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Elementary School Teachers' Understanding of Inquiry Skills and Scientific Attitude

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Abstract

This study aims to assess elementary school teachers' inquiry skills and scientific attitudes related to science. The instrument used in this study evaluates four groups of skills: conceptualizing and planning design, implementation, analysis, interpretation, and communication. Additionally, it assesses six categories of scientific attitudes: the nature of science, the basis of science, characteristics of scientists, goals of science, benefits of science, and responses regarding scientists. This research instrument underwent validation by two experts in the field of science. Validation results using Kendall's Tau calculations showed a value of 0.853 for the inquiry ability instrument and 0.807 for scientific attitude, and both falling into the 'very high' category. The study involved 49 elementary school teachers. Findings revealed that teachers' inquiry skills were categorized as 'weak', indicated by an average percentage below 50% in each skill group. Regarding scientific attitude, respondents' responses varied significantly between positive and negative statements, despite similarities found in two categories: 'basic science' and 'purpose of science'. This study highlights the necessity to consider the the learning process science, particularly emphasizing the development of inquiry skills and fostering positive scientific attitudes, from elementary school through university education.

Keywords: *inquiry skills, scientific attitudes, elementary teacher*

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Abstrak

Penelitian ini bertujuan untuk mengetahui bagaimana keterampilan inkuiri guru baik dari sisi proses maupun sikap ilmiah terkait dengan sains. Proses yang diujikan dalam instrument ini terdiri dari empat kelompok keterampilan: mengkonsepsi dan merencanakan desain, implementasi, analisis dan interpretasi, serta mengkomunikasikan. Pada sikap ilmiah terdiri dari enam kategori yaitu: sifat dari ilmu sains, dasar ilmu sains, hal yang dimiliki ilmuan, tujuan ilmu sains, manfaat ilmu sains, dan tanggapan mengenai ilmuan sains. Instrumen penelitian ini telah dilakukan validasi pada dua orang doktor pada bidang sains. Berdasarkan hasil validasi menggunakan perhitungan Kendall's Tau memiliki nilai sebesar 0,853 untuk instrument kemampuan inquiry dan nilai sebesar 0,807 untuk sikap ilmiah serta keduanya termasuk ke dalam kategori sangat tinggi. Responden dalam peneitian ini terdiri dari 49 orang guru sekolah dasar yang didapatkan bahwa keterampilan inkuiri berada pada kategori "lemah" hal ini ditunjukkan dengan persentase rata-rata responden pada setiap kelompok dibawah 50%. Sedangkan pada sikap ilmiah didapatkan bahwa respon responded terhadap pernyataan sikap ilmiah antara pernyataan positif dan negatif cukup berbeda walaupun ada dua kategori sikap ilmiah yang sama responnya. Dua kategori itu adalah pada "dasar ilmu sains" dan "tujuan dari sains". Studi ini menunjukkan bahwa proses pembelajaran sains dari SD sampai dengan perguruan tinggi perlu untuk diperhatikan terutama hal yang berkaitan dengan keterampilan inkuiri dan sikap ilmiah.

Kata kunci: *kemampuan inkuiri, sikap ilmiah, guru sekolah dasar*

INTRODUCTION

The teacher plays a pivotal role in the classroom learning process, especially in science lessons, to attain optimal learning outcomes. It is crucial for teachers not only to guide students in mastering scientific concepts and formulas but also to cultivate the processes and attitudes integral to scientific learning. (Anam, 2021; Hardianti & Kuswanto, 2017; Rahayu et al., 2022). In the science learning journey, students should be encouraged to learn through inquiry. This approach enables students to develop scientific skills and attitudes, empowering them to acquire scientific knowledge by employing high-level reasoning, applying scientific concepts, and effectively communicating scientific principles (Berland et al., 2016; Jerrim et al., 2020).

Students need to be involved in the inquiry because this is one of the objectives of science education (National-Research-Council, 2013), Science lessons will run optimally if three of the following 1) the teacher must understand how to inquire (St. Pierre, 2019; Turiman et al., 2012), 2) students are given opportunities to develop inquiry skills (Marshall et al., 2017), 3) it is necessary to ensure that students make progress in achieving these skills (Cairns & Areepattamannil, 2019; Cartwright & Hallar, 2018).

In applying inquiry learning, teachers must be able to guide students in carrying out various activities such as asking questions, identifying problems, investigating, collaborating, making decisions, producing solutions to problems or answers to a question and being able to communicate conclusions (Strat et al., 2023). In addition, through this learning, it can encourage a meaningful learning atmosphere to develop higher-level thinking and active knowledge construction (Wörner et al., 2022). Inquiry learning is learning that is compatible with the constructivist approach which emphasizes that knowledge is developed actively by

students. While it is not transmitted directly from teacher to student, it requires teachers who have adequate inquiry skills to optimize learning (Berie et al., 2022).

Based on the explanation, One critical factor for achieving optimal learning is a teacher's proficiency in inquiry-based teaching. However, these expectations often do not align with the reality, as evidenced by research conducted by (Rahayu et al., 2022), which stated that teacher inquiry skills needed to be improved in producing more optimal science learning in Elementary Schools. Apart from that, a study from (Lotter et al., 2018) stated that higher education institutions are not capable enough to provide qualified teachers with the ability to inquire to be able to produce not only scientific products but also scientific skills and attitudes. One of the requirements for teaching science is having a teacher who understands science and the nature of science lessons (Widodo et al., 2017). If the teacher has it, the quality of the learning provided will be better (Rollnick, 2017).

Teacher understanding regarding inquiry learning that can develop students' scientific skills and attitudes needs to be carried out following the opinion (Norris et al., 2018) that inquiry learning can increase interest and contribute positively to pre-service teachers' scientific skills and attitudes. However, research evidence conducted by Akani (2015) stated that both pre-service and in-service teachers are constrained in defining problems, making hypotheses, predicting, and planning and analyzing experimental results. In addition, Anam (2020) also found that pre-service teachers lack skills in planning experiments, hypothesizing, communicating, and concluding. Interestingly, there was no observable difference between participants with a scientific background and those without in these skills.

It is also found that the teacher's scientific attitude still needs to be developed in accordance with the explanation from Riegle-Crumb et al (2015) which stated that there is a logical relationship between teachers' scientific attitudes towards subjects and student learning outcomes. Elementary teachers who have a negative scientific attitude will result in less coverage of science content and less interesting and effective teaching. In addition, according to Akın et al (2016) when teachers teach science, their negative attitudes can influence their pedagogical practices and, consequently, their ability to engage students in the learning process. Therefore, studying teachers' understanding of inquiry skills and scientific attitudes, particularly among elementary school teachers, is crucial to gauge their comprehension throughout the educational journey, from elementary school to university level. Insights gleaned from research of this nature can provide valuable input for enhancing future science-related lectures across educational levels, spanning from elementary school to university.

METHODS

Research methods

The research method employed is quantitative by using online survey methods (Braun et al., 2021). This study aims to describe elementary school teachers' understanding of inquiry skills and scientific attitudes and to analyze whether developing these two skills is necessary for the lecture process. This online survey was conducted on 49 elementary school teachers in South Tangerang, Indonesia, all of whom were enrolled in the Elementary School Teacher Education study program across various campuses. The research process was carried out by distributing online instruments and through an interview to reinforce what they understood related to inquiry skills and scientific attitudes in science lessons. There are two research instruments: inquiry skills and scientific attitudes.

Inquiry Skills Instrument

The scientific skills used in this study are inquiry abilities developed by Ješková et al (2018) and Rahayu et al (2022), which consist of four main skills: Concepting and planning designs, Implementation, Analysis and Interpretation, and Analysis and Interpretation, each of which consists of sub-skills. And question indicators. The number of questions from this instrument consists of 30 questions. Table 1 will show the Skill Groups, Sub-Skills, and Inquiry Skills Question Indicators.

Table 1. Skill Groups, Sub-Skills, and Inquiry Skills Question Indicators

Skill Group	**Sub-Skills**	**Question Indicators**
Concepting and planning designs	Defining the problem	Can formulate problems from practical activities to be carried out
	Formulating a hypothesis	Can determine hypotheses from experiments that will or have been carried out
	Designing variables and relationships between variables and the experimental process	Can design experimental or research plans to prove a certain phenomenon
	Predicting experimental results	Can predict from plans and results from experiments/research conducted based on existing patterns or explanations
Implementation	Determine what is measured, observed, and recorded	Can determine what is measured, observed, and recorded from the experiment/research that will be carried out
	Processing and analyzing data	Can process and analyze the data presented based on the experiments that have been done
Analysis and Interpretation	Change the data representation in the form of graphs/diagrams and tables	Can change the form of representation in one form to another
	Generalizing from experimental results	Can generalize from research data
	Making conclusions	Can make conclusions based on phenomena and experimental data
Communicating	Outlining a formal report on the results obtained	Can describe a formal report on the results of experiments or research obtained

Scientific Attitude Instrument

The scientific attitude instrument employed in this study was developed by Çakır & Akbulut (2022), which divided scientific attitudes into six main categories, namely the nature of science, the basis of science, things that scientists must have, the goals of science, the benefits of science, and responses about science scientists. The number of instruments in Table 2 will show more detail about the categories and statements used in this study.

Table 2. Indicators from the Scientific Attitude Instrument

Category	Statement	
	Positive	**Negative**
Nature of Science	Science is tentative	Science is fixed/absolute
Basic Science	Observation of natural phenomena and experiments is the basis of scientific explanation	The basis of scientific explanation lies with the authorities
Scientist needs	Scientists need an honest and objective attitude needed to become a scientist	Science needs to know all scientific truths and take sides with other sciences
Purpose of Science	Science is an activity that generates ideas	Science is a technological development activity
Benefits of Science	Advances in science required public support in their day	Public understanding of science will contribute nothing to the advancement of science or human well-being
Responses to Science Scientist	Being a scientist is an interesting and rewarding job	Being a scientist is a boring job

Two experts, both with doctoral degrees in science education, validated the instruments for assessing inquiry skills and scientific attitudes. The experts suggested minor improvements, particularly in the writing section, before the instruments' usage. They noted that the content of the instruments is of good quality and deemed them feasible for implementation. The inquiry ability instrument comprises 30 questions, while the instrument evaluating scientific attitudes consists of 51 statements.

Based on the expert validation results found that the validity of the two instruments used with Kendall's Tau calculations had a value of 0.853 for the inquiry ability instrument and 0.807 for the scientific attitude values, and both were included in the 'very high' category. Furthermore, the experts suggested improvements for the instrument deployment/testing process to ensure better data quality. They recommended extending the allotted time for respondents to complete the process, allowing for a more focused approach. Additionally, they proposed incorporating features that would enable assessment of respondents' progress, providing valuable feedback on their actions. Researcher tested the reliability of the two instruments using Cronbach's Alpha calculations and found that the inquiry skills instrument had a value of 0.739. In contrast, the scientific attitude instrument had a value of 0.774, both of which were included in the 'high' category.

Data analysis

The responses from respondents will be assessed based on two main criteria. For the inquiry skills instrument, one point will be awarded for a correct answer, and zero points for an incorrect answer. Conversely, the scientific attitude instrument evaluates responses as appropriate or inappropriate regarding the scientific attitude, presented in the form of positive or negative sentences. The results of this assessment will be averaged, and percentages to later

be classified and interpreted in the categories Anam (2020) and Rahayu et al (2022). The categories of the interpretation results can be seen in Table 3.

Table 3. Interpretation of percentage of participant test

Range	Category
80-100	Very good
70-79	Good
60-69	Enough
40-59	Less
30-39	Very less

RESULTS AND DISCUSSION

This section discusses the research results through the two main points. The analysis of inquiry skills and scientific attitudes of elementary school teachers will be presented below.

Inquiry Skills of Respondents

The inquiry skills of elementary school teachers based on the distributed instruments show that the teachers inquiry skills need to be further developed. Table 4 will show the percentage of respondents from their inquiry skills.

Table 4. Percentage of Respondents' Inquiry Skills

Skill Group	Sub-Skills	Percentage	Average Percentage of each indicator
Concepting and planning designs	Defining the problem	18,37	**46,77**
	Formulating a hypothesis	44,90	
	Designing variables and relationships between variables and the experimental process	83,67	
Implementation	Predicting experimental results	40,14	**34,69**
	Determine what is measured, observed, and recorded	41,50	
	Processing and analyzing data	27,89	
Analysis and Interpretation	Change the data representation in the form of graphs/diagrams and tables	41,50	**47,62**
	Generalizing from experimental results	49,66	
	Making conclusions	51,70	
Analysis and Interpretation	Outlining a formal report on the results obtained	36,73	**36,73**

Table 6 shows that of the four skill groups tested, the average percentage was under 50% or included in the "less" category. However, for each sub-indicator, some percentages exceeded 50%, with one reaching 83.67%, meeting the high criteria. These skills certainly need to be a concern regarding the inquiry learning process carried out by teachers in schools. Teachers must have qualified inquiry skills to provide optimal learning to their students (Akgün et al., 2016; Darmaji et al., 2019; Duruk et al., 2017; Herder et al., 2018).

In addition, inquiry skills are used by researchers, scientists, teachers, and students to think and learn about science. These are also helpful for science learning and activities, including investigative and interpretation processes (Turiman et al., 2012). It can be developed by first understanding the teacher's inquiry skills in the learning process. It can guide students to connect experiences integrating the new concepts and the previous ones. Through this skill, students can more optimally describe the concepts/theories, predicting, asking questions, test their predictions, and interpreting the data. This follows science lessons that lead students to be able to develop cognitive, psychomotor, and social skills (Anam, 2021; Savitri et al., 2017; Supahar et al., 2017).

Scientific attitude

From the trials evaluating teachers' scientific attitudes, it was observed that respondents' comprehension of scientific attitudes encompassed various aspects: the nature of scientific knowledge, the foundations of science, essential attributes for scientists, the objectives and benefits of science, and reactions toward scientists, assessed through both positive and negative inquiries can see in Table 7.

Table 7. Teachers' Responses to Scientific Attitude Statements

Category	Statement			
	Positive	**Category**	**Negative**	**Category**
Nature of Science	3.13	Agree	2.89	Disagree
Basic Science	2.93	Disagree	2.93	Disagree
Scientist needs	3.51	Agree	2.43	Disagree
Purpose of Science	3.48	Agree	3.20	Disagree
Benefits of Science	3.14	Agree	2.14	Disagree
Responses to Science Scientist	3.20	Agree	2.12	Disagree

Based on Table 7, teachers' responses to scientific attitude statements between positive and negative statements are quite different, even though two categories of scientific attitudes have the same response. The two categories are "basic science" and "purpose of science". Meanwhile, the essence of the two categories of attitudes is very different, if based on scientific knowledge, it compares the positive statement of "Observation of natural phenomena and experiments is the basis of scientific explanation" and the negative "The basis of the scientific explanation lies with authority". This is very different. The positive statement states that science results from observation, research, and other activities, while the negative statement explains that science is a proposal that can only be given to scientists.

In the section addressing the purpose of science, two distinct statements emerged. The positive statement emphasizes that 'Science is an activity that generates ideas,' whereas the essence of the negative statement suggests that 'Science is an activity involved in developing technology.' Despite their apparent similarity, these statements delineate a fundamental difference: science isn't solely about advancing technology. The essence of scientific goals encompasses uncovering unknown facts, adaptation, and enhancing daily life. Simultaneously, technology development represents only a fraction of science's broader objectives.

An understanding of science attitudes is the aspect needed by the teacher in teaching science. Based on research conducted by Lin et al (2014), Fauth et al (2019) dan Chi et al

(2018) shows that the understanding of teachers' scientific attitudes towards science education not only affects their performance in carrying out the learning process but also affect student success, their performance, and attitudes towards science lessons. Therefore, knowledge of the teacher's scientific attitude towards teaching science must bring out a positive attitude in students so that they can develop curiosity, the emergence of various skills, and others (Erdogan, 2017).

The findings from these studies emphasize the necessity of cultivating scientific skills and attitudes in students right from an early age within the science learning process. When both aspects are taught and nurtured at an early stage, students can cultivate their interests and talents, boost motivation and active engagement in the learning process, foster curiosity and a passion for learning, enhance their research skills, develop a deeper comprehension beyond mere facts, and empower them to take charge of their learning journey, effectively achieving their learning objectives (Laden, 2020). Through a learning process that pays attention to these two skills, students can develop the ability in observing, classifying, communicating, measuring, predicting, planning experiments, hypothesizing, interpreting data, and concluding (Akinbobola & Afolabi, 2010; Duruk et al., 2017). The acquisition of scientific skills and attitudes stands as a crucial outcome, vital for interpreting educational events and programs across all stages of scientific studies, encompassing disciplines like biology, physics, and chemistry. Yet, for students to acquire these skills effectively, teachers must possess them first, optimizing the development of these critical attributes in their students.

CONCLUSION

This study showed that the inquiry skills of elementary school teachers need to be improved because, in general, they are still in the "weak" category. In addition to the scientific attitude, it was found that the response of prospective teachers to statements of scientific attitude between positive and negative statements was quite different even though there were two categories of scientific attitudes that were the same—the response. The two categories are "basic science" and "purpose of science" Inquiry skills, and a scientific attitude are essential in learning science in elementary schools. Therefore, both skills need to be considered and developed in the lecture process and training for both teachers and prospective teachers.

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