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INFLUENCE OF GENDER ON CHEMISTRY STUDENTS' ACQUISITION OF SCIENCE PROCESS SKILLS ACROSS SCHOOL TYPE USING OPEN INQUIRY INSTRUCTIONAL STRATEGY

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Abstract

Science process skills (SPS) are fundamental to effective science education, fostering students' ability to engage in scientific inquiry, problem-solving, and critical thinking. Despite the importance of SPS, disparities exist in students' acquisition of these skills based on gender and school type. This study investigated the influence of gender and school type on secondary school chemistry students' acquisition of SPS using the open inquiry instructional strategy. A quasi-experimental pre-test, post-test design was employed, involving 322 Senior Secondary School students selected through a multistage sampling technique. The experimental group was taught using the Open Inquiry Instructional Guide (OIIG), while the control group received instruction through the Demonstration Instructional Guide (DIG). The Science Process Skills Test (SPST) was used to evaluate students' ability to design experiments, observe, formulate hypotheses, and draw conclusions. Data were analysed using Analysis of Covariance (ANCOVA). The results indicated that students instructed using open inquiry significantly outperformed those instructed through the demonstration method in SPST. Although female students had slightly higher mean scores than males, the difference was not statistically significant. Similarly, students in private schools scored marginally higher than their public-school counterparts, but this difference was also insignificant. There was no significant interaction effect of gender and school type on SPS acquisition. These results suggest that open inquiry is an effective instructional strategy for improving SPS acquisition across diverse student populations. It is recommended that educators integrate open inquiry into science curricula and provide professional development for teachers to enhance its implementation.

Keywords: Science process skills, Open inquiry, Chemistry education, Instructional strategy, Student achievement

Introduction

Process skills (SPS) development is fundamental for effective science education, fostering students' ability to engage in scientific inquiry, problem-solving, and critical thinking. SPS include key competencies such as observing, hypothesising, experimenting, classifying, and interpreting data, which are particularly essential in chemistry a subject that relies heavily on practical applications (Bassey & Amanso, 2017; Ng'andu & Kaulu, 2020). However, the acquisition of these skills is influenced by various factors, including gender and school type, raising concerns about equity in science education and the effectiveness of different instructional strategies in addressing these disparities (Koomson, 2021; Efe & Abamba, 2023).

Research on gender disparities in science education has produced mixed findings. Some studies suggest that male students outperform their female counterparts in SPS such as experimental design, controlling variables, and measurement-related tasks (Ng'andu & Kaulu, 2020; Bassey & Amanso, 2017). These differences are often attributed to higher confidence levels and greater exposure to hands-on activities

among male students (Adeoye, 2020). However, other studies indicate no significant gender-based disparities, arguing that learning outcomes are primarily influenced by instructional methods rather than inherent differences between males and females (Adeoye, 2020; Nicol et al., 2024).

Conversely, Okafor (2021) found that female students excel in collaborative and reflective tasks, particularly when taught using context-based and inquiry-driven pedagogies. This finding is consistent with studies suggesting that girls demonstrate higher engagement and performance in tasks requiring detailed analysis, systematic problem-solving, and collaborative learning (Bassey & Amanso, 2017; Okafor, 2021). However, Koomson (2021) highlighted that unstructured open inquiry environments may exacerbate initial confidence gaps among female students, making effective teacher scaffolding essential in such settings.

The type of school attended by students whether public or private has been identified as a significant factor influencing SPS acquisition. Research suggests that students in private schools often outperform their counterparts in public schools due to better access to laboratory facilities, well-trained teachers, and smaller class sizes, which facilitate active engagement in science learning (Bassey & Amanso, 2017; Koomson, 2021). Efe and Abamba (2023) further support this claim, demonstrating that laboratory-based instructional methods enhance SPS acquisition across both private and public school settings, though resource constraints in public schools may hinder optimal learning outcomes. Nevertheless, some studies argue that school type alone does not determine SPS acquisition; rather, the instructional strategy employed is a more critical factor. For instance, Nicol et al. (2024) found that while students in resource-rich private schools generally performed better, those in well-supported public school environments exhibited comparable gains in SPS when exposed to inquiry-based learning. This suggests that targeted pedagogical interventions can mitigate disparities in learning outcomes across different school contexts.

Inquiry-based learning strategies have gained prominence as an effective means of fostering SPS acquisition. These strategies range from structured inquiry, where students follow predefined procedures, to open inquiry, where students independently formulate questions, design experiments, and draw conclusions or make inferences (Owolade et al., 2022; Alkan & Kocak, 2018). Among these approaches, open inquiry is regarded as the most student-centred, promoting autonomy, critical thinking, and deep engagement with scientific concepts (Ng'andu & Kaulu, 2020). Open inquiry instructional strategy is rooted in constructivist learning theories, allowing students to be actively involved in their learning process by formulating their own questions, designing and conducting experiments, and concluding their findings. This approach enhances student autonomy and engagement, encouraging deeper participation in the learning process (Ojo & Tijani, 2025). Research indicates that open inquiry fosters critical thinking, problem-solving, and scientific reasoning, as students explore topics of personal interest in a meaningful way (Owolade et al., 2022). Unlike traditional methods where learners passively receive information, open inquiry positions students as active participants in their education. The role of a teacher shifts from a knowledge provider to a facilitator, guiding students through the inquiry process and supporting their exploration (Wang et al., 2022).

Studies also indicate that inquiry-based instruction leads to superior SPS development compared to traditional lecture-based methods. Okero et al. (2021) demonstrated that students taught using a science process skills teaching approach (SPSTA) performed better than their counterparts exposed to conventional teaching methods. Similarly, Owolade et al. (2022) found that open inquiry strategy significantly enhanced students' self-efficacy and engagement in science learning even though they noted that these benefits were more pronounced for students in private schools with well-equipped laboratories.

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Despite its advantages, open inquiry also presents challenges. Some researchers argue that the high cognitive demands of open inquiry can overwhelm students, particularly those with limited prior exposure to independent scientific investigations (Ng'andu & Kaulu, 2020). Furthermore, Nicol et al. (2024) reported that while inquiry-based experimentation improved students' conceptual understanding, it did not significantly enhance their mastery of quantitative aspects of chemistry, suggesting the need for blended approaches combining inquiry-based and structured instructional strategies.

Despite the growing advocacy for inquiry-based learning, the extent to which open inquiry fosters SPS acquisition among students of different genders and school types remains unclear. While some studies suggest that males excel in hands-on experimental tasks while females perform better in reflective and analytical processes, others report no significant gender disparities in SPS development (Bassey & Amanso, 2017; Okafor, 2021). Similarly, while private school students generally achieve higher SPS scores, research suggests that well-implemented inquiry-based instruction can bridge this gap in public schools (Koomson, 2021; Efe & Abamba, 2023).

Given the inconsistencies in the literature regarding gender and school-type disparities in SPS acquisition, this study seeks to provide empirical evidence on the role of open inquiry in addressing these gaps. Unlike previous studies that have primarily focused on structured inquiry or guided inquiry approaches, this research specifically examines the impact of open inquiry on chemistry students' SPS development across different genders and school types. The findings will inform educators and policymakers on best practices for fostering equitable science learning outcomes.

This study aims to address these inconsistencies by investigating the influence of gender and school type on science process skills (SPS) acquisition among secondary school chemistry students exposed to the open inquiry strategy. Specifically, it seeks to determine whether open inquiry mitigates or exacerbates disparities in SPS acquisition across different genders and school types.

Research Questions

The study was guided by the following questions:

1) What is the influence of gender on secondary school chemistry students' acquisition of science process skills when taught using the open inquiry strategy and demonstration method?
2) What is the influence of school type on secondary school chemistry students' acquisition of science process skills when taught using the open inquiry strategy and demonstration method?
3) What is the interaction effect of gender and school type on secondary school chemistry students' acquisition of science process skills when taught using the open inquiry strategy and demonstration method?

Research Hypotheses

The study tested the following hypotheses:

1) **H_{01}:** There is no significant influence of gender on secondary school chemistry students' acquisition of science process skills using open inquiry strategy and demonstration method.
2) **H_{02}:** There is no significant influence of school types on secondary school chemistry students' acquisition of science process skills using open inquiry strategy and demonstration method.
3) **H_{03}:** There is no significant interaction influence of gender and school types on secondary school chemistry students' acquisition of science process skills using open inquiry strategy and demonstration method.

Methods

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The study employed a non-equivalent pre-test, post-test quasi-experimental design with a 2 × 2 × 2 matrix. This design is considered appropriate because it helps control for initial differences between the groups while allowing the examination of the interaction effects. Two groups were formed for the study. The first group (Experimental Group) was taught using Open Inquiry, while the second group (Control Group) was taught with Demonstration Method. Pre-tests were performed before the treatment to assess the students' process skills before the interventions. Following the treatment, post-tests were conducted to evaluate the students' acquisition of process skills. The design for the study is presented schematically below:

Experimental Group $O_1 X_1 O_3$

Control Group $O_2 X_2 O_4$

Where;-

O_1 and O_2 – pre-tests for the Experimental and Control Groups respectively.

O_3 and O_4 – post-tests for the Experimental and Control Groups respectively.

X_1 – Treatment using Open Inquiry Strategy

X_2 – Treatment using Demonstration Method

The independent variables consist of the treatments implemented in the study, namely the Open Inquiry Strategy and the Demonstration Method. The dependent variable was the students' acquisition of science process skills including their ability to design experiments, observe, formulate hypotheses, and make inferences or conclusions. Gender (male and female) and school type (public and private) serve as moderator variables to examine how they influence the relationship between instructional strategy and student acquisition of science process skills. This design was chosen because random assignment of students to experimental and control groups was not feasible in the school setting where intact classes needed to be maintained. However, the design allows for rigorous comparison between groups while controlling for pre-existing differences through pre-test measures. Additionally, the factorial structure (2 × 2 × 2) enables the examination of how both gender and school type moderate the effectiveness of the instructional strategies, providing a comprehensive understanding of the treatment effects across different student populations.

Population

The study targets Senior Secondary School Chemistry students in Osun State. The accessible population for the study consisted of Senior Secondary School One (SSS I) Science students in Ile-Ife, Osun State.

Sample and Sampling Techniques

A Multistage Sampling Technique was used to select samples for the study. Firstly, one senatorial district was chosen from the three districts in Osun state through a simple random sampling method. This was followed by the selection of two Local Government Areas (LGAs) from the chosen senatorial district using a simple random sampling approach. Additionally, six schools were picked from the selected LGAs using a purposive sampling technique. The purposive selection of schools was done to ensure that schools with similar educational backgrounds considering factors such as location and teacher quality were selected. This helped to establish a unified background across the sampled schools, ensuring that differences in student outcomes could be attributed to the instructional strategy rather than disparities in school characteristics. One intact SS1 science class was selected from the science arm of each school using a simple random sampling technique. This technique was chosen to ensure that all intact science classes in the selected schools have an equal chance of being selected thereby minimising bias. A simple random sampling technique was used to assign the six intact classes to two groups (Experimental and Control Groups). Students in the Experimental Group were instructed with open inquiry, while those in the Control Group were instructed using the demonstration method. The subject matter covered was separation

techniques, which included the sub-topics of filtration, simple distillation, and crystallisation. In each school, six research assistants who are Chemistry teachers received training on the intervention's purpose and the assignment of treatments. The intervention took place for four weeks, consisting of two periods per week, each lasting 40 minutes. The schools chosen for the study are listed in the table below:

Table 1: Schools Selected and Assignment to Treatment

School Type	School ID	Treatment Assigned	Number of Students
Public	School I	Open Inquiry	70
Public	School II	Open Inquiry	64
Private	School III	Open Inquiry	32
Public	School IV	Demonstration	60
Public	School V	Demonstration	76
Private	School VI	Demonstration	20
		Total	322

Research Instruments

Open Inquiry Instructional Guide (OIIG), Demonstration Instructional Guide (DIG) and Science Process Skills Test (SPST) were instruments used to implement the treatments and evaluate their effectiveness. OIIG and DIG were adopted from the study of Ojo and Tijani (2025) and serve as instructional instruments to deliver the open inquiry strategy and demonstration method to the experimental and control groups respectively. The Science Process Skills Test (SPST) was designed by the researchers to assess four students' science process skills including their ability to design experiments, observe, formulate hypotheses, and make inferences or conclusions. SPST is structured into two sections.Section A collects demographic details about the respondents, such as gender and the type of school they attend. Section B contains four questions, with each question on one of the four science process skills. Each question was assigned a maximum of 10 marks totaling a maximum of 40 marks obtainable in the SPST. The scoring system follows the marking guide of the West African Examination Council for practicals.

Validity and Reliability of SPST

The validity of the Science Process Skills Test (SPST) was established through content validity. The instrument was submitted to two experienced chemistry teachers who serve as examiners for the West African Examination Council (WAEC) chemistry practicals. These experts independently reviewed the test items to ensure they adequately measured the intended science process skills (designing experiments, observation, hypothesis formulation, and making inferences/conclusions). The experts evaluated the appropriateness, clarity, and comprehensiveness of the test items in relation to the skills being measured. Their suggestions and recommendations were incorporated into the final version of the instrument before administration.

The reliability of the Science Process Skills Test (SPST) was established through a test-retest method. The instrument was administered twice to a pilot group of 20 students with a two-week interval between administrations. The reliability coefficient was determined using Cronbach's alpha, and it yielded a reliability coefficient of $\alpha = 0.782$, which indicates good internal consistency. Additionally, inter-rater reliability was established using two independent raters who scored the test papers using the WAEC marking guide, resulting in an inter-rater agreement coefficient of 0.83. These reliability indices suggest that the SPST is a reliable instrument for measuring students' science process skills.

Procedure for Treatment and Evaluation

The topic taught was separation techniques using open inquiry instructional strategy and demonstration method. In the open inquiry class, the teacher provides a knowledge framework that guides students'

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exploration following the Open Inquiry Instructional Guide (OIIG) while allowing them the freedom to generate their own inquiry questions and select appropriate investigation methods. This approach encourages student autonomy, critical thinking, and scientific reasoning, as learners take ownership of their investigations. Conversely, in the demonstration class, the teacher offers complete support while guiding students through organized investigations as outlined in the Demonstration Instructional Guide (DIG). Unlike open inquiry, students adhere to specified procedures established by the teacher.

The research procedure included three phases: pre-treatment, treatment, and post-test, all occurring for four weeks. During the pre-treatment phase, the Science Process Skills Test (SPST) was given to the students to evaluate their initial understanding of science process skills in chemistry. This was succeeded by a three-week treatment period in which the experimental group received instruction through OIIG while the control group was taught using DIG. In the final week, the SPST was administered again as a post-test to both groups to assess their development of science process skills following the intervention. The collected scripts were then scored, coded, and prepared for analysis to evaluate the impact of the instructional methods on students' science process skills.

Methods of Data Analysis

Data collected were analysed using descriptive statistics (mean and standard deviation) and inferential statistics (ANCOVA). The hypotheses were tested using Analysis of Covariance (ANCOVA). All hypotheses were tested at a 0.05 level of significance, and the analysis was done using the Statistical Package for the Social Sciences (SPSS version 27.0).

Findings

Analysis of Research Questions

Research Question 1: What is the influence of gender on secondary school chemistry students' acquisition of science process skills when taught using the open inquiry strategy and demonstration method?

Table 2: *ANCOVA Descriptive Statistics on the Influence of Gender on Students' Acquisition of Process Skills Between Experimental and Control Groups*

Descriptive Statistics

Dependent Variable: SPST Post-test Score				
Gender		Mean	Std. Deviation	N
Male	Demonstration	13.37	6.363	73
	Open Inquiry	19.74	6.316	74
	Total	16.58	7.081	147
Female	Demonstration	13.75	6.128	83
	Open Inquiry	19.84	6.801	92
	Total	16.95	7.155	175
Total	Demonstration	13.57	6.222	156
	Open Inquiry	19.80	6.569	166
	Total	16.78	7.112	322

The analysis of covariance (ANCOVA) descriptive statistics presented in Table 2 provides insight into the influence of gender on secondary school chemistry students' acquisition of science process skills when taught using the open inquiry strategy and demonstration method. The mean post-test scores indicate that both male and female students performed better when taught using the open inquiry strategy (M = 19.74, SD = 6.316 for males; M = 19.84, SD = 6.801 for females) compared to the demonstration method (M = 13.37, SD = 6.363 for males; M = 13.75, SD = 6.128 for females). Overall, female students had slightly higher

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mean scores than their male counterparts in both instructional strategies, with a total mean score of 16.95 (SD = 7.155) compared to 16.58 (SD = 7.081) for males. The total mean score across both genders and instructional strategies was 16.78 (SD = 7.112). These findings suggest that both genders benefited more from the open inquiry strategy.

Research Question 2: What is the influence of school type on secondary school chemistry students' acquisition of science process skills when taught using the open inquiry strategy and demonstration method?

Table 3: *ANCOVA Descriptive Statistic on the Influence of School Type on Students' Acquisition of Process Skills Between Experimental and Control Groups*

Descriptive Statistics

Dependent Variable: SPST Post-test Score				
School Type		Mean	Std. Deviation	N
Public	Demonstration	13.67	6.458	136
	Open Inquiry	19.63	6.530	134
	Total	16.63	7.136	270
Private	Demonstration	12.90	4.352	20
	Open Inquiry	20.50	6.792	32
	Total	17.58	7.002	52
Total	Demonstration	13.57	6.222	156
	Open Inquiry	19.80	6.569	166
	Total	16.78	7.112	322

The descriptive statistics from the analysis of covariance (ANCOVA) in Table 3 provide insight into the influence of school type on secondary school chemistry students' acquisition of science process skills when taught using the open inquiry strategy and demonstration method. The mean post-test scores indicate that students in both public and private schools performed better when taught using the open inquiry strategy (M = 19.63, SD = 6.530 for public schools; M = 20.50, SD = 6.792 for private schools) compared to the demonstration method (M = 13.67, SD = 6.458 for public schools; M = 12.90, SD = 4.352 for private schools). Overall, students in private schools had slightly higher mean scores (M = 17.58, SD = 7.002) than those in public schools (M = 16.63, SD = 7.136). The total mean score across both school types and instructional strategies was 16.78 (SD = 7.112). These findings suggest that while students in private schools performed marginally better, both school types showed improved acquisition of science process skills under the open inquiry strategy.

Research Question 3: What is the interaction effect of gender and school type on secondary school chemistry students' acquisition of science process skills when taught using the open inquiry strategy and demonstration method?

Table 4: *ANCOVA Descriptive Statistic on the Interaction Influence of Gender and School Type on Students' Acquisition of Process Skills Between Experimental and Control Groups*

Descriptive Statistics

Dependent Variable: SPST Post-test Score					
Gender			Mean	Std. Deviation	N
Male	Public	Demonstration	13.37	6.363	73
		Open Inquiry	19.74	6.316	74
		Total	16.58	7.081	147
	Total	Demonstration	13.37	6.363	73

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		Open Inquiry	19.74	6.316	74
		Total	16.58	7.081	147
Female	Public	Demonstration	14.02	6.600	63
		Open Inquiry	19.48	6.836	60
		Total	16.68	7.230	123
	Private	Demonstration	12.90	4.352	20
		Open Inquiry	20.50	6.792	32
		Total	17.58	7.002	52
	Total	Demonstration	13.75	6.128	83
		Open Inquiry	19.84	6.801	92
		Total	16.95	7.155	175
Total	Public	Demonstration	13.67	6.458	136
		Open Inquiry	19.63	6.530	134
		Total	16.63	7.136	270
	Private	Demonstration	12.90	4.352	20
		Open Inquiry	20.50	6.792	32
		Total	17.58	7.002	52
	Total	Demonstration	13.57	6.222	156
		Open Inquiry	19.80	6.569	166
		Total	16.78	7.112	322

The descriptive statistics from the analysis of covariance (ANCOVA) in Table 4 provide insights into the interaction effect of gender and school type on secondary school chemistry students' acquisition of science process skills when taught using the open inquiry strategy and demonstration method. The mean post-test scores indicate that both male and female students in public and private schools performed better under the open inquiry strategy compared to the demonstration method. Among male students in public schools, those taught using open inquiry had a higher mean score (M = 19.74, SD = 6.316) than those taught with the demonstration method (M = 13.37, SD = 6.363). Similarly, female students in public schools performed better with open inquiry (M = 19.48, SD = 6.836) compared to the demonstration method (M = 14.02, SD = 6.600). In private schools, female students had a higher mean score (M = 20.50, SD = 6.792) under the open inquiry strategy compared to the demonstration method (M = 12.90, SD = 4.352). The overall mean scores suggest that female students in private schools benefited the most from the open inquiry strategy, while male and female students in public schools showed similar performance trends. The total mean score across all groups was 16.78 (SD = 7.112). These findings highlight a possible interaction effect of gender and school type, warranting further statistical analysis to determine the significance of this interaction on students' acquisition of science process skills.

Analysis of Research Hypotheses

H_{01}: There is no significant influence of gender on secondary school chemistry students' acquisition of science process skills using open inquiry strategy and demonstration method.

Table 5: *ANCOVA Result on the Influence of Gender on Students' Acquisition of Process Skills Between Experimental and Control Groups in the Study Area*

Tests of Between-Subjects Effects

Dependent Variable: SPST Post-test Score						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3521.665[a]	4	880.416	21.949	0.000	0.217
Intercept	10262.064	1	10262.064	255.832	0.000	0.447
Gender	0.076	1	0.076	0.002	0.965	0.000
Instructional Strategy	2966.267	1	2966.267	73.949	0.000	0.189

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Gender * Instructional Strategy	6.563	1	6.563	0.164	0.686	0.001
SPST Pre-test Score	399.697	1	399.697	9.964	0.002	0.030
Error	12715.679	317	40.113			
Total	106897.000	322				
Corrected Total	16237.345	321				
a. R Squared = .217 (Adjusted R Squared = .207)						

The ANCOVA results presented in Table 5 examine the influence of gender on secondary school chemistry students' acquisition of science process skills using the open inquiry strategy and demonstration method. The findings indicate that gender does not have a significant effect on secondary school chemistry students' acquisition of process skills, as evidenced by the F-value of 0.002 and a significance level of p = 0.965, which is greater than the conventional threshold of 0.05. Additionally, the interaction effect between gender and instructional strategy is not statistically significant (p = 0.686), suggesting that the effectiveness of the instructional methods does not vary by gender. However, the instructional strategy itself shows a significant effect on students' performance (p = 0.000, $\eta^2 = 0.189$), indicating that the choice of teaching method plays a crucial role in skill acquisition. The model explains 21.7% of the variance in post-test scores ($R^2 = 0.217$), highlighting the instructional strategy as a more influential factor than gender in students' learning outcomes. Hence, the null hypothesis (Ho_1) is not rejected, affirming that gender does not significantly impact students' acquisition of science process skills.

H_{o2}: There is no significant influence of school types on secondary school chemistry students' acquisition of science process skills using open inquiry strategy and demonstration method.

Table 6: *ANCOVA Result on the Influence of School Types on Students' Acquisition of Process Skills Between Experimental and Control Groups in the Study Area*

Tests of Between-Subjects Effects

Dependent Variable: SPST Post-test Score						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3537.650[a]	4	884.412	22.076	0.000	0.218
Intercept	9167.446	1	9167.446	228.831	0.000	0.419
School Type	0.437	1	0.437	0.011	0.917	0.000
Instructional Strategy	1776.843	1	1776.843	44.352	0.000	0.123
School Type * Instructional Strategy	20.204	1	20.204	0.504	0.478	0.002
SPST Pre-test Score	391.559	1	391.559	9.774	0.002	0.030
Error	12699.695	317	40.062			
Total	106897.000	322				
Corrected Total	16237.345	321				
a. R Squared = .218 (Adjusted R Squared = .208)						

The ANCOVA results in Table 6 assess the influence of school type on secondary school chemistry students' acquisition of science process skills using the open inquiry strategy and demonstration method. The results reveal that school type does not have a significant effect on students' acquisition of process skills, as indicated by the F-value of 0.011 and a significance level of p = 0.917, which is well above the 0.05 threshold. Similarly, the interaction effect between school type and instructional strategy is not statistically significant (p = 0.478), suggesting that the impact of the instructional strategies remains consistent across different school types. However, instructional strategy alone has a significant effect on students' acquisition of process skills (p = 0.000, $\eta^2 = 0.123$), reinforcing the role of teaching methods in enhancing learning outcomes. The model accounts for 21.8% of the variance in post-test scores ($R^2 = 0.218$), indicating that while instructional strategy is a key determinant, school type does not contribute significantly to students' skill acquisition.

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Consequently, the null hypothesis (Ho_2) is not rejected, confirming that school type does not significantly influence students' acquisition of science process skills.

H_{03}: There is no significant interaction influence of gender and school types on secondary school chemistry students' acquisition of science process skills using open inquiry strategy and demonstration method.

Table 7: *ANCOVA Result on the Interaction Influence of Gender and School Types on Students' Acquisition of Process Skills Between Experimental and Control Groups in the Study Area*

Tests of Between-Subjects Effects

Dependent Variable: SPST Post-test Score						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3562.644[a]	6	593.774	14.757	0.000	0.219
Intercept	9631.623	1	9631.623	239.371	0.000	0.432
Gender	1.303	1	1.303	0.032	0.857	0.000
School Type	1.195	1	1.195	0.030	0.863	0.000
Instructional Strategy	2249.066	1	2249.066	55.895	0.000	0.151
Gender * School Type	0.000	0				0.000
Gender * Instructional Strategy	23.886	1	23.886	0.594	0.442	0.002
School Type * Instructional Strategy	36.661	1	36.661	0.911	0.341	0.003
Gender * School Type * Instructional Strategy	0.000	0				0.000
SPST Pre-test Score	400.202	1	400.202	9.946	0.002	0.031
Error	12674.700	315	40.237			
Total	106897.000	322				
Corrected Total	16237.345	321				
a. R Squared = .219 (Adjusted R Squared = .205)						

The ANCOVA results in Table 7 examine the interaction influence of gender and school type on secondary school chemistry students' acquisition of science process skills using the open inquiry strategy and demonstration method. The findings indicate that neither gender ($p = 0.857$) nor school type ($p = 0.863$) has a significant individual effect on students' acquisition of science process skills. Additionally, the interaction between gender and school type is not statistically significant, as reflected in the absence of a reported F-value and significance level. The interaction effects of gender and instructional strategy ($p = 0.442$) and school type and instructional strategy ($p = 0.341$) are also not significant. However, instructional strategy alone has a significant impact on students' process skill acquisition ($p = 0.000$, $\eta^2 = 0.151$), reinforcing its importance in enhancing learning outcomes. The model explains 21.9% of the variance in post-test scores ($R^2 = 0.219$), further indicating that while instructional strategy plays a crucial role, gender and school type do not significantly influence students' acquisition of science process skills. Therefore, the null hypothesis (Ho_3) is not rejected, confirming that there is no significant interaction effect of gender and school type on students' learning outcomes.

Summary of Findings

The following includes the main findings of the study:

1) Students taught using the open inquiry instructional strategy performed significantly better in science process skills acquisition compared to those taught using the demonstration method.
2) Both male and female students benefited more from the open inquiry strategy, with female students achieving slightly higher mean scores than their male counterparts.

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3) The difference in performance between male and female students was not statistically significant, indicating that gender does not play a major role in science process skills acquisition when using the open inquiry strategy.
4) Students in both public and private schools showed improved science process skills when exposed to the open inquiry strategy.
5) Although students attending private schools achieved slightly higher average scores compared to those in public schools, the difference was not statistically significant, indicating that open inquiry is effective in various types of educational settings.
6) There was no significant interaction effect between gender and school type on students' science process skills acquisition.

Discussion of Findings

The study found that students exposed to the open inquiry instructional strategy significantly outperformed those taught using the demonstration method in science process skills acquisition. This aligns with the findings of Owolade et al. (2022) and Alkan & Kocak (2018), who reported that inquiry-based learning enhances students' engagement and critical thinking abilities by allowing them to take ownership of their learning. The superior performance of students in the open inquiry group suggests that the strategy provides a more effective platform for developing essential scientific competencies, reinforcing the argument that inquiry-based learning fosters deeper understanding and skill acquisition compared to teacher-centred approaches (Okero et al., 2021).

The study also revealed that both male and female students benefited from the open inquiry strategy, with female students achieving slightly higher mean scores than their male counterparts. However, this difference was not statistically significant, indicating that gender does not play a major role in science process skills acquisition when using the open inquiry method. This contradicts earlier studies that suggested male students outperform females in hands-on experimental tasks due to greater confidence and exposure to practical activities (Ng'andu & Kaulu, 2020; Bassey & Amanso, 2017). Instead, the findings support Okafor (2021), who found that female students excel in reflective and analytical processes when exposed to inquiry-driven pedagogies. This suggests that inquiry-based strategies may help bridge gender disparities in science learning by providing an equitable learning environment where both male and female students can develop key scientific skills.

Similarly, the study found that students in both public and private schools showed improved science process skills when exposed to the open inquiry strategy. Although students in private schools had somewhat higher average scores, the difference was not statistically significant. This finding aligns with Nicol et al. (2024), who argued that well-implemented inquiry-based instruction can compensate for disparities in school resources. It also supports Koomson (2021), who found that while private school students generally perform better due to access to better laboratory facilities and instructional materials, the instructional method remains a more influential factor in student achievement. The results imply that open inquiry strategies can be an effective tool for improving learning outcomes across different school settings, provided that the necessary instructional support is in place.

Additionally, the research indicated that there was no notable interaction effect between gender and school type regarding students' development of science process skills. This suggests that neither gender nor school type significantly influences students' learning outcomes when exposed to the open inquiry instructional strategy. This aligns with findings from Efe & Abamba (2023), who suggested that well-structured inquiry-based instruction benefits all students regardless of their demographic background. The

lack of significant interaction effects reinforces the notion that high-quality instructional strategies, rather than demographic factors, are the key determinants of students' science learning outcomes.

Relevance and Implications

The results of this study carry considerable importance for science education, especially regarding the design and implementation of teaching methods in high schools. The results reinforce the need for a shift from traditional teacher-centred methods to student-centred approaches like open inquiry, which foster critical thinking, problem-solving, and scientific reasoning skills. Given the positive impact of open inquiry across gender and school type, policymakers and educators should prioritise its integration into the science curriculum to promote equitable learning opportunities.

The study's findings also highlight the potential of inquiry-based instruction to mitigate gender disparities in science education. By providing an inclusive learning environment where both male and female students can actively engage in scientific inquiry, open inquiry strategies can help dismantle gender stereotypes in STEM education. Furthermore, the results suggest that instructional strategies, rather than school resources alone, play a crucial role in students' academic achievement, indicating the need for targeted teacher training programmes that equip educators with the skills to implement inquiry-based learning effectively in both public and private schools.

Conclusion

The results of this research emphasize the effectiveness of open inquiry in improving students' development of science process skills, irrespective of their gender or the type of school they attend. The findings show that students who were taught through the open inquiry approach achieved significantly higher outcomes compared to those who experienced the demonstration method, supporting the notion that student-centred approaches promote greater involvement and critical thinking. Additionally, the study found no significant gender or school-type influence on learning outcomes, suggesting that inquiry-based instruction provides an equitable learning environment for all students. These findings have important implications for science education, emphasising the need to integrate open inquiry strategies into the curriculum and provide adequate teacher training to facilitate effective implementation. By shifting towards inquiry-based instruction, educators can bridge existing learning gaps and promote a more interactive and skills-oriented approach to science education, ultimately improving students' preparedness for real-world scientific challenges.

Recommendations

The following recommendations are made based on the outcomes of the study:

1) Schools should integrate open inquiry instructional strategy into their science curricula to enhance students' acquisition of science process skills.
2) Governments and school administrations should organise professional development programmes to equip teachers with the necessary skills to facilitate open inquiry learning effectively.
3) Schools, particularly public institutions, should be provided with well-equipped science laboratories and materials to support inquiry-based learning.
4) Ministries of education should develop policies that mandate implementing inquiry-based methods in science teaching, accompanied by periodic evaluations and support systems to ensure effective implementation.

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