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Science Investigatory Projects as Aids in Enhancing Scientific Skills of Grade Nine Learners

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ABSTRACT

This study determined the effectiveness of Science Investigatory Projects (SIPs) in enhancing the scientific skills of Grade 9 learners in a selected rural public school in Infanta, Quezon. A mixed-method experimental intervention design using a convergent parallel approach was employed. Quantitative data were gathered through pretest-posttest assessments, teachers' observational checklists, written-report rubrics, and oral-defense evaluations, while qualitative data were collected through focus group discussion with 10 learners. Results showed that both control and experimental groups started with comparable scientific-process-skill levels. After the intervention, the experimental group improved from a satisfactory overall pretest mean of 8.97 to a very satisfactory posttest mean of 14.84, while the control group remained satisfactory. The experimental group also achieved exemplary performance in written reports (M = 9.23) and proficient performance in oral defense (M = 7.89), compared with the control group's beginning and developing levels, respectively. Teachers' observations also favored the experimental group (M = 3.42, Always) over the control group (M = 2.49, Often). Qualitative findings revealed that SIPs developed learners' foundational and integrated science-process skills, research writing, communication, collaboration, motivation, resilience, and positive mindset, although learners encountered challenges related to resources, time management, and group conflicts. The study concludes that SIPs are effective instructional aids for strengthening scientific skills and holistic learner development when supported by structured guidance, collaboration, and adequate resources.

Keywords: *collaboration skills, critical thinking, science investigatory projects, scientific skills, student engagement, science process skills*

INTRODUCTION

Science education plays a central role in developing learners who can think critically, solve problems, and apply scientific knowledge to real-world concerns. The Philippine science curriculum emphasizes inquiry, experimentation, innovation, and research-oriented learning. In this context, Science Investigatory Projects (SIPs) provide opportunities for learners to ask questions, design investigations, collect and analyze data, and communicate evidence-based conclusions.

SIPs are authentic learning tasks that allow students to experience the scientific process beyond textbook discussion. They encourage learners to explore local problems, test ideas, work collaboratively, and defend their findings. Sanchez and Rosaroso (2019) described science investigatory project instruction as an important journey in secondary science education, while De La Cruz (2017) and Lintao and Belen (2020) emphasized its contribution to scientific-process-skill development. When properly guided, SIPs can strengthen critical thinking, creativity, independence, communication, and motivation.

Despite these advantages, learners often encounter barriers when conducting investigatory projects. They may have limited research experience, insufficient resources, difficulty formulating research problems, weak data-analysis skills, and anxiety during oral presentations. Garcia and Mendoza (2018) identified barriers to conducting SIPs in public high schools, while other studies note the importance of structured mentoring, scaffolding, and resource support. These challenges are especially relevant in rural public-school settings where instructional and material resources may be limited.

The present study addressed this concern by evaluating SIPs as instructional aids for enhancing the scientific skills of Grade 9 learners in a rural public school in Infanta, Quezon. Using a mixed-method experimental intervention approach, the study compared control and experimental groups, assessed written and oral scientific outputs, documented classroom observations, and explored learner experiences through focus group discussion. The study contributes school-based evidence on how SIPs enhance scientific-process skills, research competencies, collaboration, communication, and resilience.

Literature Review

Science Process Skills and Scientific Literacy

Science process skills are essential competencies that enable learners to observe, measure, classify, infer, predict, communicate, identify variables, formulate hypotheses, experiment, interpret data, and draw conclusions. Gizaw and Sota (2023) described science-process-skill improvement as a major concern in science learning, while Inayah (2020) emphasized that these skills support inquiry and problem-solving.

International assessments such as TIMSS highlight the importance of scientific literacy, which requires learners to apply concepts and scientific reasoning in meaningful contexts (Mullis et al., 2020). In the Philippine curriculum, the development of scientific skills is closely linked to inquiry-based and performance-oriented instruction. Therefore, learners need tasks that require them to generate questions, investigate systematically, and communicate findings.

SIPs support this goal because they provide hands-on opportunities for learners to experience the actual process of scientific inquiry. Through investigatory work, students do not merely memorize concepts; they use scientific methods, make decisions, and interpret evidence. These activities strengthen both basic and integrated science-process skills.

Science Investigatory Projects as Inquiry-Based and Experiential Learning

SIPs reflect inquiry-based and experiential learning. Learners identify problems, plan procedures, gather data, analyze findings, and present results. Reiss et al. (2023) described investigative school science research projects as a field requiring continued development, while Lodge et al. (2025) highlighted students' experiences in investigative research projects. These studies support the value of research-based learning in science classrooms.

Project-based and guided-inquiry approaches have been shown to improve science-process skills and cognitive outcomes. Nasir et al. (2019) reported that project-based learning and guided inquiry improved students' science-process skills and cognitive outcomes. Chengere et al. (2025) likewise found that guided inquiry-based laboratory activities enhanced secondary students' science-process skills. These findings support SIP implementation as an active approach to scientific learning.

SIPs also develop higher-order thinking. Learners must identify variables, control experimental conditions, interpret patterns, and justify conclusions. Such activities support the development of critical thinking and evidence-based reasoning (Bybee, 2015; Barrouillet, 2018).

Collaboration, Communication, and Learner Support in SIPs

SIPs require learners to communicate ideas, divide tasks, solve problems, and make decisions as a group. Salvador and Gonzales (2018) identified project-based learning as a vehicle for collaboration and creativity in science education. Wahono et al. (2025) also emphasized that integrated STEM education can strengthen collaboration and decision-making skills.

Research writing and oral defense are important parts of investigatory work. Through written reports, learners formulate research questions, define terms, develop hypotheses, control variables, gather data, interpret results, and write conclusions. Through oral defense, learners organize ideas, demonstrate content mastery, use visual aids, respond to questions, and communicate scientific explanations. Agustin and Manalo (2023) emphasized that investigatory projects strengthen reasoning skills.

Learner support is necessary for successful SIP implementation. Teacher guidance, feedback, family encouragement, peer assistance, and emotional support help students manage complex research tasks. Corwin et al. (2022) highlighted the relationship between students' emotions, coping, and outcomes in response to research-based challenges. Structured support can therefore help learners overcome difficulties and develop resilience.

METHODS

Research Design

The study employed a mixed-method experimental intervention design using a convergent parallel approach. The quantitative phase used a quasi-experimental pretest-posttest design to compare the scientific skills of control and experimental groups. The qualitative phase used focus group discussion to explore learners' experiences, challenges, and coping strategies. Quantitative and qualitative findings were analyzed separately and integrated through a joint display.

Research Locale

The study was conducted in a selected rural public school in Infanta, Quezon. The setting was appropriate because the study focused on Grade 9 learners' development of scientific skills through Science Investigatory Projects in an authentic public-school context.

Participants and Sampling Technique

The quantitative phase involved Grade 9 learners assigned to control and experimental groups. Stratified random sampling was used to ensure representation in the quantitative component. For the qualitative phase, purposive sampling was used to select 10 Grade 9 learners who actively participated in the SIP activities and focus group discussion. Participation was voluntary, and confidentiality was observed through participant coding.

Research Instrument

The study used several instruments to assess learners' scientific skills. A validated 20-item pretest-posttest assessment measured Basic Science Process Skills and Integrated Science Process Skills. A teachers' observational checklist documented learners' engagement and science-process-skill development during implementation. Rubrics were used to evaluate written reports and oral defense performance. A validated semi-structured focus group discussion guide was used to gather qualitative data on students' experiences, challenges, and coping strategies.

Data Gathering Procedure

The study was implemented through a 16-week SIP intervention program involving research workshops, mentoring, collaborative activities, experimentation, report writing, and oral defense. Pretests were administered to both groups before the intervention. The experimental group engaged in SIP-based activities, while the control group received regular instruction. During implementation, teacher observations were recorded. After the intervention, posttests, written-report assessment, oral-defense evaluation, and focus group discussion were conducted. Quantitative and qualitative data were then organized for analysis.

Data Analysis

The quantitative data were analyzed using mean, standard deviation, t-tests, and Two-Way ANOVA where applicable. The qualitative data were analyzed using Braun and Clarke's thematic analysis, which involved coding, categorizing, and generating themes from the participants' responses. A convergent parallel joint display was used to integrate the quantitative results and qualitative themes.

Ethical Consideration

Ethical standards were observed throughout the study. Permission was secured from appropriate authorities before data gathering. Participation was voluntary, and the learners' confidentiality was protected through coding. The purpose of the study was explained to the participants, and the data were used only for research purposes. Because the participants were basic education learners, the final submission should explicitly document parental or guardian consent, learner assent, and the institutional ethics-review reference number, when available.

RESULTS AND DISCUSSION

Pretest and Posttest Scientific Process Skills

Both control and experimental groups initially demonstrated comparable baseline competencies. In the pretest, the control group obtained an overall mean of 9.03, interpreted as Satisfactory, while the experimental group obtained an overall mean of 8.97, also interpreted as Satisfactory. After the intervention, the control group remained Satisfactory with a posttest mean of 10.44. In contrast, the experimental group improved to a Very Satisfactory level with a posttest mean of 14.84. The improvement was evident in both Basic Science Process Skills and Integrated Science Process Skills.

Table 1. *Pretest and Posttest Scientific Process Skills of Control and Experimental Groups*

Skill area	Test	Control M	Control SD	Control VI	Experimental M	Experimental SD	Experimental VI
Basic Science Process Skills	Pretest	5.00	1.77	Satisfactory	5.03	1.77	Satisfactory
Basic Science Process Skills	Posttest	5.64	1.91	Satisfactory	7.53	1.81	Very Satisfactory
Integrated Science Process Skills	Pretest	4.03	2.04	Fair	3.94	1.37	Fair
Integrated Science Process Skills	Posttest	4.81	1.86	Satisfactory	7.31	1.82	Very Satisfactory
Overall Scientific Skills	Pretest	9.03	3.20	Satisfactory	8.97	2.53	Satisfactory
Overall Scientific Skills	Posttest	10.44	3.14	Satisfactory	14.84	3.07	Very Satisfactory

The source manuscript reports that t-test results confirmed no significant difference during the pretest but significant differences during the posttest. This supports baseline equivalence and indicates that the experimental group outperformed the control group after SIP implementation. The results reinforce the value of hands-on and inquiry-based activities for developing scientific skills (Bybee, 2015; Chengere et al., 2025; Nasir et al., 2019).

Written Report and Oral Defense Performance

The experimental group demonstrated stronger research-output performance than the control group. In the written report, the experimental group obtained an average mean of 9.23, interpreted as Exemplary, while the control group obtained 5.40, interpreted as Beginning. The strongest experimental-group indicator was collecting data (M = 9.80), while analyzing and interpreting data obtained a lower but still Proficient rating (M = 7.47).

Table 2. *Written Report Performance of Grade 9 Learners*

Indicator	Control M	Control VI	Experimental M	Experimental VI
Creating research questions	4.33	Beginning	9.20	Exemplary
Defining terms operationally	4.20	Beginning	9.73	Exemplary
Formulating hypotheses	4.67	Beginning	9.47	Exemplary
Controlling variables	6.60	Beginning	9.27	Exemplary

Collecting data	7.47	Beginning	9.80	Exemplary
Analyzing and interpreting data	4.93	Beginning	7.47	Proficient
Creating conclusions	5.60	Beginning	9.67	Exemplary
Average	5.40	Beginning	9.23	Exemplary

In oral defense, the experimental group obtained an average mean of 7.89, interpreted as Proficient, while the control group obtained 4.91, interpreted as Developing. This indicates that SIPs helped learners improve organization and clarity, content mastery, visual-aid use, responses to questions, and communication delivery.

Table 3. *Oral Defense Performance of Grade 9 Learners*

Indicator	Control M	Control VI	Experimental M	Experimental VI
Organization and clarity	4.67	Developing	7.80	Proficient
Content mastery	4.67	Developing	8.13	Proficient
Visual aids	5.13	Developing	7.07	Proficient
Responses to questions	5.20	Developing	8.47	Proficient
Communication and delivery	4.87	Developing	8.00	Proficient
Average	4.91	Developing	7.89	Proficient

Observed Science Process Skills During Implementation

Teachers' observational checklist results showed that the experimental group demonstrated higher engagement and stronger science-process-skill development than the control group. The control group obtained an overall weighted mean of 2.49, interpreted as Often. The experimental group obtained an overall weighted mean of 3.42, interpreted as Always. This pattern indicates that SIP-based instruction promoted more consistent curiosity, critical thinking, responsibility, accurate recording of data, logical experimental design, and communication of ideas.

Table 4. *Teachers' Observational Checklist Results*

Indicator	Control WM	Control VI	Experimental WM	Experimental VI
Curiosity and interest in the topic	3.1	Often	3.9	Always
Follows the scientific method properly	2.7	Often	3.2	Often
Works collaboratively with group members	2.9	Often	3.2	Often
Demonstrates critical, analytical, and higher-order thinking	2.8	Often	3.8	Always
Observes proper experimental safety procedures	2.4	Sometimes	3.3	Always
Manages time effectively	2.5	Often	2.8	Often
Shows responsibility and independence	2.8	Often	3.9	Always
Records observations and data accurately	3.1	Often	3.6	Always
Experimental design is logically structured	0.0	Not Observed	3.4	Always
Communication of ideas is clear	2.6	Often	3.1	Often
Average	2.49	Often	3.42	Always

Qualitative Themes on SIP Experiences

The qualitative component generated nine themes. Learners reported that SIPs developed knowledge and scientific skills, increased interest and motivation, and improved collaboration. They also described challenges, including lack of prior research knowledge, resource and time-management problems, and group conflicts. Despite these difficulties, learners coped through teacher guidance, support systems, collaborative task management, time organization, positive mindset, and resilience.

Table 5. *Qualitative Themes from the Focus Group Discussion*

Theme	Categories/Synthesis
Developed knowledge and scientific skills	Foundational skills, research writing, communication, and presentation improved through active experimentation.
Increased interest, motivation, and support	Teacher guidance, family support, peer assistance, feedback, and enjoyment sustained learners' motivation.
Improved collaboration skills	Sharing ideas, task division, role assignment, and cooperation strengthened teamwork and responsibility.
Lack of knowledge and scientific skills	First-time research experience, difficulty writing reports, low confidence, and oral-defense anxiety challenged learners.
Problems in resources and time management	Limited access to laptops/materials, environmental disruptions, school workload, and time pressure affected implementation.
Group conflicts	Misunderstanding, unequal participation, stress, and nervousness affected collaboration.
Seeking teachers' guidance and support systems	Teacher mentoring, family/peer assistance, and emotional support helped learners cope.
Collaborative task management and time organization	Task division, scheduling, feedback, teamwork, and resourcefulness helped learners' complete outputs.
Positive mindset and building resilience	Learners treated errors as learning opportunities and developed gratitude, persistence, and growth-oriented thinking.

The qualitative findings explain why the experimental group performed better. Learners described SIP as hands-on, meaningful, and collaborative. They learned how to measure and classify data, organize findings, write conclusions based on experimental results, and present their research with greater confidence. These accounts support the quantitative evidence that SIPs improved scientific skills, research competencies, and communication performance.

Integration of Quantitative and Qualitative Findings

The convergent analysis showed that the quantitative and qualitative findings supported each other. The experimental group's higher posttest, written report, oral defense, and observation scores were explained by learners' descriptions of increased scientific knowledge, collaboration, motivation, teacher guidance, and resilience. At the same time, the qualitative themes showed that SIP implementation requires scaffolding because learners encountered resource limitations, time pressure, and group conflicts.

Table 6. *Integrated Joint Display of Findings*

Quantitative result	Related qualitative theme	Meta-inference
Experimental group improved from 8.97 to 14.84 overall and reached Very Satisfactory.	Developed knowledge and scientific skills	SIP enhanced foundational and integrated scientific skills through active inquiry and research practice.
Experimental group obtained 9.23 in written reports, interpreted as Exemplary.	Improved collaboration skills	Collaboration, brainstorming, and task delegation supported stronger research writing and organization.
Experimental group obtained 7.89 in oral defense, interpreted as Proficient.	Communication and presentation skills within Theme 1	SIP strengthened learners' confidence, content mastery, and scientific communication.
Experimental observation mean was 3.42, interpreted as Always.	Increased interest, motivation, and support	Teacher guidance, peer cooperation, and family support sustained engagement.
Challenges remained during SIP implementation.	Resource/time-management problems and group conflicts	Successful SIP implementation requires resources, scaffolding, and conflict-management support.
Learners completed outputs despite difficulties.	Seeking guidance, collaborative management, and resilience	Support systems and positive mindset helped learners cope with research challenges.

CONCLUSION

Science Investigatory Projects significantly enhanced the scientific skills of Grade 9 learners. The experimental group demonstrated greater improvement than the control group in Basic Science Process Skills, Integrated Science Process Skills, written report performance, oral defense, and observed science-process-skill engagement. SIPs strengthened learners' ability to formulate research questions, define terms operationally, develop hypotheses, control variables, collect and analyze data, create conclusions, organize ideas, use visual aids, respond to questions, and communicate findings. Qualitative findings further showed that SIPs increased scientific knowledge, motivation, collaboration, confidence, resilience, and positive mindset. Although learners encountered difficulties in resources, time management, research writing, and group work, they coped through teacher guidance, peer collaboration, family support, task organization, and perseverance. Overall, SIPs served as effective instructional aids that promoted cognitive, social, and emotional development in science learning.

Recommendation

Science teachers should integrate Science Investigatory Projects as a regular instructional strategy supported by structured guidance, scaffolding, and continuous feedback. Schools should provide adequate materials, technological tools, laboratory access, and time allocations to support learners, especially in rural public-school settings. Teacher professional-development programs should include training on facilitating SIPs, mentoring students, guiding data analysis, and managing collaborative project work. School administrators may establish SIP monitoring systems and learning action cell sessions focused on research-based science instruction. Future researchers may examine the long-term effects of SIPs on scientific literacy, academic performance, and career interest; involve larger and more diverse samples; and explore digital, community-based, or interdisciplinary approaches to investigatory projects.

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