

Article

Teacher Performance Level to Guide Students in Inquiry-Based Scientific Learning

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Abstract: The strategies employed by teachers and students in the open inquiry-based learning approach are crucial, especially when presenting researchable questions formulated by students under the guidance of the teacher. This effectively promotes the teaching and learning of various disciplines. Participant observation was conducted in the science classroom for secondary education teachers to establish the level achieved by teachers in the development of the open inquiry-based learning experience and to identify the taxonomic level of researchable questions (RQs). An observation rubric was applied, revealing that 83% of in-service teachers reached a satisfactory level, while 67% of pre-service teachers were classified as unsatisfactory in terms of using the open inquiry-based approach. Both groups formulated high-order inquiry questions, with a clear inclination in favor of in-service teachers compared to pre-service teachers. These results highlight the importance of university training in focusing on inquiry skills, particularly in planning, inferences, and evaluation. Through this observational analysis, valuable information about the current state of open inquiry-based learning is contributed, advancing science education in Peru.



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Keywords: inquiry-based teaching; scientific questions; researchable questions; scientific research; question formulation

1. Introduction

Learning science through inquiry is one of the most widely accepted approaches at all educational levels [1]. It allows for the modeling of the laws and theories of the world around us, making science more accessible and relevant to our reality [2]. Any inquiry-based activity must meet two conditions: it should include a researchable question and involve data analysis. However, a significant weakness exists where students, as well as teachers, struggle to formulate researchable questions [3]. When formulating a researchable question (RQ), a distinction must be made between the variable controlled or manipulated in an experiment, known as the independent variable, and the dependent variable, which takes values based on the former variable for data acquisition from both types of variables [4]. Additionally, other variables that converge in the relationship between these variables, termed intervening variables, should be considered. This is a necessity not only to teach scientific knowledge but also attitudes and emotions to foster environmental awareness in students. Questions in the classroom are often posed as non-researchable based on content [3]. Consistent with Akuma [5], it is observed that during the phases of initiation, planning, and implementation of practical work in the classroom, true inquiry-based learning is not achieved.

If there are good questions, they generate scientific knowledge. Therefore, a conceptual understanding of the analyzed phenomena is necessary [3]. This understanding allows for the connection of scientific concepts and reflection on what is known and what students

would like to know, all starting from observations to facilitate measurement or investigation [6]. A researchable question leads to practical research, while a non-researchable question fails to prompt students to collect data or evidence [6]. If the question starts with “Why...?” and “How...?” they are non-researchable since a methodology for data collection cannot be designed based on them. On the other hand, questions starting with “What happens if...?” or “Is there any difference if...?” allow for hypothesis formulation and experimental design planning [3].

Taking all this into consideration, the important role that questions play in the classroom and in science education can be recognized, serving as an educational tool that promotes the teaching and learning of various disciplines [7]. They are also considered important in the process of scientific and technological literacy [8,9]. Therefore, from the review of qualitative and quantitative studies to understand scientific ideas associated with natural phenomena, PIs (inquiry practices) can be identified, which allows for data collection and analysis [3]. Consequently, a study found that teachers who do not know how to formulate PIs can overcome deficiencies with support and feedback [10]. Similarly, when analyzing high-order inquiries that allow for the relationship between variables, those aimed at making predictions presented greater difficulties [4].

According to the results of PISA, which evaluates scientific competence conducted by the Organization for Economic Cooperation and Development (OECD), the performance of Peruvian students in science was below the average of participating countries in 2018 [11]. This situation persisted in the 2022 evaluation results, where 32.2% of participants did not reach basic competencies, placing them in level 1a. Only 28.2% managed to use basic or everyday content and procedural knowledge to recognize or identify explanations for simple scientific phenomena, such as providing a scientific explanation for given information [12]. These findings highlight the importance of understanding the current state of science education in Peru, thereby underscoring the relevance of our study on inquiry-based learning in the Peruvian context.

Among the examined gaps, there is still a need to analyze the development of the scientific competence of science teachers and discover effective and practical strategies they employ in teaching [13]. There is also a need to continue learning how to formulate researchable questions to challenge their students [4]. Additionally, it is necessary to analyze how teachers select researchable questions, and if they can differentiate between spontaneous and decontextualized questions and those of high value [14]. Thus, our study will emphasize the gap proposed by this latter author.

The importance of this study lies in analyzing the level of complexity of researchable questions formulated by students, guided by the teacher and the strategies employed to guide the inquiry-based learning approach. In the Peruvian context, there is a scarcity of studies related to the teaching of sciences [13]. It is crucial to discern the types of high-order or low-order researchable questions posed in the classroom to promote reasoning, creativity, and critical thinking development. Therefore, this study in the Peruvian context has limited references [13], prompting the identification of the performance level achieved by in-service and pre-service teachers, as well as their ability to formulate researchable questions and address problematic situations that arise when implementing the inquiry method in the science classroom.

2. Literature Review

Inquiry-Based Learning in Science

Researchable questions (IQs) are defined as realistic and situated problems for the teaching of science, identified and constructed by students through evidence [15]. This implies possessing knowledge to integrate something new [3,15,16]. Teaching through inquiry in science involves three processes: posing questions and formulating hypotheses, planning and conducting investigations, and analyzing data [16]. Therefore, inquiry must propose questions, plan investigations, and review information for evidence. Thus, starting with a good question is crucial [16]. The formulation of questions involves the

following: (a) intentionality, responding to the contents to be developed in the school curriculum, (b) contextualization, starting from real-life scenarios in students' everyday lives, (c) significance, promoting interest, (d) ethics, developing ecocentric behaviors toward the environment, and (e) motivation, considering the time to carry out the activity [4].

García Gonzalez [17] established three categories to classify questions: (1) questions oriented toward obtaining data or a concept (QDCs); (2) questions that question explanatory causes (QCs); and (3) researchable questions (RQs), which invite observation, measurement, or investigation that leads to reflective processes such as "What would happen if. . .?" [3]. Another proposal by [4,18] suggests that the evaluation of IQs can be categorized using a taxonomy of high-order and low-order questions. This study was conducted based on this classification, as represented below in Figure 1.

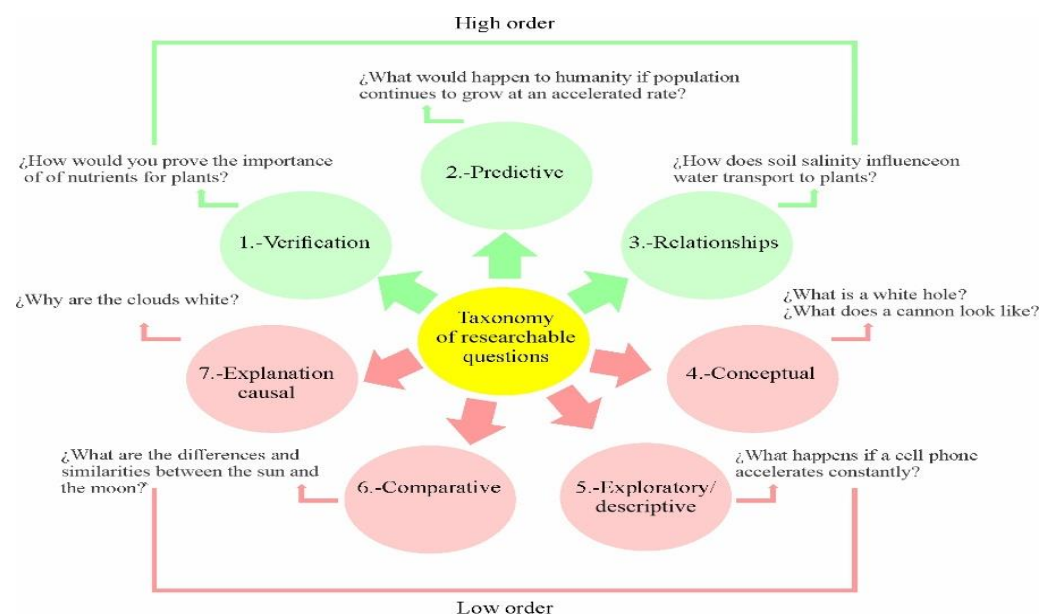


Figure 1. Taxonomy of researchable questions.

Inquiry-based learning is an educational methodology that fosters critical thinking, curiosity, and students' ability to investigate and solve problems. There are several types of inquiry-based learning that can be implemented: problem-based learning (PBL), project-based learning (PBL), inquiry-based learning, case-based learning, Socratic learning, guided inquiry-based learning, and open inquiry-based learning [19].

Different educational systems conduct periodic assessments of continuous professional development to ensure that teachers maintain and enhance their performance over time. Teacher performance is comprehensive, with variables of progress rather than product [20]. There are four levels of performance: basic level, intermediate level, sufficient level, and outstanding level. For better understanding, these levels were adapted to deficient, fair, good, and very good, respectively [21].

In most educational institutions, teaching is primarily focused on conceptual content, leaving little room for the development of scientific thinking skills; therefore, better teacher training is necessary. In many cases, there is a lack of teaching that promotes understanding of the inquiry-based didactic model [22].

The teacher provides researchable questions or problem statements and procedures to enable students to conduct investigations; they should present their research questions on their own. Most texts already include research questions and procedures. Thus, students' participation in open-ended research nature projects grants them the responsibility of determining the purpose and research questions, allowing them to learn about the role of a scientist [23].

Within the realm of inquiry-based planning with science learning sessions, it remains an empirical topic requiring further in-depth studies. Analytical scoring rubrics are scarce in research related to the classroom performance of pre-service teachers, who consider that they should provide qualitative analyses based on performance level descriptions and quantitative analyses with an overall score [24]. These assessments allow for feedback and self-reflection [25]. The learning evidence monitored by administrators or specialists helps analyze the inquiry approach used by the teacher, which can be structured, guided, or open, with the latter being optimal. This open approach enables students to generate their investigable questions, explain phenomena scientifically, evaluate and design scientific investigations, and interpret data and evidence to communicate results [26].

The Peruvian Ministry of Education establishes the teacher performance evaluation rubric based on Domain 2: Teaching for Student Learning, with four levels. Levels I and II refer to inappropriate behaviors, while Levels III and IV refer to appropriate behaviors [27]. This rubric analyzes student engagement in the learning process, performance measurement, behavior, development of creativity, critical thinking, and problem-solving in an environment of respect and closeness. In this context, rubric-based observations imply a good observation based on an explicit understanding of what constitutes good instruction, following the official parameters of the subject approach taught, generated by each educational sector. Therefore, it promotes instruction, allows for evaluation and support, fosters better teacher training, and encourages collaboration among teachers and peers [25]. Thus, the rubric for inquiry in science will serve as a support for analyzing and understanding how teachers plan and elevate students' capacities toward scientific knowledge and practice.

3. Methodology and Materials

This research was conducted using a mixed-methods approach, incorporating both qualitative and quantitative data collection methods based on inquiry-based teaching. The qualitative aspect employed hermeneutic phenomenology, utilizing participant observation to describe pedagogical aspects in the classroom, thereby gaining deeper insights into events and optimizing pedagogical practice [28]. An observation rubric, aligned with the guided inquiry approach proposed by the Ministry of Education of Peru, was used. This approach aimed to achieve the following objectives: establish the level attained by teachers in developing inquiry-based learning experiences, and identify the taxonomic level of the investigable questions (IQs) during science classes.

Content analysis of the learning session stages—context, generation of the investigable question, inferences (generating and recording data and information, and analyzing data), and evaluation—allowed for the classification of inquiry questions according to taxonomy and complexity levels. This classification was consensually agreed upon by the research team and quantitatively analyzed using frequencies and percentages.

This study was conducted from 18 September to 24 November 2023. Prior to the study, permission was requested from UGEL Sur in the city of Arequipa to invite teachers to training sessions on Scientific Inquiry in the classroom. Initially, 21 in-service teachers enrolled in the course, of whom only 6 provided informed consent for the observation of their science teaching practices. Subsequently, fifth-year students from the Natural Sciences program at a local public university were invited, resulting in 6 pre-service teachers participating as well. In total, there were 12 participants. Inclusion criteria required that they develop learning experiences solely based on open inquiry competence and conduct learning sessions with secondary school students (see Table 1).

A rubric was employed as the instrument, comprising differentiated criteria and specific performances to be evaluated [29]. It includes scores that assign value to the analyzed situation [30]. The evaluation rubric was developed with four capabilities and four hierarchical levels for teaching performance in inquiry-based instruction (see Table 2), both in a simplified and extended version (Appendix A).

Table 1. Teachers in service and pre-service.

Teachers	Gender	Public Education Institution	Professional Category
Teacher 1	Female	A	Service
Teacher 2	Female	A	Service
Teacher 3	Female	B	Service
Teacher 4	Female	B	Service
Teacher 5	Female	C	Service
Teacher 6	Female	C	Service
Teacher 7	Female	A	Pre-service
Teacher 8	Female	A	Pre-service
Teacher 9	Female	D	Pre-service
Teacher 10	Female	C	Pre-service
Teacher 11	Male	E	Pre-service
Teacher 12	Female	E	Pre-service

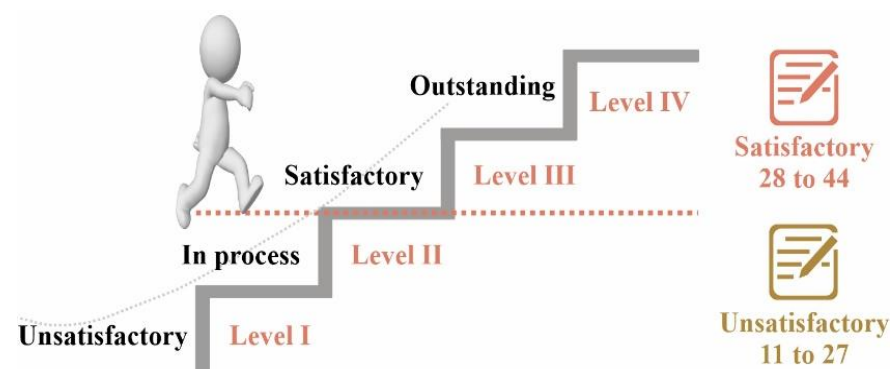
Table 2. Performance levels achieved by teachers in science teaching.

Capabilities	Levels			
	I	II	III	IV
Researchable question				
Planning of investigations	Does not reach to demonstrate the minimum aspects of performance.	Both achievements and deficiencies that characterize the teacher at this level are observed.	Most of the desired behaviors in teaching performance are observed.	All the desired behaviors in teaching performance are observed.
Making inferences				
Evaluation				

Source: Hierarchical rubrics for the evaluation of researchable questions.

The evaluation instrument was administered by the authors of this study. The learning experiences lasted three sessions, approximately 5 h of non-participant observation per week per teacher. To identify the range achieved by the teaching performance, the levels of competence in the values of the rubric used by the Peruvian Ministry of Education [27] were used.

The scale consists of two levels of performance achievement: unsatisfactory, which covers a range of scores from 11 to 27, and satisfactory, which is located in the range of 28 to 44. The evaluation was carried out by means of a rubric composed of 11 items; Levels III and IV are formulated in positive terms, referring to the achievements that the teacher must demonstrate to be placed in any of these levels. In contrast, Levels I and II are formulated in terms of inadequate behaviors [27], where the teacher does not achieve the required performances, as represented below in Figure 2.

**Figure 2.** Levels of achievement of inquiry competency performance.

To evaluate the formulation of inquiry questions, it is proposed to categorize them by type and quality using a taxonomy of high order and low order [18]. For this purpose, the researchers were assigned to conduct observations and keep a record of annotations to document each of the inquiry capabilities reached and extract the proposed researchable

questions (RQs) in the classroom. Subsequently, through consensus among the researchers, these questions were classified according to the taxonomy (see Table 3).

Table 3. Taxonomy of researchable questions (RQ).

Low Order				High Order		
I	II	III	IV	VI	VII	VII
Conceptual	Exploratory descriptive	Comparative	Causal explanation	Verification	Prediction	Relationships

For triangulation at the level of teaching performance using the inquiry method, the rubric was employed. These data were processed using counts, frequencies, and percentages, utilizing SPSS 25 and JAMOVI 2.3.28. Additionally, for the categorization of the taxonomy of researchable questions, a content analysis was conducted among the researchers involved in this study. This analysis was based on observation record, which, in turn, allowed for the tracking of the didactic and disciplinary sequence of what was developed by the teachers who voluntarily participated in this study. The results were compared with the existing literature.

4. Results

To analyze the level reached by teachers in the development of the inquiry-based learning experience, the following was found (See Table 4):

Table 4. Levels achieved by teacher by performance.

Professional Category	Performance/Frequency Percentage	Levels					
		I	II	III	IV	Total	
SERVICE	Question researchable						
	Question researchable	f		3	3	6	
		%		50%	50%	100%	
	Review related literature	f		5	1	6	
		%		83%	17%	100%	
	Explicitly and specifically identifies and includes variables in the research questions.	f	1	2	3	6	
		%	17%	33%	50%	100%	
	Planning of investigations						
	Describes sufficient experimental materials, instruments, and equipment.	f		6		6	
		%		100%		100%	
	Explains the experimental procedure in a logical and reasonable sequence.	f		1	3	2	6
		%		17%	50%	33%	100%
	Prepares appropriate strategies for data collection and recording.	f		1	2	3	6
		%		17%	33%	50%	100%
	Making inferences						
	Provides sufficient data and evidence to reach a valid conclusion.	f	1	1	3	1	6
		%	17%	17%	50%	17%	100%
	Data and evidence are not interpreted and explained.	f		1	4	1	6
		%		17%	67%	17%	100%
	No additional limitations, implementations, or improvements are mentioned.	f	3	1	1	1	6
		%	50%	17%	17%	17%	100%
	Evaluation						
	Evaluates and communicates scientific knowledge, achievements and difficulties of the inquiry process.	f		1	2	3	6
		%		17%	33%	50%	100%
	Context and process of obtaining data for the final report.	f	1	3		2	6
		%	17%	50%		33%	100%

Table 4. Cont.

Professional Category	Performance/Frequency Percentage	Levels				
		I	II	III	IV	Total
PRE-SERVICE	Question researchable					
	Question researchable	<i>f</i>	2	3	1	6
		%	33%	50%	17%	100%
	Review related literature	<i>f</i>	1	4		6
		%	17%	67%		100%
	Explicitly and specifically identifies and includes variables in the research questions.	<i>f</i>	2	2	2	6
		%	33%	33%	33%	100%
	Planning of investigations					
	Describes sufficient experimental materials, instruments, and equipment.	<i>f</i>	2	1	2	6
		%	33%	17%	33%	100%
	Explains the experimental procedure in a logical and reasonable sequence.	<i>f</i>	1	2	1	6
		%	17%	33%	17%	100%
	Prepares appropriate strategies for data collection and recording.	<i>f</i>	1	2	2	6
		%	17%	33%	33%	100%
	Making inferences					
	Provides sufficient data and evidence to reach a valid conclusion.	<i>f</i>	3	2	1	6
		%	50%	33%	17%	100%
	Data and evidence are not interpreted and explained.	<i>f</i>	1	2	1	6
		%	17%	33%	17%	100%
	No additional limitations, implementations, or improvements are mentioned.	<i>f</i>	3	3		6
		%	50%	50%		100%
	Evaluation					
	Evaluates and communicates scientific knowledge, achievements, and difficulties of the inquiry process.	<i>f</i>	1	2	3	6
		%	17%	33%	50%	100%
	Context and process of obtaining data for the final report.	<i>f</i>	5	1		6
		%	83%	17%		100%

Source: SPSS. V.25.

The main objective of this study was to establish the level reached by teachers in the development of the inquiry-based learning experience, both for in-service and pre-service teachers. The assessment was conducted using a Likert scale with achievement levels ranging from “unsatisfactory” to “satisfactory”. Regarding the level of inquiry, the results revealed distinctive patterns between in-service and pre-service teachers. In-service teachers demonstrated a stronger performance, with 17% located at the “unsatisfactory” level and 83% reaching the “satisfactory” level. This finding indicates a higher level of competence and skills developed in in-service teachers compared to their pre-service counterparts. In-service teachers excelled in aspects such as literature review and formulation of researchable questions, identifying variables, and describing experimental materials and instruments used in their learning experience.

In contrast, among pre-service teachers, 67% were placed at the “unsatisfactory” level, while 33% reached the “satisfactory” level. This distribution suggests that the majority of pre-service teachers face difficulties in specific aspects related to the formulation of researchable questions, planning investigations, interpretations and inferences, and evaluation. (see Figure 3).

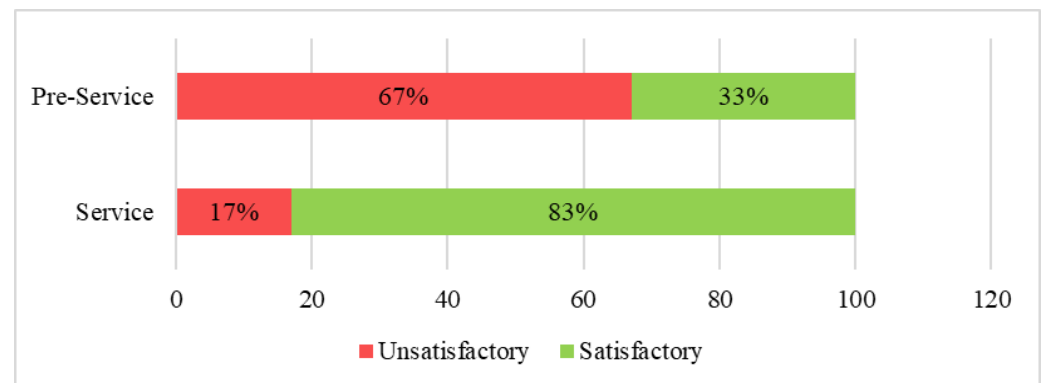


Figure 3. Level achieved by teachers in the development of the inquiry-based learning experience.

Regarding the prevalence level of the type of researchable questions formulated by students under the guidance of teachers in science education, based on the topics covered, it is evident that both in-service and pre-service teachers adopted a balanced approach in formulating researchable questions. In-service teachers formulated verification, predictive, and relational questions at 100%. These questions cover a variety of topics, including nutrition in pregnant women, acid-base indicators, renewable energy, microorganisms, nutrients, and honey quality. This suggests an emphasis on consolidating knowledge, anticipating outcomes, and understanding the interrelationships between concepts. Pre-service teachers formulated verification, predictive, and relational questions at 83.3%, and conceptual questions at 17%. This indicates their interest in consolidating knowledge, exploring relationships, fostering outcome anticipation, as well as seeking generalizations and conceptual definitions. These questions cover a variety of topics, including carbon composition, calcium in bones, Earth's shape, pH in ecosystems, genetic factors, and genes.

Regarding the type of question, there is a low-order conceptual question at 17%, highlighting the low number of conceptual questions with an absence of exploratory, comparative, or causal explanation questions. This can be considered as progress in the instruction of pre-service teachers (see Table 5).

Table 5. Prevalence level of the type of researchable questions.

Professional Category	Issue	Question Researchable	Type Question Researchable	f	% Total
SERVICE	- Nutrition in pregnant women - Acid-base indicators - Renewable energy	- "How could we help pregnant women prevent disease in the future with the help of a healthy diet?"	Verification question	3	50%
		- "In what way do we find out how the pH of certain substances are basic or acidic by changing the color of litmus paper?"			
		- "Is it possible to state that the higher and/or consumption of ENR, ER there is more and/or less environmental pollution and health, why?"			
	- Microorganisms	- "What will happen to the number of microorganisms as the days go by?"	Predictive question	1	17%
	- Nutrients - Honey quality	- "How does the amount of nutrients affect the development of plants?"	Relationship question	2	33%
		- "What effects do the characteristics of the bees have on the type of honey, product of the bees?"			

Table 5. Cont.

Professional Category	Issue	Question Researchable	Type Question Researchable	f	% Total
PRE-SERVICE	- Carbon composition	- "Do carbon moieties depend on their composition?"	Verification question	2	33 %
	- Calcium in bones	- "Do bones need Ca to stay strong?"			
	- Shape of the Earth	- "How does the shape of the Earth influence the results?"	Relationship question	3	50 %
	- Ph in ecosystems	- "How does the PH level affect or influence the development of species in ecosystems?"			
	- Genetic factor	- "How does the genetic factor determine the characteristics of a student organism?"			
	- Genes	- "What genetic factors are involved in the manifestation of genes?"	Conceptual	1	17%
Total				12	100%

Source: SPSS. V.25.

In-service teachers formulated all questions as high-order, according to the classification by [18]. This finding suggests that questions posed by these teachers tend to require a more investigative and complex approach, such as verification, prediction, or analysis of relationships between variables. In contrast, among pre-service teachers, 83% of the questions formulated are classified as high-order, while 17% are classified as low-order, following the same classification [18]. This pattern reveals that, although there is a tendency to formulate high-order questions in both groups of teachers, pre-service teachers exhibit a lower proportion of low-order questions compared to in-service teachers. In both teacher groups, there is a trend toward formulating high-order questions, indicating an interest in promoting more advanced research or critical thinking skills among students (see Table 6).

Table 6. Taxonomic level reached for researchable questions.

Professional Category	Taxonomic Level	Frequencies	% Total
Service	High order	6	100.0%
Pre-service	High order	5	83%
	Low order	1	17%

Source: SPSS. V.25.

4.1. Session Conducted by Teacher P.1 of Science and Technology

Session title: Investigating plant nutrition

The teacher initiated the topic by presenting the purpose, indicating the competency and skills to be developed, the evidence, and the evaluation indicators. She contextualized the situation involving Miguel and his garden.

4.1.1. Inquiry Question

The students followed the steps described in their inquiry sheet and identified the cause and effect through questions posed by both students and the teacher: What happened to Miguel's plants? Why did some plants grow while others did not? What factors intervened in their growth? They compiled a list of factors from which the independent variable would be deduced. Next, they read a text prepared by the teacher about types of fertilizers and which ones are most suitable for agriculture, and their relationship to nutrients. The teacher asked, "What could be the cause of the uneven development of Miguel's plants?" The students provided responses through brainstorming, guided by the teacher, and the identified variables formulated the inquiry question as follows: **How does the quantity of nutrients affect plant development?**

In the question proposed by the teacher, she mentions “quantity,” which is not considered in the inquiry strategy. The inquiry question could have been: How do different types of soil influence plant growth? The reading resource suggested by the teacher should have been about types of soil, their composition, and benefits for agriculture (see Figure 4).



Figure 4. Inquiry question formulation process and focus adjustment in plant growth investigation.

4.1.2. Research Planning

Each student in their work team writes down the materials and inputs they will need for their inquiry: types of soil, lentil seeds, water, banana peel, and egg. They do not require laboratory equipment and work with two groups, control and experimental, recording observations such as size, color, stem thickness, and leaf quantity for each pot, on an inter-daily basis for two weeks. They then analyze the information, evaluate, and communicate the process and results (see Figure 5).



Figure 5. Inquiry research planning: material selection and experimental design.

4.1.3. Make Inferences

The data provided from the observation of each pot will allow them to draw valid conclusions, although the fact of not weighing the amount of natural substances (banana peel, eggshell) used as fertilizer for the plants did not allow for something more objective. The interpretation was carried out based on the systematization of the data in a table and graphs proposed by the teacher for the students to create. No limitations or improvements are mentioned (see Figure 6).



Figure 6. Inferential analysis of observational data: drawing conclusions in plant growth experiment.

4.1.4. Evaluation

With guidance from the teacher, the students, in teams, present their conclusions, which, on this occasion, coincide with their hypothesis, the same that was contrasted and validated, considering it a qualitative rather than quantitative practice. Finally, the teacher asks them metacognitive questions, which are orally expressed, about what, how, and why they learned this information, how they relate it to everyday life, and how it can be useful to them. The students present their inquiry report in their notebook. Monitoring and feedback from the teacher to each group were observed.

However, teacher P. 1 could improve the inquiry by using the information about soils provided by herself. There is a bias or error in the inquiry methodology by only applying two types of nutrients (calcium, potassium, present in eggshells and banana peels) that increase soil alkalinity, modifying its pH, and leaving aside other essential nutrients such as nitrogen, phosphorus, iron, and sulfur for the proper development of plants. The pH level and the properties of the banana peel and eggshell added to the samples were not considered. Therefore, we argue that there is a need to reinforce scientific inquiries, the formulation of research questions, and the design and evaluation of essential scientific processes to carry out an inquiry in the classroom. Contrasting this reality, Ref. [10] argues that if teachers are trained in the pedagogical approach of inquiry, future educators will be able to ensure good learning opportunities (see Figure 7).



Figure 7. Evaluation and improvement recommendations in the inquiry process.

5. Discussion

Building knowledge and engaging students is a challenging task that teachers must promote in the classroom. This study evaluated the level of achievement of teacher performance in the development of the inquiry-based learning experience, finding that the vast majority of both in-service and pre-service teachers are at a satisfactory level, with a greater prevalence among in-service teachers. In this sense, it reaffirms the [31] assertion that a teacher, to teach using the inquiry-based method, must master subject knowledge, content, and the structure of research methods, enabling them to address difficulties that arise in the learning and teaching process [31]. It also provides the opportunity to actively construct knowledge through observations and research, using effective strategies for raising awareness of environmental issues [32]. On the other hand, Ref. [33] concludes in her research that “the use of some elements of inquiry in the classroom has a significant impact on all observed areas of student skill development”.

In the analysis of the researchable questions, the taxonomic value achieved by the in-service teachers was higher than that of the pre-service students, demonstrating that in the accompaniment they have a high value, which leads students to question, reflect, analyze, and systematize their learning experiences in science. Similarly, it was found that teachers should promote in students the ability to formulate research questions so that they feel motivated, interested, and enthusiastic to learn [31]; it was also found that prediction and observation, together with experimentation, favor scientific practice [3], which involves both the teacher and the students evaluating their achievements in cognitive, affective, and motor aspects, enhanced by the use of rubrics that allow for analyzing the desirable performance criteria [34].

Within the findings of this study, the following is observed: first, teachers manage the capacities of the inquiry method in their learning sessions. However, in pre-service students, it is more challenging to guide instruction for formulating researchable questions, planning, identifying variables, making inferences, and evaluation. Second, there is an effort to start from everyday situations that enable students to engage in learning. Similarly, Ref. [31] argues that if the natural curiosity of students is encouraged and motivated, autonomous generation of scientific knowledge occurs. Third, for teachers in continuous education, the formulated research questions are of high order, leading to the development of investigative skills while demonstrating greater expertise and mastery of instructional inquiry.

The theoretical and practical value of this study lies in non-participant observation, revealing that the teacher possesses a conceptual understanding of the phenomenon, which is a basic input to stimulate prior knowledge for generating researchable scientific questions. Verification and high-order relationship questions were the most worked on, developed with a high order among in-service teachers, posing challenges and exhibiting a higher level of complexity. This leads to a deeper understanding of research questions [23]. Similarly, it is stated that well-executed inquiry skills provide greater satisfaction, especially when conducted with an experimentation sheet, proving to be a valuable aid in the process of scientific knowledge [35]. Our research makes a valuable contribution to the field of science education by introducing an innovative tool: a detailed rubric for evaluating teachers' performance in formulating investigable questions and identifying variables. This approach distinguishes our study by providing a practical and objective guide to enhancing the implementation of the scientific inquiry model in the classroom. In contrast to other studies, our thorough analysis of teachers' question formulation underscores the importance of guiding them toward relevant and specific questions, crucial for developing students' research skills.

In the context of science education in Peru, the study results suggest progress toward a more comprehensive approach to the inquiry model. However, it is crucial for teachers to continue working on improving their skills in this area. Within the limitations of our study, it was found that teachers required more time to prepare learning experiences, as the majority postponed the dates of non-participant observation, and there was resistance from most teachers to being observed in inquiry practices. This study only conducted one opinionated intervention, and it would have been important to carry out a second visit in a non-opinionated session to analyze the strengths and weaknesses of the inquiry method.

Therefore, further research analyzing the competencies, scientific attitudes, and formulation of researchable questions in both in-service and initial training teachers [10,36] should be pursued. This work proposes an observation activity of classroom teachers in science inquiry education, evaluated with a rubric to analyze the sequence of skills to be achieved. Additionally, it assesses, through taxonomy, the researchable questions posed by students in relation to the observed learning sequence. The results demonstrate a satisfactory level and a tendency toward high-order research questions. Likewise, this study used rubrics to measure the level of acquired inquiry skills, yielding intermediate to high results [35]. In a similar vein, [37] highlights the importance of rubrics, emphasizing their value in the hypotheses presented by students. However, this study suggests conducting participant observation to provide feedback on the inquiry method processes to teachers, and to facilitate ongoing updates for scientific literacy.

6. Conclusions

Our study demonstrates that the teaching performance in the use of the inquiry method predominantly reached a satisfactory level. However, there is a minimal percentage of teachers who did not meet the required performance criteria. These differences between in-service and pre-service teachers lead to significant implications for the planning and implementation of teacher training programs based on inquiry learning.

These findings provide a valuable foundation for future research and the design of professional development strategies that address the specific needs of teachers in their

trajectory toward continuous improvement. It indicates that there is difficulty on the part of teachers in proposing researchable questions, planning, making inferences, and evaluation. Therefore, it is important to analyze and refine inquiry experiences through monitoring and interpretation of the learning processes to provide alerts and prevent student disinterest, demotivation, and routine practices by teachers.

However, despite the limitations mentioned in this study, we found a strong prevalence in high-order research questions, ranging from verification and predictive questions that focus on consolidating knowledge and anticipating results in in-service teachers to relationship questions that focus on understanding interrelationships between concepts in pre-service teachers. This indicates a limitation in scientific knowledge from the problem statement and basic concepts' framing to guide learning.

These results are positive and encouraging, indicating that both in-service teachers and future initial training students are adopting the inquiry approach in science teaching. The rubric can provide teachers with processes for reflection and personal self-regulation, as well as monitor and interpret inquiry-based learning processes with students. Additionally, it is essential to continue monitoring a larger population of basic education teachers regarding their classroom performance, aligning with the current goal of the Ministry of Education in Peru.

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Appendix A

TEACHING PERFORMANCE OBSERVATION SHEET			
SECONDARY LEVEL			
GRADE:			
SESSION TITLE:			
TEACHER IN SERVICE:		TEACHER IN INITIAL TRAINING	
OBSERVATION DATE:			

ACHIEVEMENT LEVELS									
LEVEL I		LEVEL II		LEVEL III					
UNSATISFACTORY		IN PROGRESS		SATISFYING					
It is not enough to demonstrate the minimum aspects of performance.		Both achievements and deficiencies are observed that characterize the teacher at this level.		The majority of desired behaviors are observed in teaching performance.					
				All desired behaviors are observed in teaching performance.					
PERFORMANCE: RAISES RESEARCHABLE QUESTION									
Performance Description									
Demonstrates knowledge of the investigative approach based on researchable questions, arguing the relationship between variables based on a theoretical framework, guiding the student to problematize.									
ASPECT									
Researchable question									
DESCRIPTORS			LEVEL I	LEVEL II	LEVEL III				
Raises researchable but unanswerable questions for execution.									
Asks questions that are ambiguous, generic, or poorly formulated, but contain fact-based questions.									
Poses appropriate questions related to scientific concepts and based on facts, but does not specify the question that guides the investigation.									
It raises researchable problems and concrete appropriate questions related to scientific concepts and based on facts and suggesting methodological aspects.									
ASPECT									
Review related literature									
DESCRIPTORS			LEVEL I	LEVEL II	LEVEL III				
The bibliographic citations of the theoretical framework are inadequate or inappropriate.									
The bibliographic citations of the theoretical framework are related to some part of the research.									
The bibliographic citations of the theoretical framework presented are appropriate, but the source is not specified; they are related to the research.									
The bibliographic citations of the theoretical framework are appropriate and related to the research.									
ASPECT									
Identify and explicitly include and specify variables in research questions.									
DESCRIPTORS			LEVEL I	LEVEL II	LEVEL III				
The appropriate variables (independent and dependent) in the research questions are not clearly identified.									
Identify and include some variables (independent and dependent) that are appropriate.									
Identify and include all appropriate variables (independent and dependent).									
Explicitly and specifically identify and include all appropriate variables (independent and dependent).									

PERFORMANCE: PLAN INVESTIGATIONS GUIDING APPROPRIATE PROCEDURES				
Performance Description				
Plan the inquiry process, describe the necessary resources, and explain the procedure and instruments for data collection.				
ASPECT				
Describes sufficient experimental materials, instruments, and equipment.				
DESCRIPTORS	LEVEL I	LEVEL II	LEVEL III	LEVEL IV
Describes some experimental materials, instruments, and equipment.				
Describes some specific experimental materials, instruments, and equipment without explaining the procedure for the research.				
Describes sufficient experimental materials, instruments, and equipment.				
Clearly describes sufficient experimental materials, instruments, and equipment that are appropriate.				
ASPECT				
Explains the experimental procedure in a logical and reasonable sequence.				
DESCRIPTORS	LEVEL I	LEVEL II	LEVEL III	LEVEL IV
Part of the procedure or experiment lacks logic and proper sequencing.				
The experimental procedure with logic without a clear sequence.				
The experimental procedure is explained in a logical and reasonable sequence.				
The experimental procedure is explained in a reasonable logical sequence appropriate to the research approach.				
ASPECT				
Prepare appropriate strategies for data collection and recording.				
DESCRIPTORS	LEVEL I	LEVEL II	LEVEL III	LEVEL IV
The instruments or tools are inappropriate for data collection and recording.				
Some instruments or tools for data collection and recording are presented.				
The instruments or tools are appropriate for collecting and recording data.				
The appropriate and relevant instruments or tools for data collection and recording.				
PERFORMANCE: GUIDE THE INTERPRETATION OF DATA THROUGH THE USE OF INFERENCE				
Performance description				
Guides the interpretation of data in a scientific manner and evaluates limitations to improve the research carried out.				
ASPECT				
Provides enough data and evidence to reach a valid conclusion.				
DESCRIPTORS	LEVEL I	LEVEL II	LEVEL III	LEVEL IV
The data and evidence provided in the activity are incomplete.				
There are some data and evidence from the activity to draw valid conclusions.				

The provision of data and evidence allows valid conclusions to be drawn.				
The provision of data and evidence of the activity are sufficient to draw valid conclusions.				
ASPECT				
Interprets data and evidence scientifically.				
DESCRIPTORS	LEVEL I	LEVEL II	LEVEL III	LEVEL IV
The data is interpreted and evidenced in a non-scientific manner.				
Interprets some data and demonstrates it scientifically.				
Interprets most data and evidence scientifically.				
Interprets all data and evidence scientifically found.				
ASPECT				
Addresses additional limitations, implementations, and improvements to the scientific research conducted.				
DESCRIPTORS	LEVEL I	LEVEL II	LEVEL III	LEVEL IV
No additional limitations, implementations, and improvements are mentioned.				
Some additional limitations, implementations, and improvements are mentioned.				
Comprehensively addresses limitations and implementations.				
Comprehensively addresses limitations, implementations, and improvements.				
PERFORMANCE: Evaluates learning from the inquiry process.				
Performance description				
Evaluates the inquiry process and the response to the research question evidenced in an inquiry report by the student.				
ASPECT				
Evaluates and communicates scientific knowledge, achievements, and difficulties of the inquiry process.				
DESCRIPTORS	LEVEL I	LEVEL II	LEVEL III	LEVEL IV
Supports in written form in pairs and the teacher, on the basis of scientific knowledge acquired with limitations in some processes of their inquiry.				
Supports in written form in pairs and the teacher, based on scientific knowledge acquired with the teacher's support in some processes of their inquiry.				
They generally support the achievements and difficulties of all the processes of their inquiry on the basis of scientific knowledge and communicate them to their peers and the teacher orally, in writing or graphically.				
It solidly supports and communicates on the basis of scientific knowledge the achievements and difficulties of all the processes of its investigation in oral, graphic, and written form through an investigation report.				

ASPECT				
Context and process of obtaining data for the final report.				
DESCRIPTORS	LEVEL I	LEVEL II	LEVEL III	LEVEL IV
There is constant advice to students to obtain data, and the preparation of the final report is incomplete.				
There is advice to students at times to clarify doubts about obtaining data, analysis, and development of the final report.				
The advice is minimal with argumentative logic on the part of the students to obtain data, analysis, and scientific reference for the final report.				
Students argue and draw reflections autonomously and complete the inquiry report satisfactorily.				

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