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Ronilo P. Antonio
Bulacan State University, Philippines

Jorge Victor M. Sales
De La Salle University, Philippines

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Development and Validation of the Perceived Scientific Inquiry Skills Questionnaire (P-SIS-Q) for Preservice Science Teachers

Ronilo P. Antonio, Jorge Victor M. Sales

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Abstract

In today's dynamic educational landscape, equipping preservice science teachers (PSSTs) with strong scientific inquiry skills is essential to advancing students' scientific literacy and promoting evidence-based reasoning in classrooms. Despite this importance, there is a lack of validated instruments specifically designed to assess PSSTs' self-perceived competencies in scientific inquiry. This study addresses that gap by developing and validating the Perceived Scientific Inquiry Skills Questionnaire (P-SIS-Q)—a self-report instrument originally composed of 31 items based on the Scientific Inquiry Skills Framework. The questionnaire was administered to 352 PSSTs enrolled at a state university in Central Luzon, Philippines. Exploratory factor analysis (KMO = .970; Bartlett's test, $p < .0001$) revealed a three-factor structure: (1) Planning and Conducting Scientific Investigations, (2) Analyzing, Interpreting, and Arguing from Evidence, and (3) Constructing Explanations and Communicating Findings. Internal consistency for each factor was high, with Cronbach's alpha values of .888, .895, and .864, respectively. Results showed that PSSTs perceived themselves as generally proficient in scientific inquiry, particularly in communicating scientific findings. However, they reported comparatively lower confidence in data analysis and argumentation—highlighting a need for targeted pedagogical support in these higher-order skills. The validated P-SIS-Q offers a reliable and contextually relevant tool for assessing scientific inquiry competencies in teacher education. Its development responds to the growing demand for inquiry-based science instruction and aligns with global education priorities, as reflected in international benchmarks such as PISA. The instrument can inform curriculum development, teacher training, and further research aimed at enhancing inquiry-driven science teaching across diverse educational contexts.

Introduction

Preservice science teacher education plays a pivotal role in shaping the capacity of future educators to foster scientific literacy among students—a cornerstone of 21st-century science education and a key driver of informed global citizenship (American Association for the Advancement of Science, 1993; K to 12 Science Curriculum, 2016). Scientific literacy goes beyond simply acquiring factual knowledge; it encompasses the ability to apply scientific concepts, develop informed opinions on socioscientific issues, and engage in meaningful inquiry. Central to this is the development of process skills, particularly the ability to think critically, evaluate evidence, and engage in scientific inquiry (National Research Council, 2007; Feyzioğlu, 2019). As global challenges such as misinformation, climate change, and health crises demand a scientifically literate public, the role of inquiry-based science education has become more urgent and indispensable.

Scientific inquiry, as a pedagogical and cognitive framework, empowers learners to explore the natural world through a blend of analytical, logical, and creative thinking. It entails asking investigable questions, formulating hypotheses, designing and conducting experiments, analyzing data, and effectively communicating findings (Antonio & Prudente, 2024; Llewelyn, 2013; SEI-DOST & NISMED, 2011). These competencies are foundational for students to function as critical thinkers and informed decision-makers. However, their development begins with teachers—particularly preservice science teachers (PSSTs)—who must model and scaffold these practices in authentic classroom contexts. PSSTs are expected to not only understand scientific inquiry theoretically but also embody its principles in practice, thereby cultivating a classroom culture where inquiry, reasoning, and evidence-based discussion are the norm.

Despite this recognized importance, current literature reveals a significant gap in understanding PSSTs' actual competencies and readiness to implement scientific inquiry-based instruction. Much of the existing research has focused on preservice teachers' conceptual grasp of inquiry, with limited attention to their practical skills or self-assessed preparedness. For instance, Özer and Sarıbaş (2022) examined how PSSTs engaged with scientific practices during laboratory courses, while García-Carmona et al. (2017) explored their skills in inquiry planning through guided tasks. Similarly, Güngören and Öztürk (2021) assessed PSSTs' perspectives on the nature of scientific inquiry, revealing surface-level understanding and limited depth in applying inquiry in real-world teaching scenarios. These findings suggest that while inquiry is emphasized in teacher preparation, gaps remain in how well preservice teachers perceive and internalize these skills as actionable teaching practices.

Furthermore, although a number of assessment tools for scientific inquiry exist, these are largely geared toward elementary and secondary students rather than preservice teachers. For example, Feyzioğlu (2019) developed a scale to measure self-efficacy in inquiry skills among middle-grade learners, while Lou et al. (2015) validated an inquiry skills assessment in Earth science contexts. Arnold et al. (2013) created the Science Process Skills Inventory (SPSI) for use in youth development science programs. While these instruments contribute to the broader field, they are not tailored to the unique cognitive and pedagogical demands faced by PSSTs, particularly those transitioning from student to teacher roles.

This gap is particularly critical in the Philippine education landscape. Recent results from the 2018 and 2022 Programme for International Student Assessment (PISA) indicate that Filipino students rank among the lowest globally in science performance. Many students struggle with interpreting data, evaluating scientific claims, and engaging in evidence-based reasoning—core competencies developed through sustained scientific inquiry. These results not only signal systemic challenges but also highlight the urgent need to strengthen the preparation of science teachers who can reverse this trend. Future educators must be equipped not just with content knowledge but with the pedagogical skills to nurture inquiry, critical thinking, and scientific communication among their learners.

Compounding this urgency are the pedagogical shifts brought about by the COVID-19 pandemic, which has redefined the delivery of science education. Remote and blended learning environments have challenged traditional methods, requiring teachers to design and implement inquiry-rich activities in virtual or hybrid formats. This transformation demands an even greater emphasis on teachers' ability to facilitate student-centered, inquiry-driven learning that fosters autonomy, curiosity, and deep understanding (Antonio, 2022). In this context, assessing PSSTs' perceived scientific inquiry skills is essential—not only to determine their readiness but also to inform the development of responsive training and support programs.

Despite the magnitude of this need, no validated instrument currently exists to assess the self-perceived scientific inquiry skills of Filipino preservice science teachers. This absence limits the ability of teacher education programs to evaluate and enhance inquiry competencies in a systematic, data-informed manner. There is thus a critical need to develop a culturally responsive, psychometrically sound tool that can provide insights into PSSTs' strengths and areas for growth. To address this gap, the present study seeks to develop and validate the Perceived Scientific Inquiry Skills Questionnaire (P-SIS-Q) specifically for use among preservice science teachers in the Philippines. The study aims to:

1. identify the underlying components of PSSTs' perceived scientific inquiry skills;
2. establish the reliability and construct validity of the P-SIS-Q, and;
3. assess the self-reported levels of scientific inquiry skills among PSSTs.

By providing a reliable instrument tailored to the Philippine context, this research contributes to the broader goals of enhancing science teacher education and improving inquiry-based instruction. The findings have the potential to inform curriculum design, teacher training programs, and national education policies, aligning local teacher preparation efforts with global initiatives aimed at fostering scientific literacy through inquiry.

Method

Research Design

This study employed Hinkin's (1997) model as the foundational framework for the systematic development and validation of a psychometrically sound instrument. The instrument development process followed a structured sequence that included item generation, content validation by expert reviewers, pilot administration, exploratory factor analysis (EFA), and internal consistency reliability testing. Specifically, exploratory factor analysis was utilized to identify the underlying factor structure of the instrument designed to assess the perceived scientific inquiry skills of preservice science teachers (PSSTs). The construction of questionnaire items was grounded in a comprehensive review of existing literature and theoretical frameworks relevant to scientific inquiry competencies. To complement the instrument validation, the study also adopted a descriptive survey research design to gather and analyze PSSTs' self-reported perceptions of their scientific inquiry skills. This approach allowed the researchers to generate quantitative insights into the skill profiles of future science educators.

Research Locale and Respondents

The study was conducted at a state university located in Central Luzon, Philippines. The respondents consisted of preservice science teachers enrolled in the Bachelor of Secondary Education major in Science program. Participants were selected through purposive sampling, with inclusion criteria focused on students actively enrolled in science education coursework. Following the administration of the instrument and subsequent data cleaning procedures, a total of 352 valid responses were retained for analysis. The demographic profiles of these respondents—including sex, age, year level, preferred learning modality, and prior experience with inquiry-based learning—are illustrated in Figure 1. This sample size met the recommended thresholds for factor analysis and provided a robust dataset for psychometric evaluation.

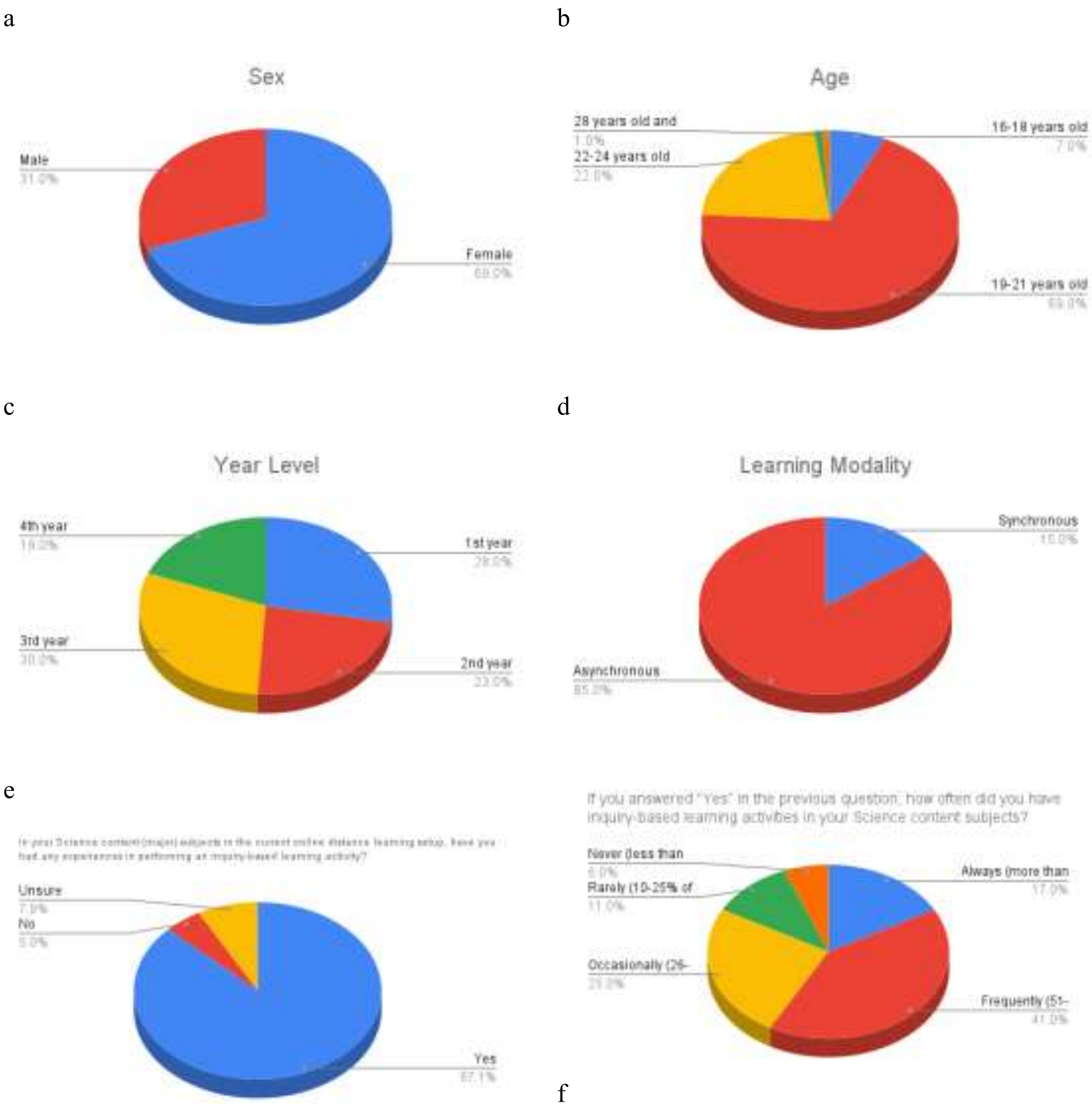

Figure 1. Profile of the Preservice Science Teachers

Of the 352 preservice science teachers (PSSTs) who participated in the study, 69% were female and 31% were male. In terms of age distribution, the majority (69%) were between 19 to 21 years old, followed by 22% who were aged 22 to 24, and 7% who fell within the 16 to 18 age range. Regarding academic year level, 30% were in their third year, 28% in their first year, 23% in their second year, and 19% in their fourth year. With respect to learning modalities during the academic year, a substantial majority (85%) reported engaging in asynchronous online learning, while 14% participated in synchronous online classes. Additionally, the vast majority (88%) of respondents indicated having prior experience with inquiry-based learning activities, whereas 5% reported no such experience and 8% were unsure. Notably, most PSSTs claimed to frequently engage in inquiry-based tasks, suggesting a level of familiarity with instructional approaches aligned with scientific inquiry.

Instrument

Perceived Scientific Inquiry Skills Questionnaire (P-SIS-Q)

The Perceived Scientific Inquiry Skills Questionnaire (P-SIS-Q) is a self-report survey instrument specifically developed for this study to assess preservice science teachers' (PSSTs') perceived competencies in scientific inquiry. The initial version of the P-SIS-Q comprised 31 items, organized into two main sections. The first section gathered demographic information, including respondents' sex, age, academic year level, preferred learning modality, and prior experience with inquiry-based learning activities. The second section focused on participants' self-assessment of their scientific inquiry skills.

The construction of the instrument was grounded in relevant literature and existing assessment tools (Arnold et al., 2013; Lou et al., 2015; National Research Council, 2012). It was primarily informed by the Scientific Inquiry Skills Framework (Lou et al., 2015), which originally grouped the items into six dimensions: asking questions (4 items), planning investigations (6 items), carrying out investigations (5 items), analyzing and interpreting data (5 items), constructing explanations (5 items), and engaging in argument from evidence (6 items). Respondents rated their level of agreement with each statement using a four-point Likert scale, where 4 indicated "Strongly Agree," 3 "Agree," 2 "Disagree," and 1 "Strongly Disagree." This scale was chosen to encourage decisive responses and minimize neutrality in self-evaluations.

Table 1. Expert-validators' Rating Results

Criteria	Mean	SD
Clarity and Direction of Items	4.67	0.58
Presentation and Organization of Items	4.67	0.58
Suitability of Items	5.00	0.00
Adequateness of the Content	4.67	0.58
Attainment of Purpose	5.00	0.00
Objectivity	5.00	0.00
Scale and Evaluation Rating	5.00	0.00
Overall Mean	**4.86**	**0.25**

To establish content validity, the questionnaire was reviewed by three science education specialists holding advanced degrees (Master's and Doctorate) in Science Education. The experts evaluated the instrument based on several criteria, including clarity and direction of items, presentation and organization, relevance and appropriateness of content, objectivity, purpose attainment, and the accuracy of the scaling system. As presented in Table 1, the instrument received an overall weighted mean of 4.86 (SD = 0.25), reflecting a high level of acceptability and expert endorsement of its content and structure.

Data Collection Procedures

The Perceived Scientific Inquiry Skills Questionnaire (P-SIS-Q) was administered as an online survey via Google Forms. Prior to data collection, formal ethical clearance and permission were obtained from the university administration. Upon approval, the online survey link was disseminated through program heads and coordinators, who facilitated its distribution to eligible preservice science teachers (PSSTs). At the onset of the survey, participants were prompted to carefully review an informed consent form, which outlined the study's purpose, procedures, estimated duration, potential risks and benefits, and provisions for confidentiality and anonymity. Participants were explicitly informed that their involvement was voluntary, and they could withdraw at any time without penalty. Data collection was conducted during the second semester of Academic Year 2021–2022, a period when the university was implementing flexible learning modalities in response to pandemic-related disruptions. Students were permitted to choose their preferred learning delivery mode, which included synchronous online learning, asynchronous online learning, or remote print-based learning.

Data Analysis

The collected data were analyzed using Statistical Package for the Social Sciences (SPSS) version 23. The analysis focused on evaluating the validity and reliability of the P-SIS-Q instrument through a series of statistical procedures. To assess the content validity, expert validation results were synthesized. For construct validity, the suitability of the dataset for factor analysis was first confirmed using the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. Subsequently, Exploratory Factor Analysis (EFA) was conducted using Principal Component Analysis (PCA) with direct oblimin rotation ($\delta = 0$) to account for possible correlations between factors (Costello & Osborne, 2005; Schreiber, 2021).

Table 2. Descriptive Interpretation

Range	Response	Verbal Interpretation
3.50-4.00	Strongly Agree	Very High
2.50-3.49	Agree	High
1.50-2.49	Disagree	Low
1.00-1.49	Strongly Disagree	Very Low

The factor structure was examined to identify underlying dimensions of perceived scientific inquiry skills. To evaluate the internal consistency reliability of each factor, Cronbach's alpha coefficients were calculated. Interpretation of reliability and validation outcomes was guided by established psychometric literature (Costello & Osborne, 2005; MacCallum et al., 1999, 2001; Jung, 2013; Watkins, 2018). In addition, descriptive statistics—

including frequency, percentage, mean, and standard deviation—were computed to describe PSSTs' self-perceived scientific inquiry skills. Each item's mean score, as well as the overall mean, was interpreted using a predefined scale (see Table 2), allowing for clear categorization of skill levels across key domains.

Results and Discussion

The Perceived Scientific Inquiry Skills Questionnaire (P-SIS-Q) was initially developed and subjected to external content validation by a panel of experts in science education. To establish its internal structural validity, the instrument underwent Exploratory Factor Analysis (EFA). Prior to conducting EFA, assumption testing was carried out to assess the dataset's suitability for factor analysis. The results of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy yielded an excellent value of .970, while Bartlett's Test of Sphericity produced a highly significant result ($\chi^2(465) = 6998.105$, $p < 0.0001$), thereby confirming that the data met the necessary prerequisites for factor extraction. Following these tests, Principal Component Analysis (PCA) with direct oblimin rotation ($\delta = 0$) was employed to explore the underlying factor structure of the instrument, in alignment with the methodological recommendations of Costello and Osborne (2005) and Schreiber (2021). The communalities reported in Table 3 ranged from 0.485 to 0.665, indicating that each item shared a moderate to strong proportion of variance with the extracted components, consistent with the benchmarks established by Mundfrom et al. (2005). Furthermore, the sample size ($n = 352$) was sufficiently robust to support the factor analysis, exceeding the minimum thresholds for reliable communalities and stable factor structures as outlined by Jung (2013) and MacCallum et al. (2001).

Table 3. Communalities

	Initial	Extraction
1. I can ask questions that arise from careful observations about the natural world (e.g., materials, events, phenomena, and experiences).	1.000	.513
2. I can identify a testable question that can be answered through a scientific investigation.	1.000	.587
3. I can evaluate a question to determine if it is testable and relevant.	1.000	.635
4. I can formulate a reasonable hypothesis that can be tested through a scientific investigation.	1.000	.619
5. I can set the objectives of a scientific investigation.	1.000	.597
6. I can identify and define variables operationally.	1.000	.603
7. I can plan a procedure to solve a particular problem.	1.000	.509
8. I can select a suitable design for an investigation to test a particular hypothesis.	1.000	.557
9. I can identify the independent, dependent, and controlled variables involved in a scientific investigation.	1.000	.496
10. I can identify flaws in the design of a scientific investigation.	1.000	.564

	Initial	Extraction
11. I can conduct a scientific investigation using appropriate procedure, materials, tools, and equipment to gather evidence.	1.000	.519
12. I can gather and record data through observation and instrumentation.	1.000	.633
13. I can compare, group, and/or order objects by characteristics.	1.000	.540
14. I can select an appropriate unit of measurement to achieve precision and consistency.	1.000	.563
15. I can describe an object in relation to another object (e.g., its position, motion, direction, symmetry, spatial arrangement, or shape).	1.000	.509
16. I can differentiate explanations from descriptions.	1.000	.418
17. I can construct a graph (e.g. line graph) that represents the collected data in a scientific investigation.	1.000	.485
18. I can identify patterns and relationships of variables in the collected data in a scientific investigation.	1.000	.599
19. I can apply statistical methods to numerical data to reach and support conclusions.	1.000	.558
20. I can organize and analyze data accurately and precisely.	1.000	.605
21. I can use data and information gathered from the investigation to develop an explanation.	1.000	.665
22. I can draw evidence-based conclusions from the data gathered.	1.000	.584
23. I can draw a conclusion about the cause-and-effect relationships in the data.	1.000	.642
24. I can apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena.	1.000	.631
25. I can differentiate inference from observations.	1.000	.621
26. I can consider alternative or possible explanations of the data gathered from an investigation.	1.000	.614
27. I can differentiate concluding statement(s) that follow logically from the data and those that may relate to faulty reasoning and misinterpretation.	1.000	.602
28. I can identify possible reasons for inconsistent results, such as sources of error or in a scientific investigation.	1.000	.679
29. I can generate an argument or counter-arguments based on data and evidence.	1.000	.556
30. I can write a complete report of a scientific investigation.	1.000	.587
31. I can communicate the results of a scientific investigation with others using appropriate presentation tools (e.g., PowerPoint presentation).	1.000	.602
Extraction Method: Principal Component Analysis.		

Principal component analysis revealed three factors with eigenvalues greater than 1, which collectively explained 57.711% of the total variance (refer to Table 4). The highest eigenvalue was 15.676 as the highest while the lowest was 1.060. This also shows that an excellent level criterion pattern (3/100) with respect to the sample size to number of extracted factors and number of variables to number of factors ratio (31/3) (Mund from Shaw, & Ke, 2005). The scree plot in Figure 2 further reflects the calculated factors.

Table 4. Total Variance Explained

Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	15.676	50.567	50.567	15.676	50.567	50.567
2	1.155	3.726	54.293	1.155	3.726	54.293
3	1.060	3.418	57.711	1.060	3.418	57.711
4	.940	3.031	60.742			
5	.858	2.768	63.510			
6	.733	2.366	65.876			
7	.711	2.292	68.168			
8	.681	2.196	70.364			
9	.638	2.058	72.421			
10	.591	1.905	74.326			
11	.586	1.889	76.215			
12	.579	1.867	78.083			
13	.515	1.662	79.744			
14	.495	1.595	81.340			
15	.476	1.534	82.874			
16	.463	1.492	84.366			
17	.441	1.422	85.788			
18	.427	1.377	87.165			
19	.403	1.300	88.464			
20	.392	1.266	89.730			
21	.372	1.201	90.932			
22	.352	1.136	92.068			
23	.337	1.088	93.156			
24	.317	1.022	94.178			
25	.301	.970	95.148			
26	.293	.944	96.092			
27	.279	.900	96.992			
28	.273	.880	97.871			
29	.257	.828	98.699			
30	.213	.688	99.387			
31	.190	.613	100.000			

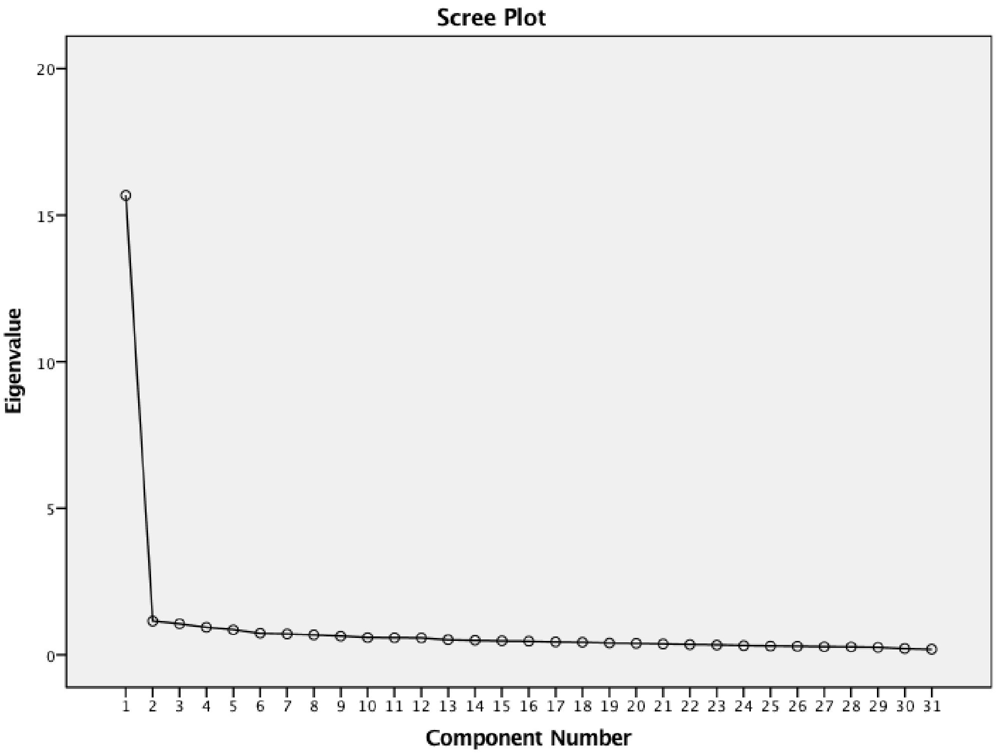

Figure 2. Scree Plot indicating the Number of Factors

The exploratory factor analysis of preservice science teachers' (PSSTs') perceived scientific inquiry skills yielded three distinct factors, each of which underwent composite reliability analysis to assess internal consistency. Following Taber's (2018) guidelines, Cronbach's alpha values above 0.70 are considered acceptable, while values in the 0.40 to 0.60 range may still be regarded as moderately reliable depending on the construct. The initial reliability analysis revealed high Cronbach's alpha coefficients of 0.913, 0.934, and 0.899 for Factors 1, 2, and 3, respectively. While these values suggest strong internal consistency, existing literature cautions that alpha coefficients exceeding 0.90 may indicate item redundancy—where multiple items measure the same aspect of a construct in a slightly repetitive manner (Jain & Angural, 2017; Tavakol & Dennick, 2011).

In light of this, a scale refinement process was conducted to improve parsimony without compromising reliability. For Factor 1, items 4 and 6 were removed, resulting in a revised alpha value of 0.888, which remained well within the acceptable range. Similarly, in Factor 2, items 18, 20, 25, and 28 were eliminated, reducing the alpha to 0.895—again reflecting strong reliability with reduced redundancy. In contrast, Factor 3 maintained a satisfactory reliability coefficient of 0.864, and therefore, no items were removed from this subscale. This refinement not only streamlined the instrument but also enhanced its efficiency and focus, resulting in a final 25-item questionnaire with robust psychometric properties suitable for assessing the perceived scientific inquiry skills of PSSTs.

Table 5 presents the three extracted factors from the exploratory factor analysis, along with their corresponding item loadings. Factor loadings with absolute values greater than |0.30| were retained for interpretation, in line with established thresholds in psychometric research (Bryant & Yarnold, 1995; Tavakol & Wetzel, 2020). Items were assigned to the factor on which they loaded most strongly, ensuring conceptual alignment and empirical clarity.

Table 5. Factor Loadings

	Factor 1	**Factor 2**	**Factor 3**
	Planning and Conducting scientific investigations	**Analyzing, Interpreting, and Arguing from Evidence**	**Constructing Explanations and Communicating Findings**
1. I can ask questions that arise from careful observations about the natural world (e.g., materials, events, phenomena, and experiences).	.693		
2. I can identify a testable question that can be answered through a scientific investigation.	.785		
3. I can evaluate a question to determine if it is testable and relevant.	.818		
5. I can set the objectives of a scientific investigation.	.671		
7. I can plan a procedure to solve a particular problem.	.516		
8. I can select a suitable design for an investigation to test a particular hypothesis.	.524		
9. I can identify the independent, dependent, and controlled variables involved in a scientific investigation.	.353		
11. I can conduct a scientific investigation using appropriate procedure, materials, tools, and equipment to gather evidence.	.461		
17. I can construct a graph (e.g. line graph) that represents the collected data in a scientific investigation.	.344		
10. I can identify flaws in the design of a scientific investigation.		.763	
14. I can select an appropriate unit of measurement to achieve precision and consistency.		.625	
15. I can describe an object in relation to another object (e.g., its position, motion, direction, symmetry, spatial arrangement, or shape).		.513	
16. I can differentiate explanations from descriptions.		.494	
19. I can apply statistical methods to numerical data to reach and support conclusions.		.794	
26. I can consider alternative or possible explanations of the data gathered from an investigation.		.617	
27. I can differentiate concluding statement(s) that		.821	

follow logically from the data and those that may relate to faulty reasoning and misinterpretation.			
29. I can generate an argument or counterarguments based on data and evidence.		.537	
30. I can write a complete report of a scientific investigation.		.692	
12. I can gather and record data through observation and instrumentation.			-.523
13. I can compare, group, and/or order objects by characteristics.			-.372
21. I can use data and information gathered from the investigation to develop an explanation.			-.625
22. I can draw evidence-based conclusions from the data gathered.			-.502
23. I can draw a conclusion about the cause-and-effect relationships in the data.			-.477
24. I can apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena.			-.387
31. I can communicate the results of a scientific investigation with others using appropriate presentation tools (e.g., PowerPoint presentation).			-.574

The first factor, labeled “Planning and Conducting Scientific Investigations,” consisted of nine items with loadings ranging from 0.344 to 0.818. This factor encapsulates PSSTs' self-perceived abilities in initiating and carrying out scientific investigations. Specifically, it reflects their skills in formulating testable questions, setting investigation goals, selecting appropriate procedures, and identifying key variables. These competencies represent foundational inquiry practices, suggesting that PSSTs view scientific inquiry as a process grounded in observation, structured investigation, and systematic planning. Items within this factor were primarily derived from the original categories of asking questions, planning investigations, and carrying out investigations.

The second factor, named “Analyzing, Interpreting, and Arguing from Evidence,” included items with loadings ranging from 0.494 to 0.821. This factor embodies PSSTs’ perceived competencies in managing and interpreting data, making evidence-based conclusions, and engaging in reasoned scientific discourse. It encompasses the ability to distinguish between explanation and description, apply statistical tools to analyze numerical data, and evaluate multiple interpretations of investigation results. Furthermore, it includes the skill to construct logical arguments and counterarguments grounded in empirical evidence. This merging of analysis and argumentation suggests that PSSTs do not view these as isolated processes but as interdependent skills cultivated during structured inquiry experiences. Items here originated from the initial dimensions of analyzing and interpreting data, conducting investigations, and engaging in argument from evidence.

The third factor, labeled "Constructing Explanations and Communicating Findings," comprised items with loadings between 0.372 and 0.574. Interestingly, the factor loadings for these items were negative, indicating a possible inverse correlation with other components of scientific inquiry skills. Despite this statistical inversion, the thematic coherence of the items remains intact. This factor reflects PSSTs' perceived abilities to synthesize findings, construct evidence-based explanations, and clearly communicate scientific results using appropriate tools and formats. It highlights their capacity to apply scientific knowledge to explain observed phenomena and convey conclusions to others. The items were originally sourced from categories such as constructing explanations, engaging in argument from evidence, and carrying out investigations, with the majority stemming from constructing explanations.

Collectively, the 25-item final version of the instrument deviates from the six-component Scientific Inquiry Skills Framework developed by Lou et al. (2015), which was originally formulated within a U.S. educational context. This discrepancy likely reflects differences in cultural and instructional practices. In the Philippine science education system, students—including PSSTs—are commonly exposed to structured inquiry activities, where investigations are guided by predefined objectives, materials, and procedures. Such environments may offer limited opportunities for students to independently generate research questions, design methods, or engage in spontaneous argumentation. Consequently, Filipino PSSTs may conceptualize scientific inquiry in terms of integrated, rather than distinct, skills—leading to the convergence of several original dimensions into three broader factors.

In this study, PSSTs conceptualized conducting scientific investigations as a unified process encompassing the formulation, planning, and execution of inquiry. Similarly, analyzing, interpreting, and arguing from evidence were perceived as an interwoven skill set, likely due to the limited opportunities for open-ended discussion and critical evaluation in their prior educational experiences. As noted by Choi et al. (2021), barriers such as insufficient student experience, time constraints, class sizes, and limited teacher training contribute to the underutilization of argumentation in science classrooms. Consequently, PSSTs may view scientific argumentation not as a stand-alone component but as an embedded aspect of data analysis and interpretation. Finally, constructing explanations and communicating findings emerged as a distinct yet integrative factor, emphasizing the synthesis of conclusions and the articulation of results in meaningful ways.

In summary, this factor structure reveals that PSSTs perceive scientific inquiry as comprising three core dimensions: (1) conducting investigations, (2) analyzing and interpreting data with evidence-based reasoning, and (3) synthesizing and communicating findings. These findings underscore the influence of local educational contexts on how inquiry skills are understood and highlight the need to tailor science teacher preparation programs to better support the development of each skill dimension in a more balanced and reflective manner.

Table 6. PSSTs' Perceived Scientific Inquiry Skills in Planning and Conducting Scientific Investigations

Statements	**SD**	**D**	**A**	**SA**	**Mean**	**Std. Dev.**
1. I can ask questions that arise from careful observations about the natural world (e.g.,	0	5.4%	56.5%	38.1%	3.33	.57

Statements	SD	D	A	SA	Mean	Std. Dev.
materials, events, phenomena, and experiences).						
2. I can identify a testable question that can be answered through a scientific investigation.	.3%	12.2%	59.9%	27.6%	3.15	.62
3. I can evaluate a question to determine if it is testable and relevant.	.6%	13.9%	56.5%	29%	3.14	.66
5. I can set the objectives of a scientific investigation.	.3%	11.4%	52.3%	36.1%	3.24	.65
7. I can plan a procedure to solve a particular problem.	.6%	10.5%	59.9%	29%	3.17	.62
8. I can select a suitable design for an investigation to test a particular hypothesis.	.3%	18.8%	60.8%	20.2%	3.00	.63
9. I can identify the independent, dependent, and controlled variables involved in a scientific investigation.	.3%	13.4%	54.5%	31.8%	3.18	.66
11. I can conduct a scientific investigation using appropriate procedure, materials, tools, and equipment to gather evidence.	.3%	11.6%	54.3%	33.8%	3.22	.65
17. I can construct a graph (e.g. line graph) that represents the collected data in a scientific investigation.	1.7%	10.8%	49.1%	38.4%	3.24	.71
Weighted Mean					**3.19**	**.47**

Note: Strongly Disagree (SD); Disagree (D); Agree (A); Strongly Agree (SA)

As shown in Table 6, nearly 95% of preservice science teachers (PSSTs) expressed a strong belief in their ability to effectively formulate and identify scientific questions derived from careful observation of natural phenomena. This particular item received the highest mean score of 3.33 (SD = 0.57), indicating a high level of confidence among PSSTs in initiating the inquiry process. This finding suggests that PSSTs are generally adept at recognizing investigable phenomena—an essential first step in the scientific inquiry cycle. In contrast, the item that received the lowest mean score of 3.00 (SD = 0.63) pertained to selecting an appropriate investigation design to test a specific hypothesis. This lower rating implies that PSSTs may experience challenges in translating research questions into methodologically sound investigation plans. Such a finding points to a potential gap in their procedural knowledge and highlights the need for more explicit instruction and modeling in experimental design within teacher preparation programs. Despite this noted difficulty, PSSTs overall reported a high perceived level of competence in planning and conducting scientific investigations, with an average mean score of 3.19 (SD = 0.47) across the subscale. The relatively small standard deviation suggests a consistent level of confidence among participants. These results underscore the importance of reinforcing investigation design skills in teacher education curricula to ensure PSSTs are fully prepared to guide authentic, inquiry-based learning experiences in their future classrooms.

Table 7. PSSTs' Perceived Scientific Inquiry Skills in Analyzing, Interpreting, and Arguing from Evidence

Statements	SD	D	A	SA	Mean	Std. Dev.
10. I can identify flaws in the design of a scientific investigation.	.9%	25.6%	54.8%	18.8%	2.91	.69
14. I can select an appropriate unit of measurement to achieve precision and consistency.	.9%	16.2%	54.8%	28.1%	3.10	.68
15. I can describe an object in relation to another object (e.g., its position, motion, direction, symmetry, spatial arrangement, or shape).	1.1%	13.1%	57.1%	28.7%	3.13	.67
16. I can differentiate explanations from descriptions.	.9%	7.4%	50.0%	41.8%	3.33	.65
19. I can apply statistical methods to numerical data to reach and support conclusions.	1.4%	23.0%	55.4%	20.2%	2.94	.70
26. I can consider alternative or possible explanations of the data gathered from an investigation.	.6%	13.6%	59.9%	25.9%	3.11	.64
27. I can differentiate concluding statement(s) that follow logically from the data and those that may relate to faulty reasoning and misinterpretation.	.6%	21.6%	58.5%	19.3%	2.97	.66
29. I can generate an argument or counterarguments based on data and evidence.	.3%	19.3%	56.5%	23.9%	3.04	.67
30. I can write a complete report of a scientific investigation.	.3%	24.1%	55.4%	20.2%	2.95	.67
Weighted Mean					3.05	.49

Note: Strongly Disagree (SD); Disagree (D); Agree (A); Strongly Agree (SA)

As illustrated in Table 7, preservice science teachers (PSSTs) reported a high perceived level of competence in the domain of data analysis, interpretation, and argumentation. Among the items in this factor, the statement regarding their ability to distinguish between explanations and descriptions received the highest mean score of 3.33 (SD = 0.65). The low standard deviation indicates a strong consensus among participants, suggesting that PSSTs are confident in differentiating between descriptive observations and explanatory statements—a foundational skill in scientific reasoning and communication. Conversely, the skill that received the lowest mean score of 2.94 (SD = 0.70) was related to the ability to identify flaws in the design of a scientific investigation. This skill is critical in the context of scientific argumentation, as recognizing methodological weaknesses strengthens the quality of evidence-based reasoning and supports the construction of valid scientific claims. The lower rating in this area suggests that while PSSTs are generally confident in interpreting data and constructing arguments, they may need additional training in evaluating the rigor and validity of experimental designs, a higher-order skill essential for full engagement in argument-driven inquiry. Overall, the weighted mean score of 3.05 (SD = 0.49) for this factor indicates that PSSTs possess a strong self-perception of their skills in analyzing data, interpreting results, and engaging in scientific argumentation. However, the variation in item-level responses highlights specific areas—particularly critical evaluation of experimental design—where targeted instructional support could further enhance their competence and readiness to implement inquiry-based instruction effectively.

Table 8. PSSTs' Perceived Scientific Inquiry Skills in Constructing Explanations and Communicating Findings

Statements	SD	D	A	SA	Mean	Std. Dev.
12. I can gather and record data through observation and instrumentation.	0	6.8%	53.4 %	39.8%	3.33	.60
13. I can compare, group, and/or order objects by characteristics.	0	9.1%	53.1 %	37.8%	3.29	.62
21. I can use data and information gathered from the investigation to develop an explanation.	.3%	8.0%	54.8 %	36.9%	3.28	.62
22. I can draw evidence-based conclusions from the data gathered.	.9%	14.2 %	55.1 %	29.8%	3.14	.68
23. I can draw a conclusion about the cause-and-effect relationships in the data.	.6%	9.4%	53.4 %	36.6%	3.26	.64
24. I can apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena.	.3%	11.4 %	57.4 %	31.0%	3.19	.63
31. I can communicate the results of a scientific investigation with others using appropriate presentation tools (e.g., PowerPoint presentation).	.3%	9.1%	48.0 %	42.6%	3.33	.65
Weighted Mean					**3.26**	**.50**

Note: Strongly Disagree (SD); Disagree (D); Agree (A); Strongly Agree (SA)

With regard to constructing explanations and communicating findings, preservice science teachers (PSSTs) demonstrated a high perceived level of competence, as reflected in the results presented in Table 8. Notably, two statements shared the highest mean score of 3.33, each accompanied by relatively low standard deviations (SD = 0.60). These statements pertained to the PSSTs' ability to gather and record data through observation and instrumentation, as well as their proficiency in communicating the results of a scientific investigation using appropriate presentation tools. These findings suggest that PSSTs feel confident in both the technical and communicative aspects of inquiry, particularly in recording observations and sharing results effectively. This high self-assessed proficiency in presentation may, in part, be attributed to their exposure to educational technology tools during the online and distance learning environment implemented throughout the pandemic. These modalities have likely equipped PSSTs with digital literacy and communication skills necessary for preparing and delivering science outputs through multimedia platforms, slide presentations, video recordings, and collaborative documents—skills that are now indispensable in modern science classrooms. However, the item regarding the ability to draw evidence-based conclusions from collected data received a slightly lower mean score of 3.14 (SD = 0.68). This suggests that while PSSTs are confident in gathering and presenting information, they may be less certain about their capacity to synthesize data into well-supported scientific conclusions. As this skill is closely tied to scientific argumentation, it reinforces earlier findings that point to a need for further development in higher-order reasoning and analytical skills. Despite this minor gap, the overall weighted mean score of 3.26 (SD = 0.50) for this factor confirms that PSSTs generally perceive themselves as proficient in constructing explanations and communicating findings. Their confidence in this area positions them well for facilitating student-centered investigations that require not only data collection but also the clear and effective dissemination of results—both essential to fostering scientific literacy in the classroom.

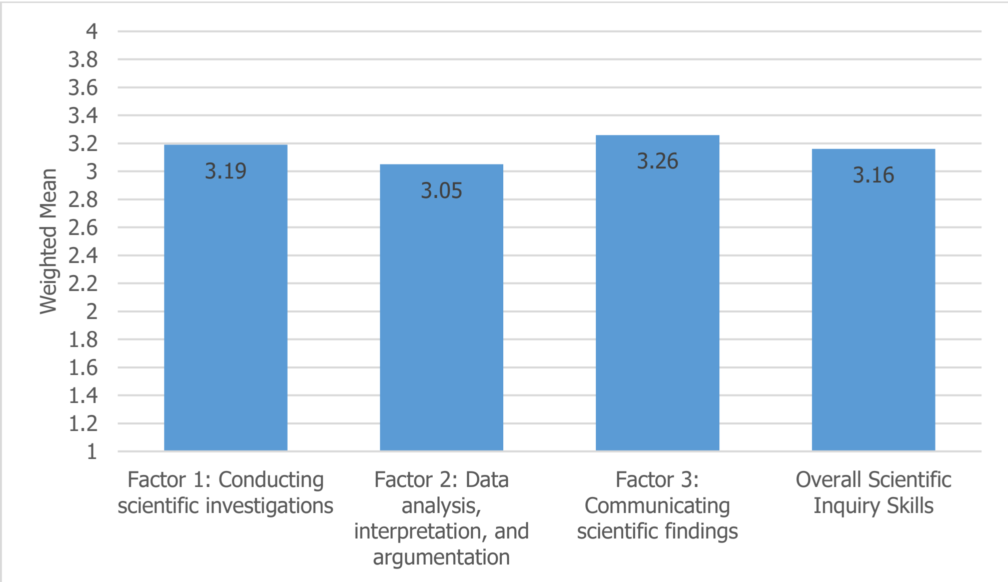

Figure 3. PSSTs' Scientific Inquiry Skills

An analysis of the responses gathered from preservice science teachers (PSSTs) using the validated P-SIS-Q instrument revealed an overall high level of perceived scientific inquiry skills, with a mean score of 3.16 (SD = 0.49), as illustrated in Figure 3. Among the three extracted factors, Factor 3: Constructing Explanations and Communicating Findings registered the highest mean score of 3.26, indicating that PSSTs perceive themselves to be particularly proficient in synthesizing results, drawing evidence-based conclusions, applying scientific principles to explain observed phenomena, and effectively communicating their findings using appropriate presentation tools. This strong performance in communication may be reflective of the digital learning context in which these students have developed fluency with a range of educational technologies.

Factor 1: Planning and Conducting Scientific Investigations followed closely with a mean score of 3.19, highlighting PSSTs' confidence in the foundational components of inquiry—such as recognizing investigable questions, planning experiments, identifying variables, and executing investigations. These competencies align well with the structured nature of many teacher education programs, which often emphasize procedural fluency and experimental design through laboratory work and guided activities.

In contrast, Factor 2: Analyzing, Interpreting, and Arguing from Evidence received the lowest mean score of 3.05 (SD = 0.49). Although this still reflects a high level of perceived competence, the relatively lower score suggests that PSSTs may feel less confident when it comes to analyzing and interpreting data, evaluating alternative explanations, and engaging in evidence-based argumentation—skills that are cognitively demanding and central to deeper scientific reasoning. This finding is consistent with earlier item-level analyses and underscores a critical area for further support in teacher preparation programs, particularly in enhancing preservice teachers' capacity for critical thinking, evaluative judgment, and scientific discourse.

Taken together, these results suggest that while PSSTs generally view themselves as skilled in scientific inquiry—particularly in communicating findings and conducting investigations—greater emphasis is needed on building their analytical and argumentation competencies to ensure they are well-prepared to facilitate authentic, inquiry-based science instruction in diverse educational settings.

Conclusion

This study aimed to develop and validate an instrument for assessing preservice science teachers' (PSSTs') perceived scientific inquiry skills within the Philippine educational context. Anchored in the Scientific Inquiry Skills Framework, the study demonstrated that the framework is applicable but required adaptation to suit the localized perspectives and learning experiences of Filipino PSSTs. Through exploratory factor analysis, the original six dimensions were consolidated into a more contextually appropriate three-factor structure: (1) Planning and Conducting Scientific Investigations; (2) Analyzing, Interpreting, and Arguing from Evidence, and; (3) Constructing Explanations and Communicating Findings. The resulting 25-item Perceived Scientific Inquiry Skills Questionnaire (P-SIS-Q) exhibited strong internal reliability across all three factors, with Cronbach's alpha values exceeding the recommended thresholds. While Factor 3 presented negative factor loadings, this deviation may be attributed to cultural or instructional factors that influence how scientific inquiry skills—particularly communication—are perceived and practiced. Overall, the findings confirm that the P-SIS-Q is a valid and reliable instrument for evaluating PSSTs' self-perceived scientific inquiry skills and offer a meaningful contribution to the field of science teacher education.

Implications and Recommendations

The findings of this study offer valuable insights for science education stakeholders, particularly those involved in the design and implementation of teacher education programs. The P-SIS-Q provides a practical and psychometrically sound tool that can help institutions assess the readiness of PSSTs to engage in inquiry-based teaching. This, in turn, can guide curriculum developers and teacher educators in identifying areas where additional support or instructional innovation is needed—particularly in data analysis and scientific argumentation, where participants showed comparatively lower perceived competence. Given the structured nature of science learning in many Philippine classrooms, there is a clear need to shift toward more open-ended, student-centered inquiry experiences. Teacher education programs are encouraged to integrate instructional strategies that foster critical thinking, evidence evaluation, and argument construction. Embedding reflective, discussion-based activities and real-world investigations within science methods courses can help PSSTs deepen their engagement with the more complex elements of scientific inquiry. Future users of the P-SIS-Q are advised to use the tool not only as a diagnostic assessment but also as a formative resource to track growth in inquiry competencies over time. Additionally, localized adaptations may further enhance its relevance in diverse cultural and institutional settings.

Limitations and Future Directions

While the study presents promising results, several limitations should be acknowledged. First, the use of a self-report instrument introduces the potential for social desirability bias and may not fully reflect actual classroom competencies. Second, the sample was drawn from a single state university in Central Luzon, limiting the generalizability of findings to other regions or types of teacher education institutions. Future research should seek to address these limitations by administering the P-SIS-Q to larger and more diverse populations, including preservice teachers from other regions and in-service educators at different stages of their careers. A confirmatory factor analysis (CFA) is also recommended to validate the stability of the three-factor model identified in this study. Furthermore, qualitative studies—such as interviews, classroom observations, or reflective journals—could provide richer insights into how PSSTs apply inquiry skills in practice and how their perceptions align with actual behaviors. By pursuing these future directions, researchers can deepen the utility and impact of the P-SIS-Q in advancing inquiry-based science education across various contexts.

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Author Information

Ronilo P. Antonio
https://orcid.org/0000-0002-2832-7203
College of Education, Bulacan State University
City of Malolos, Bulacan
Philippines
Contact e-mail: *ronilo.antonio@bulsu.edu.ph*

Jorge Victor Sales
https://orcid.org/0000-0002-6490-3626
De La Salle University
Catanduanes National High School
Division of Catanduanes
Department of Education
Philippines