

Attitudes Towards Science and Perceptions of Difficulty as Factors Affecting Students' Achievement in Science

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Abstract. This study aimed to examine the influence of attitudes toward science and perceptions of learning difficulty on elementary school students' science achievement and to identify the most dominant affective factors. A quantitative, correlational design was employed. The sample consisted of 372 students in grades IV, V, and VI from six elementary schools representing urban, peri-urban, and rural areas. Data was collected using a science attitude questionnaire, a perceived learning difficulty questionnaire, and a short-answer science achievement test. Data analysis employed validity and reliability testing, multiple regression, F-tests (ANOVA), and partial t-tests. Multiple regression analysis revealed that the model was significant ($F(7, 364) = 34.5$; $p < 0.001$), $R^2 = 0.399$, indicating that the five variables together accounted for 39.9% of the variance in students' science achievement. Attitudes toward science was the strongest predictor ($\beta = 0.441$; $t = 9.22$; $p < 0.001$), followed by perceived learning difficulty ($\beta = 0.181$; $t = 3.84$; $p < 0.001$). Partial t-test analysis revealed significant differences by school location, with peri-urban students outperforming rural students ($B = 10.492$; $p < 0.001$) and urban students ($B = 6.663$; $p < 0.001$). These findings confirm that affective factors and the learning environment play important roles in shaping elementary school students' science achievement.

Keywords: Attitudes Toward Science; Perceptions of Learning Difficulty; Science Achievement; Elementary School; Science Learning.

1. Introduction

Science, or Natural Sciences (IPA), is defined as a branch of knowledge that systematically studies natural phenomena through observation, experimentation, and scientific reasoning, and encompasses three inseparable dimensions: science as a product consisting of facts, concepts, and theories; science as a process consisting of scientific skills; and science as an attitude comprising scientific values and dispositions formed through learning experiences (Elisa et al., 2023). Science is recognized as one of the key foundations of 21st-century education, through which students are equipped with critical thinking skills, scientific literacy, and the readiness to address global challenges rooted in science and technology (Utami et al., 2022). At the elementary school level, science learning plays a role not only in building conceptual knowledge about natural phenomena but also in shaping scientific attitudes and process skills that serve as the foundation for science learning at higher levels (Bakker & Telli, 2023). Early science education is a fundamental basis for instilling the logical, critical, and exploratory mindset that students need throughout their lives (Nur et al., 2023). More than just mastery of content, authentic student achievement in science also encompasses the development of scientific attitudes such as curiosity, perseverance, and openness to empirical evidence (Irsan, 2021; Sekaringtyas et al., 2024). Thus, the quality of science learning in elementary school is a crucial early determinant of students' long-term scientific competencies.

However, international data indicate that Indonesian students' science achievement remains far from satisfactory. The results of the 2022 Program for International Student Assessment (PISA) ranked Indonesia 68th out of 81 participating countries in science, with an average score of 383, well below the OECD average of 485 (OECD, 2023). At the national level, results from the National Assessment indicate that the majority of elementary school students are not yet able

to apply scientific concepts contextually in daily life (Syahputra et al., 2022; Wardani et al., 2023). This situation cannot be explained solely by cognitive factors but is also influenced by affective factors that shape students' orientation and engagement in science learning.

Empirical studies in Indonesia have revealed that students' attitudes toward science tend to be moderate, with higher responses on the science value dimension, followed by enjoyment and confidence, while participation in science learning and activities is the lowest-scoring dimension (Wicaksono & Korom, 2023). These findings suggest that although science is recognized as valuable, active engagement and confidence in science learning remain underdeveloped among Indonesian students. At the elementary school level, research consistently shows that when students do not find pleasure in learning science, their positive attitudes toward science education are hampered. In Indonesia, many elementary school students exhibit passive attitudes toward science learning, as reflected in low participation in exploratory activities and a lack of initiative in asking scientific questions (Wardani et al., 2023). These conditions indicate that students' attitudes toward science constitute a critical affective factor that directly impacts the quality of their engagement and learning outcomes in science. These barriers manifest visibly in the classroom through diminished confidence, passive behavior in discussions, and withdrawal from group tasks. From an external perspective, the primary obstacles include teacher-centered and monotonous instructional methods, as well as limited learning facilities and resources, which further suppress students' interest and motivation (Andika et al., 2025). These findings collectively affirm that affective disengagement in elementary science learning is a systemic pattern that demands targeted pedagogical intervention.

1.1. Problem Statement

Although the urgency of improving Indonesian students' science engagement has been widely discussed, attention to the underlying psychological and affective factors remains relatively limited in the elementary school context. Attitudes toward science, which reflect students' positive or negative tendencies in responding to science learning, are a strong predictor of academic achievement in science (Liou, 2021; Mao et al., 2021). However, a concerning finding has been revealed that students' positive attitudes toward science tend to decline as they progress through school, and this decline is identified as beginning as early as the elementary level if not addressed with appropriate instructional strategies (Jimenez & Hevia, 2022). A positive attitude toward science is understood to directly encourage active engagement and sustained participation in science learning activities (Munawar et al., 2025). On the other hand, the perception of difficulty in learning science is regarded as a psychological factor that is no less important, yet is often overlooked. This perception of difficulty is frequently found to not align with students' actual abilities, so truly capable students may be impeded in their performance if science is believed to be too difficult for them (Afikah et al., 2024). Negative perceptions of the difficulty of learning science, triggered by the abstract nature of the material, unfamiliar scientific terminology, and a lack of inquiry experience, are identified as psychological barriers that undermine elementary students' motivation and engagement in learning (Novianti et al., 2022).

Although awareness of the importance of affective factors in science education is growing, empirical research on students' attitudes toward science and their perceptions of learning difficulties at the elementary school level remains limited, particularly in the Indonesian context. These two affective constructs are rarely examined together in a single study, so their combined contribution to student engagement in science learning remains unclear. Therefore, this study aims to address this gap by investigating the relationship between attitudes toward science and perceptions of learning difficulties, determining which affective factor is more dominant, and exploring these differences based on school location, grade level, and gender among elementary school students.

1.2. Related Research

Several previous studies have examined the role of attitudes toward science in students' academic achievement. A three-level meta-analysis encompassing hundreds of international

studies confirmed a positive and significant relationship between attitudes toward science and academic achievement, with self-efficacy serving as the primary mediating mechanism (Mao et al., 2021). Variations in science instructional practices, particularly inquiry-based and experimental learning, significantly moderate the relationship between students' attitudes and science achievement (Liou, 2021). Student engagement in citizen science projects has also been shown to enhance positive attitudes toward science and to strengthen academic achievement in the medium term (Araújo et al., 2021). At the elementary school level, students' perceptions of scientists significantly influence their attitudes toward science (Bakker & Telli, 2023). Furthermore, scientific attitudes and a tendency toward intellectual risk-taking among elementary school students are directly linked to how they respond to challenges in science learning; thus, positive attitudes not only improve grades but also foster scientific character (Küçükaydın, 2021).

In the dimension of perceptions of learning difficulty, there is a significant gap between students' perceptions of science difficulty and their actual critical thinking skills, which appropriate pedagogical interventions must address (Afikah et al., 2024). Students' perceptions of the STEM learning climate, including how challenging and supportive they perceive the environment to be, significantly influence their engagement and academic achievement (Fairhurst et al., 2023). Factors shaping students' perceptions of inquiry-based learning include teacher support, availability of learning resources, and self-confidence, indicating that perceptions of difficulty are not standalone variables but rather the product of complex interactions among personal and contextual factors (Vekli, 2021).

This study aims to address these gaps through three key novelties. This study simultaneously integrates two affective predictors, attitudes toward science and perceptions of learning difficulty into a single multiple regression model to test their effects on elementary students' science achievement, a combination that has never been explicitly tested within a unified analytical framework (Candia & Lay, 2025). This study systematically examines three moderator variables simultaneously, school location (urban, peri-urban, rural), grade level (4th, 5th, 6th), and gender within a single integrated analytical framework, going beyond previous studies that tested only one moderator or ignored the geographical context, a dimension that has been absent in studies of affective factors in elementary school science learning (Aditia & Széll, 2025; Mangubat, 2025). By focusing on fourth-, fifth-, and sixth-grade students from six elementary schools representing the diversity of regions in Indonesia, this study generates contextual empirical evidence that can be used by elementary education policymakers to design effective interventions responsive to differences in student location, grade level, and gender.

1.3. Research Objectives

This study was conducted with three main objectives. First, this study aims to analyze the extent to which attitudes toward science contribute to elementary school students' science learning outcomes. Second, this study examines the influence of perceptions of learning difficulty on elementary school students' science learning outcomes. Third, this study was intended to determine which variable has a more dominant influence on science achievement attitudes toward science or perceived learning difficulty, so that it can serve as a basis for developing more effective learning strategies.

2. Theoretical Framework

This section presents the theoretical foundation underlying the study, encompassing the nature of science learning in elementary school, students' science achievement, attitudes toward science, and perceptions of learning difficulty in science.

2.1. The Nature of Science Learning in Elementary School

Science learning at the elementary school level is fundamentally characterized as a process of active knowledge construction through which students engage with natural phenomena in ways that are empirically grounded and contextually meaningful (Magdalena et al., 2023).

This process is closely aligned with students' cognitive developmental stage; science learning in elementary schools is adjusted to age-appropriate stages in accordance with Piaget's theory of cognitive development. According to Piaget's theory of cognitive development (as cited in Zhang, 2022), children must go through certain stages of learning, moving from concrete information to more abstract ideas, and Piaget's four main developmental stages have provided a very useful framework for educators to construct a meaningful, age-appropriate pedagogy. In this regard, students in grades 4–6 are generally at the concrete operational stage, where understanding develops through direct interaction with concrete objects and observable phenomena (Hayat et al., 2024). Consequently, science instruction in elementary school must be pedagogically designed around concrete experiences and contextual exploration that align with students' developing cognitive capacities.

Science education in elementary school provides vital early experiences that shape students' perceptions of the natural world and scientific activities, while also serving as a foundation that determines the quality of science education at subsequent levels (Bakker & Telli, 2023). This foundation is built through learning objectives that encompass the development of basic knowledge of natural phenomena, the cultivation of a positive attitude toward science, and the mastery of scientific skills such as observation, questioning, and inference through substantive, meaningful learning experiences (Nur et al., 2023; Soslu, 2022). Thus, authentic science achievement at this level cannot be narrowly interpreted as merely the mastery of concepts, but must also include the development of science literacy and scientific attitudes such as curiosity, perseverance, and openness to empirical evidence all of which indicate that students' affective and psychological dimensions, including their attitudes toward science and their perceptions of the learning process, are integral components of the quality of science learning in elementary school that cannot be overlooked (Bazar et al., 2024; Ilhami et al., 2025).

2.2. Science Achievement of Elementary School Students

Elementary school students' science achievement is a measure of their success in mastering the knowledge, attitudes, and skills related to science education. This achievement reflects not only their cognitive ability to understand scientific concepts, but also their ability to apply scientific process skills and demonstrate a scientific attitude in their daily lives (Pataky et al., 2025). As a multidimensional construct, academic achievement in science is influenced by the interaction of internal student factors, such as motivation, self-efficacy, and self-regulation, as well as external factors, such as the quality of teaching, the availability of learning resources, and support from both the family and school environments (Zafeer et al., 2024).

Indicators of elementary school students' science achievement include the ability to understand science concepts, interpret simple information and data, apply basic scientific process skills such as observation, measurement, and inference, and relate scientific concepts to phenomena in everyday life (Dolapcioglu & Subasi, 2022). Science process skills are an essential component of scientific achievement because they serve as a bridge between conceptual understanding and practical scientific application; therefore, mastering them from the elementary level is crucial for the long-term development of students' scientific competencies. This aligns with the findings of a longitudinal meta-analysis showing that students' academic achievement tends to be stable over the long term, meaning that students' starting point in elementary school has direct implications for their learning trajectories in subsequent grades (Scherrer et al., 2025). Therefore, early intervention that focuses on strengthening both cognitive and affective aspects at the elementary school level is the most effective strategy for sustainably improving science achievement.

2.3. Attitudes Toward Science

Attitudes toward science refer to students' psychological tendencies in evaluating, perceiving, and reacting to science learning, whether regarding the subject itself, learning activities, or the practical value of science in daily life. This attitude is multidimensional, encompassing a cognitive dimension comprising beliefs about science, an affective dimension comprising feelings of enjoyment or displeasure, and a conative dimension

comprising tendencies to act in the context of science learning (Tai et al., 2022). According to social cognitive theory, human behavior is shaped by the reciprocal interaction among personal, behavioral, and environmental factors. Within this framework, self-efficacy beliefs are developed through four key sources: mastery experiences, vicarious experiences, social persuasion, and emotional or physiological states (Bandura, 1997, as cited in Yerdelen et al., (2024). All of which collectively influence an individual's confidence in performing tasks and engaging with learning. In the context of science learning, a positive attitude supported by high self-efficacy encourages students to be more active, persistent, and meaningfully engaged in the learning process (Mao et al., 2021). Affective factors such as attitude, interest, and motivation to learn have been shown to serve as important predictors of elementary school students' academic achievement; consequently, low affective readiness often hinders the attainment of optimal learning outcomes (Huda & Dewanti, 2025).

Attitudes toward science are relatively stable, but can be shaped through high-quality learning experiences (Ganajová et al., 2025; Miller et al., 2025). Authentic science learning experiences, such as the use of adapted primary scientific literature, have been shown to foster students' positive perceptions of science and promote meaningful scientific reasoning (Hidayat et al., 2021). This underscores that the quality of the learning experience is not merely a matter of exposure to content, but rather a key factor in shaping students' attitudes toward science. This finding reinforces the need for ongoing learning strategies to sustain students' positive attitudes. Demographic and contextual factors have also been shown to influence the development of students' attitudes toward science, including family background and sociocultural experiences (Mujtaba & Reiss, 2022).

2.4. Perceptions of Difficulty in Science

The perception of difficulty in learning science is a student's subjective assessment of the level of difficulty they experience when studying science. As a metacognitive experience, the perception of difficulty is not merely an opinion but rather the product of cognitive inferences that emerge in real time as students process information and engage in learning tasks (Malmberg et al., 2022). This perception is shaped by learning experiences, the ability to understand concepts, and how students interpret the learning activities they encounter. Perceptions of learning difficulty do not always align with students' actual academic abilities, yet they remain a significant psychological factor influencing the learning process and outcomes (Afikah et al., 2024). Unmanaged negative perceptions can create psychological barriers that suppress motivation and significantly reduce students' engagement in learning (Eka et al., 2025).

Perceptions of difficulty in learning science can be identified through several indicators, such as difficulty understanding concepts, barriers to understanding scientific terminology, limited science process skills, and difficulty relating science content to everyday life (Afikah et al., 2024; Fairhurst et al., 2023). The factors causing difficulties in learning science are divided into internal factors, including low interest, motivation, self-confidence, and study habits, as well as external factors such as the abundance of unfamiliar terms, overly dense material, limited learning media, and inappropriate teaching strategies (Novianti et al., 2022). These two sets of factors interact to shape students' subjective perceptions of science difficulty, which ultimately influence how they respond to and engage in the learning process. Factors influencing students' perceptions of inquiry-based science learning also include teacher support, the availability of learning resources, and self-confidence in scientific exploration (Vekli, 2021).

Perceptions and attitudes toward science contribute to scientific achievement through psychological mechanisms that influence student engagement in learning; specifically, perceptions of difficulty that are proportionate and well-managed tend to foster optimal engagement, whereas excessive perceptions of difficulty act as barriers (Candia & Lay, 2025). Scientific attitudes and a tendency to take intellectual risks among elementary school students are also closely related to how they interpret challenges in science, so that a healthy perception of difficulty can actually encourage deeper scientific exploration (Küçükaydın, 2021). Therefore, the perception of learning difficulty is not merely an obstacle to be

eliminated, but rather a psychological variable that needs to be managed through appropriate learning strategies to enable elementary school students to achieve optimal engagement and achievement in science.

3. Method

3.1. Research Design

This study employs a quantitative approach using a cross-sectional survey design, which involves collecting data from respondents at a specific point in time to determine the observational relationships between variables without researcher intervention. This approach was chosen because it yields findings that can be generalized with a high degree of reliability through empirical data collected using standardized instruments and analyzed statistically (Muhajirin et al., 2024).

The research design used was correlational, aiming to examine the relationship between the independent variables, attitude toward science (X1) and perception of difficulty in learning science (X2), and the dependent variable, students' science achievement (Y). This study also analyzed the most influential factors and differences in influence based on moderator variables: school location, grade level, and gender. A correlational design was chosen because it does not experimentally manipulate variables but rather observes relationships that occur naturally in the field (Creswell, 2009).

The data analysis process began with instrument quality testing, namely validity and reliability testing. Validity testing was conducted using the Pearson Product-Moment formula, in which the score for each instrument item was correlated with the total score of the relevant variable; an item was considered valid if its correlation (r) exceeded the r -table at the 0.05 significance level. Reliability testing measured instrument consistency using Cronbach's Alpha, with a threshold of ≥ 0.70 for an instrument to be considered reliable. Once the instruments were verified, the main analysis proceeded with multiple regression to test the simultaneous and partial effects of the independent variables on the dependent variable, including the coefficient of determination (R^2) to assess the proportion of variance explained by the model, and F- and t-tests to assess the significance of the effects.

The operational definitions of the variables are as follows: X1 is measured using indicators of students' interest, enthusiasm, and confidence in science; X2 encompasses students' subjective assessments of the difficulty of the material and the learning process; and Y is measured by test scores on mastery of scientific concepts and process skills. This analytical framework is illustrated in Figure 1 below, which depicts the regression model and the pathways for variable relationships.

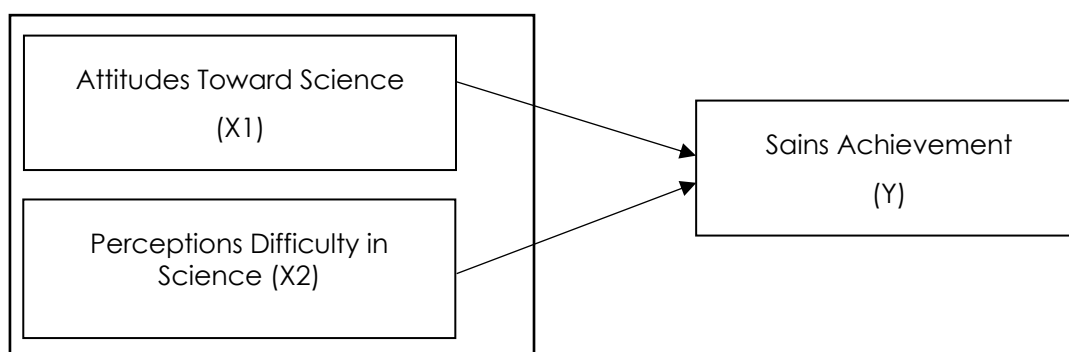


Figure 1. Conceptual Framework

3.2. Participants

The population in this study comprised all students in Grades IV, V, and VI at six elementary schools, totaling 372 students. The study employed purposive sampling to select the research schools, choosing schools based on their characteristics to represent urban, peri-urban, and

rural area categories, with two schools from each category. Once the schools were determined, all Grade IV, V, and VI students at each school were recruited as research respondents using total sampling. This approach was taken to ensure that all respondent characteristics were more comprehensively represented, including gender, grade level, and school location classification, so that the data obtained would provide a stronger picture of elementary school students' science achievement across diverse learning environments. Table 1 shows the frequency and percentage of respondents based on gender.

Table 1. Participants' Characteristics

Gender	Frequency	Percentage
Male	183	49.19
Female	189	50.81
Total	372	100%

3.3. Data Collection

Primary data collection was conducted through a survey comprising questionnaires and tests. Questionnaires were used to measure two constructs: (1) students' attitudes toward science, consisting of 5 statement items, and (2) students' perceptions of learning difficulty in science, consisting of 4 statement items. All questionnaire items were adapted to the linguistic level of elementary school students and used a closed-ended response format to facilitate efficient responses and ease data analysis. The questionnaire instruments were developed using a four-point Likert scale. The use of a four-point scale was intended to reduce the tendency toward neutral responses, thereby encouraging students to provide clearer answers to each statement. Each response option was assigned a graduated score: 1 for strongly disagree, 2 for disagree, 3 for agree, and 4 for strongly agree for positive statements. For negative statements, scores were reversed to maintain consistency with the variable's direction. In addition to questionnaires, the study used a science achievement test comprising 20 short-answer items, each carrying an equal weight of 5 points, yielding a maximum total score of 100 (20 items $\times$ 5 points = 100), developed based on science content relevant to students in Grades IV, V, and VI. All data collection was conducted directly at the schools following receipt of research permission.

The data collection instruments in this study were adapted from two prior studies. The science attitude questionnaire was adapted from an instrument used to measure students' attitudes toward science at the primary education level (Educational Assessment Research Unit and New Zealand Council for Educational Research, 2017). The perceived learning difficulty questionnaire was adapted from a prior instrument measuring students' perceived learning difficulties in science learning (Fitzgerald et al., 2020). Both instruments were adjusted to the context and characteristics of elementary school students in Indonesia, and then subjected to validity and reliability testing prior to use in data collection. Descriptions of the indicators for the science attitude questionnaire are provided in Table 2.

Table 2. Indicator of Science Attitude Instrument

Indicator	Descriptor	Item No.	Item Type
Interest in science	I think learning about science is interesting.	1	Positive
Enjoyment of science learning	I enjoy learning about science at school.	2	Positive
Interest in deepening science	I want to learn more about science at school.	3	Positive
Future orientation toward science	I want to continue learning science as I grow up.	4	Positive

Perception of the usefulness of science	I learn useful things through science at school.	5	Positive
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The science attitude instrument focuses on students' intrinsic engagement and future orientation toward science. In contrast, the perception of difficulty instrument captures students' subjective experience of challenge in the learning process, as shown in Table 3 below.

Table 3. Indicator of Science Difficulty Perception Instrument

Indicator	Descriptor	Item No.	Item Type
Difficulty understanding content	I often do not understand science lessons in class.	1	Negative
Perception of ease of science	I find science too easy.	2	Positive
Level of challenge in science	I find science challenging.	3	Positive
Perception of difficulty in science	I find science too difficult.	4	Negative

These two questionnaire instruments were complemented by a science achievement test, with item indicators presented in Table 4. The test was designed to assess conceptual understanding and scientific process skills relevant to Grades IV–VI.

Table 4. Indicator of Science Assessment Questions Instrument

Indicator	Descriptor	Item No.
Interpret the impact of the absence of light on plant survival	Analyze the need for light	1, 2
Identify the function of leaves as the site of photosynthesis and roots as water absorbers	Analyze plant parts and their functions	3, 6
Analyze the types of gases absorbed and produced by plants for the air balance	Explain the role of plants in the environment	4
Predict what would happen if green leaf pigment were damaged due to pollution	Analyze the function of chlorophyll	5
Create solutions to maintain oxygen availability in barren land	Propose conservation solutions	7
Use the context of human activity and its impact on environmental balance	Determine activities that disrupt environmental balance	8
Interpret and identify terms based on descriptions of phenomena	Relate the impact of living organisms' activities to global environmental change	9, 11
Explain the role of plants based on the presented context	Explain the role of plants in maintaining environmental balance	10

Interpret table data based on cause-and-effect relationships	Analyze the impact of human activities on health	12
Interpret descriptive information and table data	Analyze the relationship between seasonal/weather conditions and human activity	13, 14
Collect and interpret graphs	Interpret energy change data from a simple graph	15
Use evidence from the table data	Explaining energy changes	16,17
Identify representations from diagrams	Explain the energy change flow	18
Critically evaluate evidence from written facts	Analyze statements based on energy facts	19
Interact with and understand scientific knowledge based on real context	Relate the concept of energy change to everyday life	20

3.4. Data Analysis

Data analysis was conducted in stages in accordance with the research objectives. First, validity and reliability testing of the instruments were conducted to ensure the quality of the collected data. Item validity was assessed using the Pearson product-moment correlation with each variable's total score; an item was considered valid if its correlation exceeded the critical r -value at the 0.05 significance level. Instrument reliability was then assessed using Cronbach's Alpha, with a value deemed adequate if it reached or exceeded 0.70. Data analysis was carried out using Jamovi for Windows, which supports a range of statistical techniques appropriate to this study.

After instrument verification, descriptive analysis, normality testing, linearity testing, multicollinearity testing, and autocorrelation testing, all of which yielded satisfactory results, the main analytical stage was initiated. The main analysis proceeded with multiple regression to test the simultaneous and partial effects of the independent variables on the dependent variable. The F-test (ANOVA) was used to assess the overall adequacy of the model, while the partial t-test was used to assess the significance of each predictor's effect. The coefficient of determination (R^2) was used to measure the proportion of variance explained by the model. Multiple regression analysis is the appropriate statistical technique for simultaneously examining the effects of several independent variables on a single dependent variable while also identifying the relative contribution of each predictor within the model (Creswell, 2009).

3.5. Validity and Reliability

The results of validity testing confirmed that the student data collected were valid and suitable for reliability testing. The results of the validity tests for the instruments developed are shown in Tables 5, 6, and 7.

Table 5. Summary of Science Attitude Validity Test

Items	Corrected Item-Total Correlation	R table	Information
SA 1	0.739	0,101	Valid
SA 2	0.739	0,101	Valid
SA 3	0.767	0,101	Valid
SA 4	0.698	0,101	Valid
SA 5	0.761	0,101	Valid

The validity test results for the science attitude instrument indicate that all five items met the validity criteria, as evidenced by corrected item-total correlation values ranging from 0.698 to

0.767, all of which exceeded the critical r -value of 0.101. These findings suggest that each item adequately represents students' attitudes toward science and can therefore be retained for further analysis.

Table 6. Summary of Perception Difficulty Validity Test

Items	Corrected Item-Total Correlation	R table	Information
PD 1	0.732	0,101	Valid
PD 2	0.671	0,101	Valid
PD 3	0.671	0,101	Valid
PD 4	0.848	0,101	Valid

As shown in Table 6, all items in the perception difficulty instrument were found to be valid, with corrected item-total correlation values ranging from 0.671 to 0.848, exceeding the required threshold. This indicates that the instrument consistently measures students' perceptions regarding the difficulty of learning science.

Table 7. Summary of Science Achievement Validity Test

Items	Corrected Item-Total Correlation	R table	Information
EQ 1	0.352	0,101	Valid
EQ 2	0.526	0,101	Valid
EQ 3	0.410	0,101	Valid
EQ 4	0.487	0,101	Valid
EQ 5	0.423	0,101	Valid
EQ 6	0.566	0,101	Valid
EQ 7	0.499	0,101	Valid
EQ 8	0.261	0,101	Valid
EQ 9	0.569	0,101	Valid
EQ 10	0.508	0,101	Valid
EQ 11	0.462	0,101	Valid
EQ 12	0.439	0,101	Valid
EQ 13	0.338	0,101	Valid
EQ 14	0.243	0,101	Valid
EQ 15	0.551	0,101	Valid
EQ 16	0.342	0,101	Valid
EQ 17	0.442	0,101	Valid
EQ 18	0.315	0,101	Valid
EQ 19	0.245	0,101	Valid
EQ 20	0.353	0,101	Valid

The validity test results show that all items for each variable were declared valid, with item-total correlation values exceeding the r -table (0.101). Next, a reliability test was conducted for all variables, as shown in Table 8.

Table 8. Summary of Reliability Test for Science Attitude, Perception Difficulty, and Science Achievement Instruments

Reliability	Alpha Cronbach	Information
Sains Attitude (X1)	0.794	Reliable
Perception Difficulty (X2)	0.713	Reliable
Sains Achievement (Y)	0.748	Reliable

The reliability test results indicate that the instruments for each variable are sufficiently robust, with Cronbach's Alpha values > 0.70 ; therefore, all instruments are deemed reliable and suitable for use in the final analysis.

4. Findings

4.1. Multiple Regression

A multiple regression model fit test was conducted to determine the extent to which the independent variables explain variation in the dependent variable. The analysis yielded an R value of 0.631, indicating a moderately strong relationship between the independent variables and students' science achievement. A summary of the model results is presented in Table 9.

Table 9. Model Summary

Model	R	R ²	Overall Model Test				
			Adjusted R ²	F	df1	df2	p
1	0.631	0.399	0.387	34.5	7	364	<.001

Note. Models estimated using a sample size of N=372

The R² value of 0.399 indicates that the variables of attitudes toward science, perceived learning difficulty, school location, grade level, and gender collectively explain 39.9% of the variance in students' science achievement, with the remaining 60.1% attributed to factors outside the model.

The Adjusted R² value of 0.387 indicates that, after adjustment for the number of variables in the model, the model's explanatory capacity remains relatively stable.

In addition, the F-test results showed an F-value of 34.5 (7, 364) with $p < 0.001$, indicating that the regression model as a whole is significant. This suggests that the independent variables collectively influence student learning outcomes.

4.2. Simultaneous Significance F-Test (ANOVA)

The ANOVA results from the multiple regression analysis serve as a global test (an overall test) to assess the adequacy of the model. The results of the significance test are presented in Table 10.

Table 10. Simultaneous Significance Test

	Sum of Square	df	Mean Square	F	p
Total SA	18643	1	18643	84.93	<.001
Total PD	3241	1	3241	14.77	<.001
A (Locations)	6508	2	3254	14.82	<.001
B (Grades)	1625	2	812	3.70	.026
C (Gender)	444	1	444	2.02	.156
Residuals	79902	364	220		

Note. Type 3 sum of squares

The partial significance test of the model was conducted using the F-test (ANOVA) to determine each independent variable's contribution to learning outcomes. The results indicate that the Attitudes toward Science (SA) variable had a significant effect on learning outcomes ($F(1,364) = 84.93$; $p < 0.001$). The Perceived Learning Difficulty (PD) variable also showed a significant effect ($F(1,364) = 14.77$; $p < 0.001$). In addition, the school location variable had a significant effect on learning outcomes ($F(2,364) = 14.82$; $p < 0.001$). The grade-level variable also showed a significant effect ($F(2, 364) = 3.70$; $p = 0.026$). Gender, however, did not have a significant effect on learning outcomes ($F(1, 364) = 2.02$; $p = 0.156$). Accordingly, the majority of independent variables in the model had a significant effect on learning outcomes, except for the gender variable.

4.3. Coefficient T-Test

The partial t-test in multiple regression was used to assess the impact of each independent variable (X) individually on the dependent variable (Y). The purpose of this test is to identify

which variables have individually significant effects within the overall regression model. The t-test reveals the magnitude and strength of each independent variable's effect on the dependent variable. The following presents the results of the partial significance test (coefficients) in Table 11.

Table 11. Partial Significance Test

Predictor	Estimate	SE	t	p	Stand. Estimate
Intercept	11.490	4.0048	2.87	.004	
Total SA (X1)	0.509	0.0553	9.22	<.001	0.441
Total PD (X2)	0.209	0.0544	3.84	<.001	0.181
A:					
2=urban – 1=rural	10.492	1.9326	5.43	<.001	0.554
3=urban – 1=rural	6.663	1.9589	3.40	<.001	0.352
B:					
5=grade 5 – 4=grade 4	-2.693	1.9331	-1.39	.164	-0.142
6= grade 6 – 4= grade 4	2.427	1.9215	1.26	.207	0.128
C:					
2=male – 1=female	2.201	1.5486	1.42	.156	0.116

The regression coefficient test (t-test) results indicate that the Attitudes toward Science (SA) variable had a positive and significant effect on learning outcomes ($B = 0.509$; $t = 9.22$; $p < 0.001$). This indicates that every one-unit increase in attitudes toward science is associated with a 0.509-unit increase in learning outcomes, assuming all other variables remain constant. The standardized coefficient ($\beta = 0.441$) indicates that this variable has the largest relative contribution in the model.

The Perceived Learning Difficulty (PD) variable also had a positive and significant effect on learning outcomes ($B = 0.209$; $t = 3.84$; $p < 0.001$; $\beta = 0.181$). This indicates that perceived learning difficulty makes a significant contribution to learning outcomes, although smaller than that of attitudes toward science.

For the school location variable, significant differences were found between groups. Students in peri-urban schools achieved higher learning outcomes than those in rural schools ($B = 10.492$; $t = 5.43$; $p < 0.001$). Similarly, students in urban schools achieved higher learning outcomes than those in rural schools ($B = 6.663$; $t = 3.40$; $p < 0.001$).

The grade level variable, however, did not show a significant effect on learning outcomes. Comparison of Grade 5 with Grade 4 yielded $p = 0.164$, and Grade 6 with Grade 4 yielded $p = 0.207$; neither was significant.

The gender variable also did not show a significant effect on learning outcomes ($B = 2.201$; $t = 1.42$; $p = 0.156$).

5. Discussion

The results of the study indicate that attitudes toward science have a positive and significant effect on elementary school students' science achievement and are the strongest predictor among the variables ($\beta = 0.441$). Students who demonstrate high levels of interest, enjoyment, and self-confidence in learning science tend to achieve better academic outcomes. These findings are consistent with Liou (2021) and Mao et al. (2021), who found a correlation between self-efficacy, positive attitudes toward science, and students' academic achievement. Students with positive attitudes toward science are more active in learning activities and are more resilient in the face of difficulties (Munawar et al., 2025). Therefore, teachers are advised to design engaging, context-based science learning activities to increase student engagement.

Perceptions of difficulty in learning science significantly influence science achievement ($\beta = 0.181$; $p < 0.001$). Interestingly, the effect is positive, indicating that students who acknowledge the challenges of learning science are more motivated and actively engaged in the learning

process. This aligns with the findings of Fairhurst et al. (2023), who showed that students' perceptions of the STEM learning environment, including the challenge aspect, influence their academic engagement. Additionally, teacher support, the availability of learning resources, and student self-confidence influence how they perceive difficulty (Vekli, 2021). Therefore, teachers need to provide adequate scaffolding so that students' perceptions of difficulty are at a productive level challenging enough to motivate, yet not so challenging as to cause excessive anxiety.

Simultaneously, the F-test indicates that the regression model as a whole is significant ($F(7,364) = 34.5$; $p < 0.001$; $R^2 = 0.399$). The R^2 value of 0.399 indicates that attitudes toward science, perceived learning difficulty, school location, grade level, and gender together account for 39.9% of the variation in students' science achievement. These findings confirm that science achievement is not determined solely by cognitive factors, but also by a combination of affective, psychological, and contextual factors.

There are significant differences in science achievement by school location, with peri-urban students achieving higher scores than both urban and rural students. This phenomenon indicates the role of educational facilities, the quality of the learning environment, and socio-economic conditions in shaping student achievement. This aligns with the findings of Aditia and Széll (2025), who stated that contextual factors and social inequality significantly shape students' academic achievement in Indonesia. The advantages of peri-urban schools can be explained by their unique position, which provides relatively good access to educational facilities from urban areas while maintaining a conducive learning environment characteristic of less densely populated areas (Sahana et al., 2023). Furthermore, schools in rural areas often face challenges in academic achievement due to limited resources and infrastructure (Johnson et al., 2021). These findings imply the need for policies to ensure equitable access to educational resources for schools in rural areas.

This study found no significant differences in science achievement between grade levels ($p = 0.164$ for 5th grade vs. 4th grade; $p = 0.207$ for 6th grade vs. 4th grade). A meta-analysis of longitudinal studies found that students' academic achievement is relatively stable across school levels, and this stability is influenced more by affective and motivational factors than by grade level (Scherrer et al., 2025). Furthermore, no significant differences in science achievement were found based on gender ($p = 0.156$). Iwuanyanwu (2022) found that gender differences in attitudes toward science do not consistently result in differences in academic achievement, particularly when the learning environment is inclusive. The contribution of gender to science achievement is minimal when affective and pedagogical factors are controlled for (Susilawati et al., 2022). These findings indicate that inclusive learning can provide fair opportunities for all students, regardless of gender.

6. Conclusion

The findings of this study show that attitudes toward science and perceived learning difficulty both had significant effects on the science achievement of elementary school students, with attitudes toward science being the most dominant factor ($\beta = 0.441$). Simultaneously, all variables in the model explained 39.9% of the variance in students' science achievement. School location also influenced science achievement, with peri-urban students outperforming urban and rural students, while grade level and gender showed no significant differences. These findings confirm that science achievement is not solely influenced by cognitive ability, but also by affective, psychological, and learning environment factors; therefore, science learning should be designed contextually and supportively to foster positive attitudes and students' self-confidence.

Limitation

This study has several limitations that should be considered when interpreting its results. First, the study was conducted only in elementary schools in one region with a limited number of schools, so the results cannot be fully generalized to represent the conditions of elementary school

students across Indonesia. Second, data on attitudes toward science and perceived learning difficulty were collected through self-report questionnaires, which are susceptible to social desirability bias, particularly among elementary school students who are still developing their capacity for self-reflection. Third, the science test instrument covered relatively uniform content across Grades IV, V, and VI, potentially reducing its ability to differentiate cognitive ability differences across grade levels. Fourth, this study did not account for other variables that may influence science achievement, such as learning motivation, parental support, teacher instructional quality, school facilities, and family socioeconomic conditions.

In light of these limitations, future studies are recommended to broaden the sample to be more extensive and diverse, involving schools from various regions and educational levels; use measurement instruments more appropriate to students' developmental stages; and include additional relevant variables to yield more comprehensive results and stronger generalizability.

Recommendation

Further research is recommended to enhance this study by adding other variables relevant to learning outcomes, such as students' learning motivation, parental support, instructional approaches, and social environment factors. Subsequent studies could also adopt a mixed methods approach to gain more holistic insights, encompassing both quantitative and qualitative dimensions. Such research would also benefit from being expanded to different educational levels or to more diverse sample groups to strengthen the generalizability of the findings.

Based on the findings of this study, teachers should implement inquiry-based, project-based, and context-based science learning activities that connect scientific concepts with students' daily experiences. Schools should regularly monitor students' attitudes toward science through formative assessments and provide early intervention when negative attitudes emerge. Professional development programs should equip teachers with strategies for creating engaging and supportive science learning environments. Policymakers should encourage the integration of hands-on investigations, collaborative learning, and authentic scientific inquiry into the elementary science curriculum. These strategies are expected to strengthen students' interest and attitudes toward science and prevent the decline in science engagement reported in previous studies.

Declaration of Generative AI and AI-assisted Technologies

This manuscript was prepared with the assistance of Generative AI ChatGPT, Claude, and Grammarly. The AI was used to assist in drafting, language refinement, and content organization. All intellectual contributions, critical analyses, and final revisions were conducted by the authors. The authors take full responsibility for the accuracy, originality, and integrity of the content presented in this work.

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