaborative learning requires active teacher design. The teacher had to clarify group procedures, support topic planning, monitor role distribution, and create time for reflection. Cycle 2 was not merely a repetition of Cycle 1; it represented a refinement of the conditions under which groups investigated and reported. This iterative orchestration is consistent with Webb's (2009) argument that productive collaborative dialogue depends on teacher moves that encourage explanation, accountability, and interaction rather than on group formation alone.

The social-research topic makes collaborative structure especially important. Students must formulate questions, locate information, compare findings, and explain relationships among social phenomena. These tasks can be distributed across a group, but distribution alone does not guarantee collaboration. If students complete isolated pieces and combine them at the end, interaction may remain superficial. Group Investigation was used here to create interdependence around a shared inquiry process in which students had to exchange information and prepare a collective presentation. This setting allows the study to examine collaboration not as a generic soft skill but as a way of participating in disciplinary inquiry.

A final conceptual point concerns the relationship between educational design and evidence. In this study, the Group Investigation cooperative-learning model should be understood as a configuration of tasks, expectations, interactions, and feedback rather than as a single independent variable with an automatic effect. This perspective helps explain why apparently similar innovations can produce different outcomes across classrooms. Implementation quality depends on whether students understand the task, whether participation is distributed, whether teacher feedback is timely, and whether the activity requires use of the target concepts. It also clarifies why the same innovation may support one outcome more strongly than another. A worksheet may improve task organization without necessarily improving long-term retention; a collaborative model may increase communication while leaving group processing uneven; a digital tool may improve immediate performance while creating new demands for verification. The present article therefore treats the intervention as a situated pedagogical arrangement and uses the available evidence to identify plausible mechanisms rather than to assert an undifferentiated treatment effect.

The study's main contribution lies in the indicator profile across cycles. Overall collaboration increased substantially, but the pattern was uneven: communication improved most strongly, whereas group processing remained the lowest final indicator. This distinction matters for teaching because it shows that an intervention can improve visible interaction without resolving every aspect of collaborative regulation. The findings therefore move beyond a binary effective/ineffective judgment and identify where Group Investigation appeared to alter classroom practice and where further scaffolding remained necessary. The classroom-action design supports a context-specific account of improvement, not a claim that Group Investigation will produce the same pattern in other classes.

Methodologically, the study follows the improvement-oriented logic of classroom action research, in which the teacher identifies a classroom problem, implements an instructional response, observes its functioning, and refines the next cycle (Kunandar, 2008). The local sociology literature also demonstrates the value of varying cooperative structures to address participation and interest in classroom learning (Mayani & Junaidi, 2019). The distinctive contribution here is to use a social-research task in which group coordination is not incidental: investigation, evidence gathering, reporting, and reflection require students to depend on one another in ways that can be observed.

This focus is also consistent with work on collaboration assessment. Sukmawati and Permadani (2021) emphasize the need to make collaborative problem-solving skills observable, while Wentzel et al. (2018) show that peer relationships can carry academic benefits under appropriate social conditions. Indonesian learning-model literature likewise stresses the importance of deliberate instructional structure rather than assuming that interaction emerges automatically from student grouping (Mulyatiningsih, 2015; Octavia, 2020). These

perspectives support the article's use of explicit collaboration indicators as both an assessment tool and a guide for cycle-by-cycle instructional refinement.

Indonesian applications of Group Investigation provide a useful comparison with the present sociology case. Studies have reported the model in relation to learning outcomes, conceptual understanding, and classroom cooperation across subjects (Handayani et al., 2021; Pranata, 2016; Prasetyo et al., 2019). The present study shifts attention from the final group product toward the social processes that make investigation collaborative. Rather than treating 'group work' as a single condition, it traces interdependence, responsibility, interaction, communication, and group processing as separable practices that can develop unevenly across action cycles.

Method

This study used a collaborative CAR design at SMAN 9 Padang. The participants were 34 students in class X.E3, with 33 present in the pre-cycle observation. The design was selected because the research question concerned a bounded educational process rather than a population-level estimate. The study focused on social research. The central pedagogical or analytic focus was the Group Investigation cooperative-learning model. The study preserves the research design and data while clarifying the level of inference that the design can reasonably support.

The study used a collaborative classroom action research design with a pre-cycle observation and two action cycles. Five indicators were observed: positive interdependence, individual responsibility, promotive interaction, group communication, and group processing. The success criterion was an average of at least 61%. Thirty-four students were enrolled, while 33 were present during the pre-cycle observation.

Evidence came from structured observation of the five collaboration indicators during the pre-cycle, Cycle 1, and Cycle 2. The classroom action record also described the sequence of group planning, role division, library investigation, report preparation, presentation, and reflection. No standardized achievement test was used to establish the collaboration result. The study therefore relies on repeated observation of social behavior within the same class, with the indicator percentages used to summarize the direction and magnitude of change across cycles.

The analysis compared indicator percentages across the three observation points and examined which dimensions contributed most to the overall change. Communication showed the largest improvement, increasing by 59 percentage points from the pre-cycle level, whereas group processing remained the weakest final dimension at 65%. Reading the indicators separately prevents the 73% Cycle 2 mean from obscuring uneven development. The classroom descriptions were then used to relate those changes to the investigation tasks and role structures introduced during the cycles.

The credibility of the interpretation rests on the use of stable collaboration indicators across cycles and on the correspondence between the numerical trend and the observed group procedures. The enrolled/present distinction is reported explicitly—34 students were enrolled and 33 were present in the pre-cycle—so the record is not artificially standardized. The study does not claim independent observer reliability statistics that were not documented. Instead, it treats the repeated classroom observations as action-research evidence whose strength lies in transparency about the indicators and cycle sequence.

Thirty-four students were enrolled in class X.E3, with 33 present during the pre-cycle observation. Collaboration was observed through five indicators: interdependence, individual responsibility, interaction, communication, and group processing. The study compared descriptive percentages across the pre-cycle, Cycle 1, and Cycle 2 against a predetermined 61% success criterion. Field observations of task distribution, investigation, presentation, and reflection were used to interpret the numerical pattern. Because the design did not include a comparison class and the same class experienced repeated observation and teacher intervention, the percentages are treated as evidence of classroom change across cycles rather than as estimates of a causal treatment effect.

The design has several limits. Collaboration was observed in one intact class, and the two-cycle time frame does not establish whether the behaviors became durable habits. Group Investigation was introduced as a package, so the study cannot isolate whether role division, independent investigation, presentation, or reflection produced the largest change. In addition, group-level indicators do not reveal individual contribution patterns. These constraints make the findings useful for instructional improvement but not for broad causal generalization.

Results and Discussion

Collaboration was weak before the intervention

The mean pre-cycle collaboration level was 26%. Indicator-level values were 27% for interdependence, 24% for responsibility, 33% for interaction, 21% for communication, and 27% for group processing.

The pre-cycle profile shows that the problem was distributed across several components of collaboration. Students were not only communicating infrequently; responsibility, interdependence, and group processing were

also weak. This matters because a group can appear active while still depending on a small number of members. The baseline therefore justified an intervention aimed at restructuring roles and accountability rather than simply increasing discussion time.

The first cycle produced partial improvement

The overall mean increased to 44% in Cycle 1. Interdependence reached 43.5%, responsibility 47%, interaction 43.5%, communication 40.5%, and group processing 45%. Although all indicators improved, the class had not yet reached the predetermined success criterion.

Cycle 1 indicates that assigning investigative work was not sufficient by itself to produce strong collaboration. The mean rose to 44%, but the class remained below the success criterion. This partial gain is consistent with the logic of classroom action research: the first cycle functioned as both intervention and diagnosis, revealing that students needed clearer expectations for exchanging information and reflecting on group performance.

The second cycle exceeded the success criterion

The overall mean reached 73% in Cycle 2. Interdependence was 69%, responsibility 71.5%, interaction 81%, communication 80%, and group processing 65%. The largest overall gain occurred in communication, which increased by 59 percentage points from the pre-cycle level.

By Cycle 2, the overall mean reached 73%. Communication and interaction were the strongest dimensions, suggesting that students had become more willing and able to exchange information publicly. Group processing remained comparatively weaker, however, indicating that students found it easier to talk and interact than to evaluate how effectively the group itself was functioning. This difference identifies a specific target for future cycles.

Investigative roles changed the organization of group work

Students selected or worked in small groups, planned topics and interview questions, divided responsibilities, conducted library-based investigation outside the classroom, prepared reports, presented findings, and reflected on group performance. These procedures made responsibility and information exchange more observable.

The investigative sequence made collaboration observable through concrete responsibilities. Students planned questions, divided tasks, gathered information, prepared reports, and presented findings. These steps gave teachers a basis for seeing who contributed and gave students reasons to depend on information held by peers. Collaboration was therefore embedded in the architecture of the task rather than treated as an informal expectation.

The intervention changed the organization of participation

Across the reported evidence, the most consistent change concerned how participation was organized around the Group Investigation cooperative-learning model. Students or institutional actors were given clearer sequences, roles, products, or decision points than in the initial condition. This result matters because it shifts attention from the innovation as an object to the practices that the innovation made possible. The source does not provide evidence that every participant changed in the same way, but it does show a reorganization of the learning or implementation environment.

The pattern should nevertheless be read within the conditions of one class and one topic. Repeated practice, teacher feedback, growing familiarity with the procedure, and the Group Investigation structure may all have contributed to the observed change. The study demonstrates that the model was workable in this setting and highlights plausible mechanisms, while broader claims require comparison across classes and contexts.

Observed improvement remained context dependent

The improvement is closely tied to a social-research unit in which collaboration was functionally necessary. Students had to investigate, synthesize, report, and present, making interdependence visible. Group Investigation may operate differently in lessons dominated by individual conceptual explanation or short factual tasks. The case therefore illustrates a principle of disciplinary fit: collaborative models are most defensible when the learning task genuinely requires coordination among learners rather than when group work is added to content that could be completed independently.

Discussion

Collaboration as an organized social practice

The findings should be read as a change in the organization of collaboration rather than as proof that group work is automatically effective. Research on collaborative learning consistently identifies uneven participation, weak accountability, and insufficient teacher orchestration as recurring obstacles (Le et al., 2018; Webb, 2009). Conversely, learning improves when students perceive meaningful interdependence and have reasons to explain

ideas to one another (Scager et al., 2016; Laal & Ghodsi, 2012). In the present study, the value of Group Investigation lies in the way roles and investigation tasks created repeated opportunities for students to coordinate their work. The classroom-action design cannot isolate which component produced the observed improvement, but it supports a bounded interpretation that structured cooperation was associated with stronger collaborative participation.

Why communication improved most strongly

A second issue concerns why communication improved most strongly. In the present case, observable change should be read as evidence that the learning environment created additional opportunities for students to interpret, communicate, decide, or respond. This is particularly important in subjects concerned with social phenomena, citizenship, history, values, or digital judgment, because disciplinary learning requires more than completing a task. Students need opportunities to connect concepts with cases, compare perspectives, justify claims, and examine the consequences of their reasoning. The value of an interactive model is therefore strongest when activity is tied to a disciplinary form of thinking.

Group investigation and sociological ways of knowing

The third issue is group investigation and sociological ways of knowing. Teacher guidance remained essential because collaborative inquiry requires more than assigning students to groups. The teacher structured investigation questions, monitored role distribution, prompted explanation, and intervened when participation became uneven. This is consistent with research showing that cooperative learning is strengthened by explicit positive interdependence, individual accountability, and teacher support for productive dialogue (Gillies, 2016; Webb, 2009). It also addresses a recurrent obstacle identified in collaborative-learning research: students and teachers may value group work while still experiencing unequal participation, unclear responsibilities, or superficial exchange (Le et al., 2018). Group Investigation therefore redistributes responsibility for inquiry, but it does not remove the need for careful orchestration.

Limits of percentage-based classroom observation

Finally, limits of percentage-based classroom observation requires explicit attention. The evidence comes from a bounded educational study and should not be generalized statistically beyond its participants. Observation percentages may be sensitive to attendance and observer judgment; qualitative findings depend on the range of informants; exploratory factor analysis with a modest sample requires replication; and one-group pretest-posttest designs cannot exclude maturation, testing, or other contextual influences. These limitations do not make the findings useless. They instead define what the study can contribute: a transparent account of a locally implemented educational process and a set of propositions that can be tested in stronger comparative designs.

Implications for educational practice

For practice, the findings support using the Group Investigation cooperative-learning model only when its structure is aligned with a clear learning problem. Teachers should identify the specific behavior or reasoning that needs to change, design tasks that make that behavior necessary, and use observation or assessment to determine whether the intended change actually occurs. Activities should include explicit instructions, opportunities for peer or teacher feedback, and a closing phase in which learners explain what they learned and how they know it. In institutional programs, the same logic applies: roles, time, resources, and goals need to be aligned rather than merely documented.

For sociology education, the strongest potential of Group Investigation lies in the relationship between collaboration and disciplinary inquiry. Students can be asked to formulate a shared question about a social phenomenon, divide responsibility for gathering information, compare evidence, and negotiate an explanation that the group can defend. This creates a reason for collaboration beyond task completion. Cooperative-learning research suggests that group structures are most productive when members perceive that their success depends partly on one another while each person remains accountable for a contribution (Johnson & Johnson, 2009; Scager et al., 2016). In practical terms, teachers can support this by rotating roles, requiring individual notes before group synthesis, and asking every group member to explain part of the final interpretation. Such procedures would make the cooperative mechanism more visible and reduce the risk that collaboration is carried by only a few students.

The study also has an important evidentiary boundary. The observation instrument captured collaborative behaviors, not the quality of sociological understanding. Increased communication, responsibility, and group processing are educationally meaningful, but they should not be treated as direct evidence that students developed more sophisticated concepts. A future iteration could combine the collaboration indicators with a short group product rubric that assesses use of evidence, conceptual accuracy, and explanatory coherence. This would allow the researcher to test whether improved cooperation is associated with stronger disciplinary work. The current classroom-action evidence supports a narrower claim: the Group Investigation structure was associated with more organized collaborative participation in this class. That bounded claim is consistent with the

implementation-sensitive nature of cooperative learning documented in meta-analytic research (Kyndt et al., 2013; Slavin, 2014).

The findings also show why collaboration should be assessed as more than frequency of talk. A student may participate verbally without helping the group build a stronger explanation, while another may contribute through information gathering or synthesis. Gillies (2016) argues that cooperative learning depends on the quality of interaction and the teacher's capacity to structure it. For sociology, this quality can be tied directly to disciplinary work: students should be expected to compare observations, distinguish description from interpretation, and justify claims about social phenomena. Group Investigation is especially promising when the investigation product makes these contributions visible. A stronger future design could combine the existing collaboration indicators with a rubric for the quality of the group's sociological explanation, allowing researchers to test whether more equitable interaction is accompanied by deeper conceptual reasoning.

The indicator pattern has a practical consequence for the design of collaborative tasks. Communication can increase relatively quickly when students are required to present, interview, or report, but group processing asks students to evaluate how the group worked and how it should improve. That is a more demanding form of collaborative regulation. Social interdependence theory suggests that cooperation becomes productive when group goals are connected to individual responsibility (Johnson & Johnson, 2009), while research on collaborative dialogue shows that teachers often need to model the kinds of questions and explanations that sustain productive interaction (Webb, 2009). In future cycles, group-processing prompts could therefore ask students to identify which member contributed what evidence, where disagreement occurred, and what the group would change in a subsequent investigation.

Another implication concerns the teacher's role in monitoring invisible forms of contribution. Group Investigation can make speaking and presenting highly visible, but quieter contributions such as checking information, organizing notes, or connecting evidence may be overlooked if assessment focuses only on public performance. Research on collaborative learning notes that obstacles often arise from unequal participation, unclear expectations, and limited monitoring of group processes (Le et al., 2018). Teachers can address this by combining observation with brief individual reflection or peer-accountability records. Such evidence would help distinguish students who are genuinely contributing through different roles from those who are being carried by the group. It would also make the collaboration indicators more diagnostically useful for subsequent action cycles.

Implications for further research

Future research should add student-level contribution records, brief peer assessments, and traces of group decision making so that collaboration quality can be examined beyond group averages. Particular attention should be paid to group processing, the weakest final indicator, by documenting how groups diagnose ineffective strategies and revise their coordination. Longer follow-up could test whether communication gains persist in later sociology tasks. Linking collaboration indicators with the quality of research questions, evidence use, and reports would also connect social process to disciplinary learning.

A practical implication is that collaboration indicators can become part of lesson planning rather than merely end-of-lesson evaluation. Before an investigation begins, the teacher can specify what interdependence, individual responsibility, promotive interaction, communication, and group processing should look like in that particular task. During the investigation, short observation notes can identify which dimensions are developing and which require a new prompt or role structure. This turns collaboration from a broad competency slogan into a teachable set of practices that can be deliberately rehearsed across sociology units.

Conclusion

This study examined whether iterative use of Group Investigation could improve observable collaborative skills in sociology learning. The evidence indicates that the Group Investigation cooperative-learning model was associated with a meaningful reorganization of the studied learning or implementation process. The most defensible contribution is not a universal claim of effectiveness, but a context-specific account of how tasks, roles, interaction, feedback, and reflection changed within SMAN 9 Padang.

The study supports a focused conclusion: iterative Group Investigation was accompanied by substantial improvement in observed collaborative behavior, with the class mean moving from 26% before action to 73% in Cycle 2. Communication improved most, while group processing remained comparatively fragile. Because the outcome measure was collaboration, the article does not infer achievement gains that were not tested. Its contribution is to show how sociological inquiry can be organized so that collaboration becomes an observable and revisable part of the learning design.

Declarations

Author contribution

Author 1: developed the main research idea and objectives, designed the research methodology, conducted data collection and investigation, performed the data analysis, and prepared the first draft of the manuscript. Author 2: contributed to the development and implementation of the research methodology, supported the data collection and investigation process, and reviewed and revised the manuscript to improve its academic quality, clarity, and structure. Author 3: provided input into the research concept and direction, supervised and guided the overall research process, reviewed and improved the manuscript, and contributed to obtaining financial support or research funding

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Conflict of Interest

The authors declare that there is no conflict of interest related to the publication of this article.

Use of generative AI

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