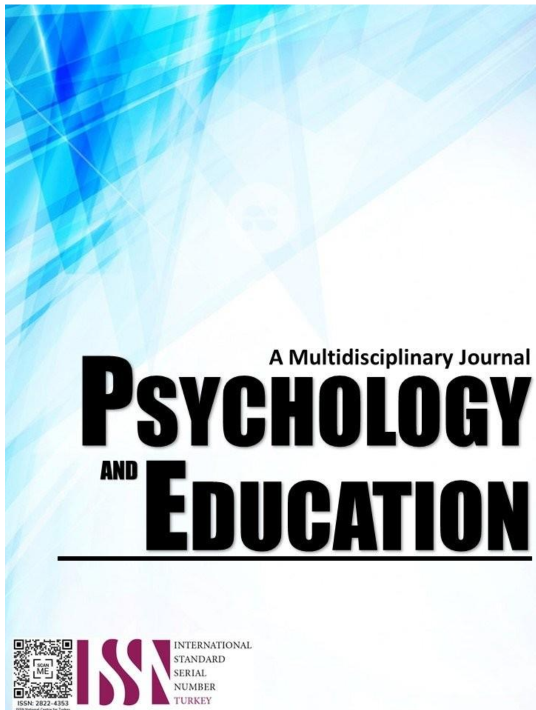
EVALUATING THE NEXUS: TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE AND ITS SIGNIFICANCE ON STUDENTS' SCIENCE PROCESS SKILLS



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Research Article

Evaluating the Nexus: Teachers' Pedagogical Content Knowledge and its Significance on Students' Science Process Skills

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Abstract

One of the methods of teaching science crucial for developing scientific skills is the development of Science process skills. This study aimed to evaluate the nexus of teachers' pedagogical content knowledge and significance on the Science process skills of the Junior High School students. A descriptive and correlational method was used. The respondents involved were three hundred thirty-one (331) students and thirteen (13) Science teachers. The data were analyzed using mean, standard deviation, Pearson r, t-test, and regression analysis. The findings reveal that Science teachers possess basic proficiency in content knowledge (M = 0.65, SD = 0.44) but excel in pedagogical knowledge (M = 4.88, SD = 0.08), classroom management (M = 4.96, SD = 0.04), and teaching strategies (M = 4.78, SD = 0.12). Their curricular expertise is extensive (M = 4.16, SD = 0.16). In contrast, students demonstrate a beginning proficiency level in basic Science process skills (M = 0.36, SD = 0.37), indicating a low foundation in applying scientific knowledge to learn concepts. However, students exhibit minimal proficiency in integrated Science process skills (M = 0.51, SD = 0.50), enabling them to understand lessons, engage in direct reasoning, and accurately interpret scientific inquiry. A significant correlation is found between Science teachers' high-quality traits in teaching strategies and students' basic Science process skills ($r = 0.620$, $p < 0.05$). The study concludes that Science teachers' basic proficiency level implies an understanding of scientific concepts and exceptional capacity to improve teaching practice through effective use of the 5Es (Engage, Explore, Explain, Elaborate, and Evaluate). The findings highlight the importance of Science teachers' pedagogical knowledge and classroom strategies in developing students' basic and integrated Science process skills, emphasizing the need for targeted professional development to enhance teachers' content knowledge and pedagogical expertise.

Keywords: *nexus, teachers' pedagogical content knowledge, basic Science process skills, integrated Science process skills*

Introduction

Effective science teaching in secondary schools relies on teachers' ability to create an environment that fosters a deep understanding of scientific concepts. Teachers must possess both pedagogical knowledge and subject expertise to guide students in exploring, developing, and testing scientific theories. However, studies indicate that inadequate science content knowledge (Ogunkola, 2016) negatively affects instruction and student achievement (Hodges et al., 2015). Some teachers avoid certain concepts due to a lack of confidence in their subject knowledge (Robinson, 2017).

Science process skills are essential for scientific investigation (Juhji, 2016; Alatas & Fachrunisa, 2018), yet research shows that students often struggle with these skills, leading to low academic performance and disengagement in practical lessons (Juhji & Nuangchalerm, 2020). Factors such as limited materials, ineffective strategies, and insufficient knowledge transfer hinder the development of these skills (Derilo, 2019). Additionally, instructional methods that limit independent thinking further obstruct students' learning experiences (Aktamis & Ergin, 2018).

The quality of science education in the Philippines remains a concern, with the country ranking among the lowest in international assessments (Malipot, 2023). Results from the 2022 PISA showed that Filipino students scored significantly below the global average, indicating a substantial gap in learning competencies (Servallos, 2023). Despite slight improvements, the overall performance remains inadequate (Olvido et al., 2024). Local studies report that a significant percentage of Grade 9 and 10 students perform at a satisfactory or poor level in science (Garcia & Garcia, 2023; Paring et al., 2021; Santos et al., 2022). However, research on students' science process skills and teachers' pedagogical content knowledge, particularly in the South Cotabato Division, remains limited.

Research Questions

The study evaluated the nexus of teachers' pedagogical content knowledge and significance on the students' science process skills. Findings served as the basis for the proposed training for teachers. It answered the following questions:

1. What are the science teachers' high-quality traits in terms of:
   - 1.1. content knowledge;
   - 1.2. pedagogical knowledge;
   - 1.3. classroom management;
   - 1.4. teaching strategies; and
   - 1.5. curricular knowledge?

2. What is the level of basic science process skills of the students in terms of:
    2.1. observing;
    2.2. comparing;
    2.3. classifying;
    2.4. measuring;
    2.5. inferring;
    2.6. predicting; and
    2.7. communicating?
3. What is the level of integrated science process skills of the students in terms of:
    3.1. collecting data;
    3.2. interpreting data;
    3.3. formulating hypothesis;
    3.4. identifying variables;
    3.5. defining operationally;
    3.6. controlling variables;
    3.7. formulating models; and
    3.8. experimenting?
4. Is there a significant relationship between the science teachers' teachers' high-quality traits and the students' basic and integrated science process skills?
5. Is there a significant difference in the students' basic and integrated science process skills?
6. Is the teacher's content knowledge significantly contributing to pedagogical knowledge?

Methodology

Research Design

This research study utilized descriptive correlational methods. Descriptive research was used to describe the teachers' knowledge of pedagogical content and students' process skills in science. Moreover, the correlational research method was applied to determine the relationship between the teachers' pedagogical knowledge and the students' basic and integrated science process skills (Olvido et al., 2024).

To support the claims, Aman (2020) cited that the goal of descriptive research design is not only to get a picture of the current thoughts, feelings, or behaviors in a given group of people but also to measure two or more relevant variables and assess a relationship between or among them. Moreover, Siedlecki (2020) emphasized that descriptive correlational research design describes some phenomena that are quantifiable and can be elicited using close-ended scales.

Respondents

The researcher utilized two types of respondents: Science teachers and Junior High School students. The teacher-respondents are regular permanent teachers assigned in a selected public school in the Division of South Cotabato. This school has over one hundred teachers and a student population of approximately 3,000. It offers both junior high school and senior high school curricula in accordance with DepEd Order No. 51, series of 2015.

In selecting the teacher respondents, the researcher included all regular, permanent teachers, regardless of their plantilla positions, who teach Science subjects. A total of thirteen (13) Science teachers participated in the study. The student respondents were chosen based on enrollment in the Junior High School program, resulting in a total of three hundred thirty-one (331) JHS students included as respondents (School Form 7, 2024).

This study employed complete enumeration sampling to determine the number of teacher respondents. By using this method, all Science teachers meeting the criteria were included in the research. The study focused on all Science teachers, as well as regular and permanent.

Ary et al. (2010) determined that the sample constitutes a limited group under observation. Creswell (2018) states that a sample is a subset of the population of interest that the researcher intends to examine to generalize findings about the entire population wherein teachers are small in number. Table 1 shows the distribution of Science teachers and JHS students per grade.

Table 1. *Distribution of Respondents by Grade Level, SY 2023-24*

	Grade Level	*Number of Students*	*Sample size*	*Number of Teachers*
1	Grade 7	668	94	3
2	Grade 8	529	75	3
3	Grade 9	535	76	3
4	Grade 10	609	86	4
	Total	2 341	331	13

Instrument

The study employed a combination of researcher-made assessments and standardized tests to evaluate both teachers' pedagogical content knowledge and students' science process skills. The researcher-made instruments include a Teacher Assessment Survey, designed to gauge the high-quality traits of teachers in areas such as content knowledge, pedagogical knowledge, classroom management, teaching strategies, and curricular knowledge, using Likert-scale items for self-reporting. Complementing this, a Student Science Skills Questionnaire was developed to assess students' basic and integrated science process skills through scenarios and tasks that require demonstration of skills like observing, inferring, and predicting. Additionally, standardized tests recognized for their reliability in measuring competencies in scientific inquiry were utilized as benchmarks, providing a comparative perspective on student performance. This combination of instruments aims to gather comprehensive data that accurately reflects the relationship between teachers' pedagogical content knowledge and students' science process skills, ensuring that the findings are robust, valid, and relevant to the study's objectives.

Procedure

The study utilized a structured data-gathering tool divided into four parts to assess the pedagogical content knowledge of Science teachers and the Science process skills of students.

Part I evaluated the pedagogical and curricular knowledge of teachers through a questionnaire consisting of six (6) statements for each category. Responses were measured using a 5-point Likert scale: 5 – Very High Extent, 4 – High Extent, 3 – Moderate Extent, 2 – Less Extent, and 1 – Least Extent.

Part II assessed the content knowledge of Science teachers using a standardized multiple-choice test on basic and integrated Science process skills. The test comprised 26 items, 13 of which focused on basic Science process skills and 13 on integrated Science process skills. Salz and Figueroa (2019) adapted the test from the OECD PISA framework.

Part III measured the Science process skills of Junior High School students using a standardized multiple-choice test adapted from the PISA pretest sample (Region XII, 2024) and OECD PISA (Salz & Figueroa, 2019). The 26-item test was equally divided into basic and integrated Science process skills and covered six key components: living things and their environment, matter, earth and space, force, motion, and energy.

Part IV gathered data on teachers' pedagogical knowledge, teaching strategies, and classroom management through a checklist. The Classroom Observation Tool (COT) was utilized, and master teachers conducted observations of science teachers. The results of the COT were recorded in the checklist, which included the teacher's name and ratings for each objective related to pedagogical knowledge, teaching strategies, and classroom management.

Data Analysis

The data gathered was immediately encoded, processed, and analyzed. It was computed using the appropriate statistical tools. Mean and standard deviation were used to determine the Science teachers' high-quality traits. Mean Percentage Score (MPS) was used to determine the level of students' basic and integrated Science Process Skills.

Meanwhile, Pearson r Moment Correlation was used to determine the relationship between Science teachers' high-quality traits and students' basic and integrated Science process skills. A T-test was used to determine the significant difference in the students' basic and integrated science process skills. Regression analysis was used to determine the significant contribution of teachers' content knowledge to pedagogical knowledge.

Results and Discussion

The results are presented in the succeeding tables with corresponding discussions and explanations.

Level of Science Teachers' High-Quality Traits

The first research problem determines the level of Science teachers' high-quality traits relative to their content knowledge, pedagogical knowledge, classroom management, teaching strategies, and curricular knowledge.

Table 2 shows the level of high-quality science teachers' traits relative to their content knowledge. In general, the level of teachers' content knowledge in Science obtained Basic Proficiency with mean of 0.65, (SD=0.44). The results indicate that the teachers' content knowledge level has developed the fundamental skills and core understandings. Furthermore, the result implies that science teachers understand scientific concepts and strongly grasp scientific processes at the basic proficiency level.

The present findings are consistent with the ideas of Makarwi (2015). The fundamental scientific process abilities significantly enhanced instructors' topic expertise in science instruction. The efficacy of science process skills significantly impacts learning outcomes when educators exhibit proficient process skills. The result underscores the necessity for continuously developing fundamental scientific process skills (Juhji & Nuangchalerm, 2020).

Table 2. *Level of Science Teachers' High-Quality Traits in Terms of Content Knowledge*

Skills	*Mean*	*SD*	*Verbal Description*
Classifying	0.85	0.38	High Proficiency
Measuring	1.46	0.78	Advanced Proficiency
Inferring	0.85	0.38	High Proficiency
Predicting	0.77	0.44	High Proficiency
Communicating	0.77	0.44	High Proficiency
Collecting Data	0.35	0.24	Beginning Proficiency
Interpreting Data	0.19	0.25	Beginning Proficiency
Formulating Hypothesis	0.54	0.52	Minimal Proficiency
Identifying Variables	0.85	0.38	High Proficiency
Defining Operationally	0.62	0.51	Basic Proficiency
Controlling Variables	0.69	0.48	Basic Proficiency
Formulating Models	0.15	0.38	Beginning Proficiency
Experimenting	0.38	0.51	Beginning Proficiency
Overall Mean	0.65	0.44	Basic Proficiency

Legend: 0.91+, Exceptional Proficiency; 0.81-0.90, Advance Proficiency; 0.71-0.80, High Proficiency; 0.61-0.70, Basic Proficiency; 0.51-0.60, Minimal Proficiency; 0.00-0.50, Beginning Proficiency

Table 3 shows the Level of science teachers' high-quality traits in terms of pedagogical knowledge. The consistent ratings for all indicators substantiate the overall results. The Science teachers demonstrated outstanding performance in their pedagogical knowledge in teaching Science ($\bar{x}$=4.88, SD=0.88). The result means that Science teachers possess exceptional capacity to improve their teaching practices. It implies that teachers' specialized knowledge for creating effective instructional strategies or applying teaching methods visible or shown in their lessons during classroom observation is outstanding.

Table 3. *Level of Science Teachers' High-Quality Traits in Terms of Pedagogical Knowledge*

Indicators	*Mean*	*SD*	*Verbal Description*
1. Utilizes knowledge of subject matter across various curriculum domains.	5.00	0.00	Outstanding
2. Effectively manages student behavior by applying constructive and non-violent punishment to maintain environments conducive to learning.	5.00	0.00	Outstanding
3. Employs differentiated, developmentally suitable learning experiences to cater to learners' gender, needs, strengths, interests, and experiences.	5.00	0.00	Outstanding
4. Administers classroom organization to involve students individually and collectively in significant exploration, discovery, and practical activities across various physical learning settings.	4.91	0.09	Outstanding
5. Formulates, oversees and executes developmentally structured pedagogical processes to fulfill curriculum standards in diverse instructional settings.	4.88	0.13	Outstanding
6. Chooses, cultivates, arranges, and employs suitable educational resources, including information and communication technology, to meet learning objectives.	4.80	0.12	Outstanding
7. Develops, chooses, arranges, and implements diagnostic, formative, and summative assessment procedures following curriculum standards.	4.80	0.12	Outstanding
8. Employs many pedagogical tactics to cultivate imaginative and critical thinking alongside other advanced cognitive skills.	4.79	0.11	Outstanding
9. Employs a variety of pedagogical tactics that improve student performance in literacy and numeracy competencies.	4.74	0.12	Outstanding
Overall Mean	4.88	0.08	Outstanding

Legend: 4.20 – 5.00, Outstanding; 3.40 – 4.19, Very Satisfactory; 2.60 – 3.39, Satisfactory; 1.80 – 2.59, Unsatisfactory; 1.00 – 1.79, Poor

The present findings are relevant to Tretter et al.'s (2013) ideas. Teachers develop subject-relevant information when allowed to engage in conversations and devise techniques for its presentation. Furthermore, Azam (2019) illustrates that to deliver accessible and inclusive science education to students from various backgrounds. Science educators must understand the distinct backgrounds of certain student groups to meet their unique learning requirements.

Table 4. *Level of Science Teachers' High-Quality Traits in Terms of Classroom Management*

Indicators	*Mean*	*SD*	*Verbal Description*
1. Effectively regulates learner behavior by implementing positive and non-violent disciplinary methods to maintain conditions conducive to learning.	5.00	0.00	Outstanding
2. Employs differentiated, developmentally suitable learning experiences to cater to learners' gender, needs, strengths, interests, and experiences.	5.00	0.00	Outstanding
3. Formulates, oversees and executes developmentally structured instructional methodologies to fulfill curriculum standards and diverse educational settings.	4.88	0.13	Outstanding
Overall Mean	4.96	0.04	Outstanding

Legend: 4.20 – 5.00, Outstanding; 3.40 – 4.19, Very Satisfactory; 2.60 – 3.39, Satisfactory; 1.80 – 2.59, Unsatisfactory; 1.00 – 1.79, Poor

The level of science teachers' high-quality traits in terms of classroom management is presented in Table 4. The teachers' classroom management level is outstanding (x̄=4.96, SD=0.04).

The result indicates that the classroom management qualities of teachers are observed to be substantial in teaching Science, wherein every teacher can manage the learning behavior during classroom instruction to ensure that the learning environment is focused on the learning needs of the students. The result implies that Science teachers display an exceptional capacity to improve their teaching practice through effective classroom management that affects the learning needs and experiences of the students.

The present findings are relevant to Alam and Mohanty's (2023) idea that students' learning environment is more than simply a classroom. It is a place where students feel comfortable and supported in their quest for knowledge and are motivated by their surroundings. Teachers' methods of instruction and strategies for managing students' learning behavior impact the learning environment.

Table 5. *Level of Science Teachers' High-Quality Traits in Terms of Teaching Strategies*

Indicators	*Mean*	*SD*	*Verbal Description*
1. Develops, chooses, arranges, and implements diagnostic, formative, and summative assessment procedures following curriculum standards.	4.80	0.12	Outstanding
2. Employs a variety of pedagogical tools to cultivate critical and creative thinking, along with other advanced cognitive skills.	4.79	0.11	Outstanding
3. Employs a variety of instructional tactics that improve student performance in literacy and numeracy abilities.	4.74	0.12	Outstanding
Overall Mean	4.78	0.12	Outstanding

Legend: 4.20 – 5.00, Outstanding; 3.40 – 4.19, Very Satisfactory; 2.60 – 3.39, Satisfactory; 1.80 – 2.59, Unsatisfactory; 1.00 – 1.79, Poor

The level of Science teachers' high-quality traits in terms of teaching strategies is displayed in Table 5. In general, science teachers possess outstanding qualities in utilizing teaching strategies (x̄=4.78, SD=0.12).

The result means that science teachers exert extraordinary efforts, knowledge, and skills to have in-depth practices and use different methods by integrating science in preparation for developing science skills among students. DepEd has launched the use of the Khan Academy application in teaching science as part of the strategy. The result implies that Science teachers use the 5Es approach and other methods in teaching Science based on the classroom observation tool.

Doyle et al.'s study (2020) suggests that teachers who have been in the classroom for a long time are familiar with various teaching strategies. They arrived at learning strategies for a wide range of scenarios. Teachers had high-level knowledge of science instructional strategies (Fulden-Guler, 2021).

Table 6. *Level of Science Teachers' High-Quality Traits in Terms of Curricular Knowledge*

Topics	*Mean*	*SD*	*Verbal Description*
Living Things and Their Environment	4.40	0.13	Very High Extent
Earth and Space	4.11	0.31	High Extent
Force, Motion, Energy	4.11	0.09	High Extent
Matter	4.00	0.11	High Extent
Overall Mean	4.16	0.16	High Extent

Legend: 4.20 – 5.00, Very High Extent; 3.40 – 4.19, High Extent; 2.60 – 3.39, Moderate Extent; 1.80 – 2.59, Less Extent; 1.00 – 1.79, Least Extent

Table 6 demonstrates the level of science teachers' high-quality traits relative to curricular knowledge. Science teachers manifested high-quality traits in their curricular knowledge (x̄=4.16, SD=0.16).

The result indicates that science teachers understand the range of programs designed to teach a particular topic or subject at a particular level. Furthermore, they possess an extraordinary understanding of the curriculum on how respiratory and circulatory systems work together, the functioning of respiratory and circulatory systems, and the location of genes in chromosomes. The result implies that science teachers are knowledgeable and have satisfactorily mastered the pedagogical content in the science curriculum, specifically on living things and their environment, earth movements and space, force, motion, energy, and matter.

The present study is inconsistent with Azam's ideas (2019). Topics about force and motion are incorporated into K -12 science curricula and are perceived as challenging for science educators due to their abstract characteristics. Educators instruct based on their comprehension of a concept regardless of its validity, and students' perceptions reflect this understanding (Sodervik et al., 2014).

Level of Basic Science Process Skills of the Students

The second research problem concerns the students' level of basic science process skills. Table 7 presents the study's findings.

The students manifested a beginning proficiency level in basic Science skills (x̄=0.36, SD=0.37). The result means most students possess low foundational science skills relative to integrating PISA concepts. These skills are closely related to science learning, following the nature of science, product, process, and attitude dimensions. The result implies that the students only apply a small amount of scientific knowledge to select common scenarios. They can present obvious scientific explanations that flow directly from the evidence.

Table 7. *Level of the Students' Basic Science Process Skills as shown in PISA 1 Results*

Skill	*Mean*	*SD*	*Verbal Description*
Observing	0.36	0.48	Beginning Proficiency
Comparing	0.46	0.54	Beginning Proficiency
Classifying	0.58	0.49	Minimal Proficiency
Measuring	0.02	0.13	Beginning Proficiency
Inferring	0.45	0.50	Beginning Proficiency
Predicting	0.42	0.18	Beginning Proficiency
Communicating	0.20	0.25	Beginning Proficiency
Overall Mean	0.36	0.37	Beginning Proficiency

Legend: 0.91+, Exceptional Proficiency; 0.81-0.90, Advance Proficiency; 0.71-0.80, High Proficiency; 0.61-0.70, Basic Proficiency; 0.51-0.60, Minimal Proficiency; 0.00-0.50, Beginning Proficiency

Kruea-In and Fakcharoenphol's ideas (2015) indicate that fundamental scientific process abilities establish an intellectual foundation for scientific investigation. These abilities encompass observing, classifying, measuring, forecasting numerically, utilizing spatial and temporal linkages, concluding, and communicating.

The learners' fundamental and integrated SPS were assessed as medium and low. Moreover, a notable disparity existed in students' performance relative to their majors, gender, and grade levels. Students exhibiting a high basic SPS score tended to achieve a higher integrated SPS score (Irwanto & Prodjosantoso, 2018).

Science education should enable students to refine, elucidate, or pose scientifically relevant inquiries, design and execute experiments to gather data about these inquiries, construct explanations based on evidence to address the questions, connect explanations with scientific principles, and articulate and substantiate their inquiries (Kusuma & Rusmansyah, 2022).

The Level of Integrated Science Process Skills of the Students

The third research problem determines the students' level of integrated science process skills. The study's findings are shown in Table 8.

Table 8. *Level of the Students' Integrated Science Process Skills as shown in PISA 2 Results*

Skills	*Mean*	*SD*	*Verbal Description*
Collecting Data	0.54	0.50	Minimal Proficiency
Interpreting Data	0.52	0.50	Minimal Proficiency
Formulating Hypothesis	0.53	0.50	Minimal Proficiency
Identifying Variables	0.52	0.50	Minimal Proficiency
Defining Operationally	0.59	0.49	Minimal Proficiency
Controlling Variables	0.46	0.50	Beginning Proficiency
Formulating Models	0.52	0.50	Minimal Proficiency
Experimenting	0.44	0.50	Beginning Proficiency
Overall Mean	0.51	0.50	Minimal Proficiency

Legend: 0.91+, Exceptional Proficiency; 0.81-0.90, Advance Proficiency; 0.71-0.80, High Proficiency; 0.61-0.70, Basic Proficiency; 0.51-0.60, Minimal Proficiency; 0.00-0.50, Beginning Proficiency

The findings reveal that students' overall integrated Science process skills are minimal proficiency ($\bar{x}$=0.51, SD=0.50). The result indicates that students can show their understanding and skills regarding higher skills. The result implies that most students with integrated science skills possess credible explanations in common circumstances or draw findings from modest studies. It leads to understanding the lessons patterned in PISA and engaging in direct reasoning and accurate interpretations of scientific or technological findings.

The present findings are relevant to the ideas of Temiz (2020) that integrated science process skills involve identifying and defining variables, gathering and transferring data, creating data tables and graphs, explaining the relationships between variables, interpreting data, modifying data, modifying materials, developing hypotheses, planning investigations, drawing generalizations, and drawing conclusions are all examples of integrated science process skills (Kim, 2018). According to Inaya et al. (2020), most integrated scientific procedures learned are good. It was also observed that pupils with high SPS can better understand the material.

Significant Relationship between the Science Teachers' High-Quality Traits and Basic and Integrated Science Process Skills of the Students

The fourth research problems deal with the significant relationship between Science teachers' high-quality traits and students' basic and integrated science process skills.

Table 9 presents the significant relationship between the science teachers' high-quality traits and the students' basic and integrated science process skills. As shown, the high-quality traits in teaching strategies are significantly related to teachers' basic science process skills (t-computed=0.620 > t critical =0.553). The result implies that the teaching strategies of science teachers could affect their basic science process skills in teaching Science lessons based on the PISA approach. In another way, the increase or decrease of the students' basic science process skills depends on the quality traits of science teachers' in using the different teaching strategies that aligned with the PISA approach.

Table 9. *Relationship between the Science Teachers' High-Quality Traits and Basic and Integrated Science Process Skills of the Students*

Quality Traits	*PISA 1 (Basic Science Process Skills)*	*PISA 2 (Integrated Science Process Skills)*
Dimension 1 (Content Knowledge)	-0.369	-0.045
Dimension 2 (Pedagogical Knowledge)	-0.405	-0.039
Dimension 3 (Curricular Knowledge)	0.297	-0.251
Dimension 4 (Teaching Strategies)	-0.620*	0.134
Dimension 5 (Classroom Management)	-0.298	-0.215
Overall QT	0.03	-0.245

Note: critical r (df=11, .05) = 0.553

Seemingly, evidence shows that no significant relationship was manifested on the content knowledge (t-value=-0.369; -0.045), pedagogical knowledge (t-value=-0.405; -0.039), curricular knowledge (t-value=0.297; -0.251) and classroom management (t-value=-0.298; -0.215) on the basic and integrated Science process skills of the students. This means that teachers' quality traits on their pedagogical knowledge, curricular knowledge and classroom management could not affect the science process skills of students in basic and integrated. The effectiveness of the teachers in the mentioned quality traits has no bearing to improve the basic and integrated science process skills of the students.

Kurniawan et al. (2020) indicated that scientific process skills are crucial for cultivating students' critical thinking through effective pedagogical tactics. Instructing science process skills aims to enhance students' comprehension of facts and concepts and their interrelation with scientific theory and influence their views toward the discipline. Using fundamental scientific skills can be successfully illustrated through experiential, practical activity (Juhji & Nuangchalerm, 2020).

Furthermore, Saputro (2019) asserted that scientific process skills and manipulative abilities are essential competencies that students must cultivate and should serve as the standard objectives for science education in schools. Consequently, effective learning strategies must be employed to enhance pupils' skills acquisition.

Significant Difference in the Basic and Integrated Science Process Skills of Students

The fifth research problem concerns the significant difference in the students' basic and integrated science process skills. Table 10 shows the study's findings.

Table 10. *Results of the T-test analysis between the Basic and Integrated Science Process Skills of the Students*

Skills	*n*	*Mean*	*SD*	*df*	*t*	*p*
Basic Students Process Skills	162	5.06	2.11	322	-4.08	0.0001
Integrated Students Process Skills	162	6.30	3.25			

Note: p<.05, significant

The findings reveal that the t-test analysis of the students' basic and integrated science process skills showed a significant difference (t-stat= -4.08, p=0.0001), which was less than 0.05 significance level. Thus, the null hypothesis is rejected; hence, there is a significant difference in the students' basic and integrated science process skills as manifested in the mean scores. The result implies that students perform better or higher in different Science process skills, particularly in integrated processes, through exhibiting in-depth information analysis and possessing the ability to execute the integrated science process abilities of variable control, operational definition, hypothesis formulation, data interpretation, and experimentation with great proficiency. The integrated Science process skills are higher than the basic science skills because teachers are competent in using strategies to advance integrated science skills.

The integrated science process skills require higher order cognitive abilities which might have already developed well or have been allowed to grow in the learning environments in Science among students compared to the basic science skills. Variety of teaching strategies developed and implemented to improve students' SPS in classrooms (Gizaw & Sota, 2023).

This study is consistent with the findings of Jardinico III and Linaugo (2023) that gaining knowledge of the scientific method greatly aids students in developing their cognitive capacities and their ability to participate in the learning process actively. It piques students' curiosity about thinking and demonstrates the value of teaching process skills (Batisla-Ong, 2021). Students have the basic scientific knowledge required to attain integrated SPS. Students' having high level of proficiency in Science subject understands and applies scientific principles.

Significant Contribution of Teachers' Content Knowledge to Pedagogical Knowledge

The sixth research problem evaluates whether Teachers' Content Knowledge significantly contributes to Pedagogical Knowledge. Pedagogical content knowledge results from instructors' combining or synthesizing their pedagogical and subject-matter expertise.

Table 11. *Regression Analysis of the Science Teachers' Content Knowledge and Pedagogical Knowledge*

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	4.91	0.11	43.65	0.0000
Content Knowledge	-0.05	0.17	-0.28	0.7939

Notes: R2=.0071, F (1,11) =.0790, p=.7939

Table 11 reflects the regression analysis results between the science teachers' content and pedagogical knowledge (F (1,11) =.0790, p=.000) less than 0.05 significance level. Thus, the alternative hypothesis is accepted. The result means that content knowledge significantly contributes to the pedagogical knowledge of Science teachers. The result implies that content knowledge is used to determine the development of pedagogical and disciplinary science teachers. The higher content knowledge and pedagogical knowledge of Science teachers is effective in teaching science subjects.

Suharta and Parwati's (2020) study demonstrated a favorable, direct, and indirect association between pedagogical and subject knowledge. The teacher's comprehension of the subject matter is known as content knowledge (CK), whereas their grasp of learning and how pupils learn is known as pedagogical knowledge (PK).

Conclusions

The following conclusions were drawn from the findings and the tested hypothesis.

The basic proficiency level of the Science teachers shows their understanding of scientific concepts, specialized knowledge for creating effective instructional strategies which display an exceptional capacity to improve their teaching practice by using the 5Es approach and other strategies. Science teachers have very satisfactorily mastered the pedagogical content in the science curriculum.

The students have a low foundation of basic skills in applying scientific knowledge to learn science concepts by presenting scientific explanations that are obvious and flow directly from the evidences.

It also concludes that students possess acceptable science-integrated skills that help them understand the lessons patterned in PISA, engage in direct reasoning, and accurately interpret scientific inquiry.

Students' basic science process skills have significant relationship on science teachers' teaching strategies.

Lastly, students perform better in the integrated process by exhibiting in-depth information analysis and possessing the ability to execute different skills like variable control, operational definition, hypothesis formulation, data interpretation, and experimentation with great proficiency.

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