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Article

The Relationship Between the Affective and Cognitive Aspects of Scientific Curiosity and Students' Conceptual Knowledge

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ABSTRACT

In the 21st-century educational era, mastery of scientific concepts has become a primary requirement in science education. This quantitative study, employing an ex-post facto correlational design, aims to analyze the relationship between the affective and cognitive aspects of scientific curiosity and students' conceptual knowledge. Data were collected through questionnaires and tests administered to 75 seventh-grade students at SMPN 2 Ponorogo, selected using simple random sampling. The data were analyzed using Pearson product-moment and multiple correlation tests. The results indicate a significant and very strong positive relationship between both the affective aspect (r = 0.988) and the cognitive aspect (r = 0.973) with conceptual knowledge, each contributing partially. Simultaneously, both aspects have a very strong relationship with students' conceptual knowledge (R^2 = 0.978), proving that the independent variables can explain 97.8% of the variation in the dependent variable. In conclusion, both the affective and cognitive dimensions of scientific curiosity are critical predictors of students' conceptual understanding. These findings imply that science educators should design instructional strategies that synergistically stimulate students' emotional interest and intellectual questioning from the beginning of the learning process to effectively enhance their conceptual knowledge.

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INTRODUCTION

In the 21st-century educational era, a deep understanding of scientific concepts has become one of the primary requirements in the study of natural sciences. Although various learning resources and educational technologies are becoming increasingly accessible, numerous studies indicate that students' conceptual knowledge remains relatively low. This situation is also evident in Indonesia, where conceptual understanding remains a challenge, even though it is one of the core competencies students must master (Widiyatmoko & Shimizu, 2018). Various studies indicate that many students struggle to understand the relationships between scientific concepts and fail to apply them in new contexts.

Rahmawati et al., (2022) found that students struggle to connect various scientific representations. Similar findings were reported by Saputra & Mustika (2022), who noted that the majority of students are not yet able to link concepts or apply them in new situations.

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Overall, these research findings confirm that the main issue in science learning at the junior high school level still lies in students' low conceptual knowledge. This problem was also identified at SMP Negeri 2 Ponorogo, one of the public schools in Ponorogo Regency.

Based on the results of initial observations of 7th-grade science instruction, it was found that students' ability to understand science concepts also showed a tendency to remain low. This was evident when students were asked to explain the reasoning behind their answers to questions; most students provided only brief responses. This situation suggests that their ability to connect and apply concepts has not yet developed optimally, indicating a weakness in students' conceptual knowledge.

Given the issues regarding conceptual knowledge outlined above, scientific curiosity is expected to be linked to students' conceptual knowledge. Theoretically, research on scientific curiosity suggests that curiosity is triggered by information gaps and contributes to the process of exploration and the acquisition of new knowledge (Jirout & Klahr, 2012). Curiosity in the context of science is a key element underpinning students' ability to examine and understand science concepts at their core.

Based on a systematic literature review conducted by Grossnickle (2016), curiosity in an educational context is composed of two main, mutually interacting aspects: the affective aspect and the cognitive aspect. This classification has strong theoretical roots, as explained in Berlyne (1960) book, which states that curiosity involves affective responses in the form of emotional arousal, as well as cognitive processes triggered by conceptual conflict. Specifically regarding conceptual knowledge, previous studies have demonstrated that scientific curiosity acts as a crucial driver. Aryani & Sartika (2024) showed that high scientific curiosity drives students to engage in conceptual exploration more actively and meaningfully.

Furthermore, Kim et al. (2025) explained that scientific curiosity functions as an internal driver for students to regulate their thinking processes and direct their attention to conceptual aspects they have not yet understood. This indicates that curiosity acts as a gateway to higher scientific thinking activities, including the ability to logically connect science concepts. However, most previous studies have focused more on the influence of curiosity on learning outcomes in general, rather than on the direct relationship between these affective and cognitive dimensions and students' conceptual knowledge. For example, a study by Nehru & Irianti (2020) concluded that curiosity was not significantly correlated with science learning outcomes.

In line with this, Jannah et al. (2021) found that students' curiosity levels remained relatively low, particularly regarding the dimension of the courage to ask questions. This inconsistency indicates that measuring curiosity as a single, broad construct may obscure its true dynamics. A student might possess a strong emotional interest in a phenomenon (affective aspect) but lack the critical thinking courage or persistence to explore and resolve their conceptual gaps (cognitive aspect). Because these two dimensions play different roles, it is necessary to examine them separately to understand exactly how each aspect contributes to students' conceptual knowledge.

This gap between the ideal learning outcomes and the reality in the field serves as the empirical basis for this study. Therefore, this study aims to examine the relationship between the affective and cognitive aspects of scientific curiosity and students' conceptual knowledge using a correlational method. The selection of this method aims to objectively measure the strength of the relationship between variables without manipulating the treatment. Specifically, this study focuses on analyzing the relationship between the affective and cognitive aspects of scientific curiosity and conceptual knowledge, both partially and simultaneously. The results of this study are expected to contribute to the development of science learning strategies capable of fostering scientific curiosity in a balanced manner, thereby enhancing students' conceptual knowledge more effectively.

METHODS

This quantitative study employs a correlational ex-post facto design to determine the relationship between the affective and cognitive aspects of scientific curiosity as independent variables and students' conceptual knowledge as the dependent variable. This study employed an ex-post facto correlational design, in which data were collected after the phenomena or variables under investigation had occurred naturally (Darmawan et al., 2023). The correlational method is considered the most appropriate because its primary focus is to identify the strength of the relationship between variables, allowing researchers to understand the dynamics of the relationship between scientific curiosity and students' conceptual knowledge based on empirical data without experimental treatment or manipulation (Hasbi et al., 2023).

The study was conducted at SMP Negeri 2 Ponorogo, located at Jalan Basuki Rahmat No. 44, Surodikraman Village, Ponorogo District, Ponorogo Regency. The research took place during the second semester of the 2025–2026 academic year, specifically in February 2026. The population comprised all seventh-grade students who had completed their science coursework for the odd semester of the 2025–2026 academic year, totaling 299 students. The sample size of 75 students was determined using Slovin's formula with a 10% margin of error and selected via simple random sampling to minimize selection bias.

To guide the empirical testing, the following research hypotheses were formulated:

1. H_1: There is a significant relationship between the affective aspect of scientific curiosity and students' conceptual knowledge.
2. H_2: There is a significant relationship between the cognitive aspect of scientific curiosity and students' conceptual knowledge.
3. H_3: There is a significant relationship between the affective and cognitive aspects of scientific curiosity simultaneously and students' conceptual knowledge.

Data were collected using questionnaires and a test. The affective and cognitive aspects of scientific curiosity were measured using questionnaires structured on a 4-point Likert scale (ranging from strongly disagree to strongly agree, omitting a neutral option to increase measurement sensitivity). The affective aspect questionnaire initially consisted of 25 items across three indicators (feeling happy when receiving new information, willingness to explore information sources, and enthusiasm towards knowledge gaps); after empirical validity testing using Pearson product-moment ($r_{\text{table}} = 0.396$), 15 items were proven valid and reliable (Cronbach's Alpha = 0.846).

The cognitive aspect questionnaire initially consisted of 25 items across two indicators (asking in-depth questions, and persistence and concentration in problem-solving); 13 items were proven valid and reliable (Cronbach's Alpha = 0.750). Meanwhile, students' conceptual knowledge was measured using a multiple-choice test (4 options) focusing on the topic of heat, based on Bloom's cognitive dimensions of understanding (C2) and applying (C3). Out of 20 initial items, 12 items were proven valid and reliable (Cronbach's Alpha = 0.775).

Prior to inferential analysis, data were subjected to instrument testing (validity and reliability) and classical assumption tests, including normality (Kolmogorov-Smirnov test), linearity (ANOVA linearity test), multicollinearity (Tolerance and VIF values), and heteroscedasticity (Glejser test). The final data analysis was conducted using descriptive statistics and inferential statistics via SPSS version 27, employing Pearson product-moment correlation analysis for partial hypotheses and multiple correlation analysis for simultaneous hypotheses.

RESULTS AND DISCUSSION

Validity and Reliability Testing

Validity is a measure that indicates the degree to which an instrument accurately measures what it is intended to measure; an instrument is considered valid if there is no

discrepancy between the collected data and the actual data pertaining to the research subject (Sugiyono, 2015). The process of validating the research instrument began with content and construct validity tests involving expert validators, namely Ms. Rahmi Faradisya Ekapti, M.Pd., and Ms. Ida Nurhayati, S.Pd. Based on the experts' assessments, the questionnaire instrument for the affective aspect of scientific curiosity received a score of 3.9 (97.5%), the cognitive instrument scored 3.75 (93.75%), and the conceptual knowledge test instrument scored 3.85 (96.25%). All three instruments were categorized as very good and relevant, and were therefore deemed suitable for use in the research after revisions were made in accordance with the experts' recommendations.

The next stage was the empirical validity test, which was conducted on a non-sample group of 25 seventh-grade students at SMPN 2 Babadan. This test used the Pearson product-moment correlation technique with a significance level of 5%, yielding a table-r value of 0.396. The purpose of this test was to ensure that each statement and question accurately measured the variables under study before the instruments were administered to the actual research sample. Based on the results of the analysis of the pilot test data for the questionnaire instrument, several items were found to not meet the validity criteria. In the affective aspect instrument, out of a total of 25 items, 10 had a calculated r value < table r value, leaving 15 valid items.

Meanwhile, in the cognitive aspect instrument, 12 items were found to be invalid out of a total of 25 items, leaving only 13 items to be used for data collection in the study. In the student conceptual knowledge test instrument, the validity test results showed that out of the 20 test items administered, 8 items were deemed invalid because their calculated r-value was less than the table r-value. Therefore, only 12 items were deemed eligible for use in collecting conceptual knowledge data. The selection of these instrument items was conducted rigorously to ensure data quality and the accuracy of the research results.

As the final stage of instrument testing, a reliability test was conducted using Cronbach's alpha coefficient to ensure the internal consistency of the data. An instrument is deemed reliable and suitable for use if the resulting reliability coefficient is above the standard threshold, generally ≥0.60 (Yusuf et al., 2024). The test results showed a value of 0.846 for the affective aspect questionnaire, 0.750 for the cognitive aspect questionnaire, and 0.775 for the conceptual knowledge test. Since all of these values are greater than 0.60, it can be concluded that the three research instruments are reliable and ready to be used to collect data in the field consistently and accurately.

Classical Assumption Tests

A series of classical assumption tests was conducted to ensure that the regression model used meets the criteria for parametric statistical analysis, so that the research results are scientifically valid. The first step was the normality test, which aimed to determine whether the data obtained by the researcher for each variable followed a normal distribution. The method used in this study was the Kolmogorov-Smirnov test (Sudirman et al., 2020).

Table 1. Normality Test Results

		Afective Aspect	Cognitive Aspect	Conceptual Knowledge
N		75	75	75
Normal Parameters[a,b]	Mean	43.97	37.56	6.53
	Std. Deviation	6.566	5.033	2.844
Most Extreme Differences	Absolute	.085	.074	.087
	Positive	.061	.074	.081
	Negative	-.085	-.055	-.087
Test Statistic		.085	.074	.087
Asymp. Sig. (2-tailed)[c]		.200[d]	.200[d]	.200[d]
Monte Carlo Sig. (2-tailed)[e]	Sig.	.200	.384	.170

		Afective Aspect	Cognitive Aspect	Conceptual Knowledge
99% Confidence Interval	Lower Bound	.190	.372	.160
	Upper Bound	.210	.397	.180

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.
e. Lilliefors' method based on 10000 Monte Carlo samples with starting seed 2000000.

Based on the results of the statistical test using SPSS version 27, as shown in Table 1, a significance value of 0.200 was obtained for the affective aspect of scientific curiosity (X1), the cognitive aspect of scientific curiosity (X2), and conceptual knowledge (Y). Since all of these significance values are greater than 0.05, it can be concluded that the normality assumption is met and all research data are normally distributed. The next step is the linearity test, which is used to determine whether the two variables have a significant linear relationship. This test is important because a linear relationship indicates that changes in the independent variable will be consistently followed by changes in the dependent variable (Yusuf et al., 2024).

Table 2. Linearity Test Results for the Affective Aspect of Scientific Curiosity Regarding Conceptual Knowledge

			Sum of Squares	df	Mean Square	F	Sig.
Conceptual Knowledge *Affective Aspect	Between Groups	(Combined)	176.221	24	7.343	.869	.638
		Linearity	.405	1	.405	.048	.828
		Deviation from Linearity	175.817	23	7.644	.905	.592
	Within Groups		422.445	50	8.449		
	Total		598.667	74			

Table 3. Linearity Test Results for the Cognitive Aspect of Scientific Curiosity Regarding Conceptual Knowledge

			Sum of Squares	df	Mean Square	F	Sig.
Conceptual Knowledge* Cognitive Aspect	Between Groups	(Combined)	187.669	18	10.426	1.421	.158
		Linearity	21.682	1	21.682	2.954	.091
		Deviation from Linearity	165.987	17	9.764	1.330	.209
	Within Groups		410.998	56	7.339		
	Total		598.667	74			

Based on Table 2, the sig. value for deviation from linearity was 0.592 for the affective aspect of scientific curiosity, while Table 3 shows a sig. deviation from linearity of 0.209. Since both values are greater than 0.05, it can be concluded that there is a significant linear relationship between the independent and dependent variables in this research model.

The testing continued with a multicollinearity test, which aimed to determine whether there were very strong correlations among the independent variables in the regression model. A good regression model should not have perfect or near-perfect relationships among its independent variables so that the estimation results are not biased. The test results showed no very strong linear relationships among the independent variables; therefore, the regression model was deemed free from multicollinearity (Sudirman et al., 2020).

Table 4. Multicollinearity Test Results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.398	3.079		1.103	.274		
	Affective Aspect	-.025	.051	-.058	-.493	.624	.975	1.026
	Cognitive Aspect	.113	.066	.199	1.705	.093	.975	1.026

a. Dependent Variable: Pengetahuan_Konseptual

Based on Table 4, the tolerance value is 0.975 (> 0.1) and the Variance Inflation Factor (VIF) is 1.026 (< 10). Thus, the affective and cognitive variables are considered independent of one another. Finally, the heteroscedasticity test aims to determine whether there is unequal variance in the residuals from one observation to another within the regression model. If the variance of the residuals remains constant across observations, this is called homoscedasticity, which is a requirement for a good regression model (Gun, 2020).

Table 5. Heteroscedasticity Test Results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.688	1.704		2.165	.034
	Aspek_Afektif	.027	.028	.111	.951	.345
	Aspek_Kognitif	-.069	.037	-.218	-1.880	.064

a. Dependent Variable: abs_res

Based on Table 5, it is evident that the significance values for the affective aspect of scientific curiosity and the cognitive aspect of scientific curiosity are 0.345 and 0.064, respectively, both of which are greater than 0.05. Therefore, it can be concluded that the regression model does not exhibit heteroscedasticity, making the model stable. As a conclusion from the classical assumption tests, the data in this study have been proven to be normally distributed, exhibit a linear relationship, are free from multicollinearity, and show no evidence of heteroscedasticity. The fulfillment of all these assumptions indicates that the research model possesses a very high level of accuracy and consistency. Therefore, the research data are deemed highly suitable for proceeding to the inferential statistical analysis stage to test the established hypotheses.

Hypothesis Testing

The product-moment correlation test was used to measure the strength and direction of the partial relationship between each independent variable and the dependent variable. The results of the product-moment correlation test indicate a significant relationship between the independent variables and the dependent variable. In this study, the analysis was conducted using SPSS version 27.

Table 6. Product-Moment Correlation Test Results for the Affective Aspect of Scientific Curiosity and Students' Conceptual Knowledge

		Affective Aspect	Conceptual Knowledge
Affective Aspect	Pearson Correlation	1	.988**
	Sig. (2-tailed)		.000
	N	75	75
Conceptual Knowledge	Pearson Correlation	.988**	1
	Sig. (2-tailed)	.000	
	N	75	75

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7. Product-Moment Correlation Test Results for the Cognitive Aspect of Scientific Curiosity and Students' Conceptual Knowledge

		Cognitive Aspect	Conceptual Knowledge
Cognitive Aspect	Pearson Correlation	1	.973**
	Sig. (2-tailed)		.000
	N	75	75
Conceptual Knowledge	Pearson Correlation	.973**	1
	Sig. (2-tailed)	.000	
	N	75	75

**. Correlation is significant at the 0.01 level (2-tailed).

Based on Table 6, the affective aspect variable of scientific curiosity yielded a significance value (2-tailed) of 0.000 (< 0.05) with a Pearson correlation coefficient of 0.988. Meanwhile, the statistical results for the cognitive aspect of scientific curiosity in Table 7 showed a significance value of 0.000 (< 0.05) with a Pearson correlation of 0.973. Both findings confirm that the relationship between the affective and cognitive aspects and students' conceptual knowledge is positive and falls into the "very strong" category. This indicates that improvements in both aspects of students' scientific curiosity will be directly correlated with higher levels of conceptual knowledge.

Table 8. Multiple Correlation Test Results for the Affective and Cognitive Aspects of Scientific Curiosity and Students' Conceptual Knowledge

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.989[a]	.978	.977	.431	.978	1577.657	2	72	.000

a. Predictors: (Constant), Aspek_Kognitif, Aspek_Afektif

Furthermore, multiple correlation analysis is used to determine the combined relationship between two or more independent variables and one dependent variable. The strength of this relationship is indicated by the R value. The closer the value is to 1, the stronger the simultaneous relationship. In addition, the R-squared (R^2) value indicates the extent to which the independent variables contribute to explaining the variation in the dependent variable (Khoiri, 2021). The multiple correlation analysis revealed a correlation coefficient (R) of 0.989, confirming a very strong relationship between all independent variables simultaneously and the dependent variable. The coefficient of determination (R^2) value of 0.978 indicates that the independent variables in this study account for 97.8% of the variation in students' conceptual knowledge, while the remaining 2.2% is influenced by other factors outside the model.

Furthermore, the Adjusted R-Square value of 0.977—which is close to the R^2 value—proves that the regression model used is stable, accurate, and exhibits a very high level of consistency. The simultaneous significance test using the calculated F-value further reinforces these findings. The calculated F-value was 1,577.66, which is significantly larger than the critical F-value of 3.12, with a p-value of 0.000 (< 0.05). These results indicate that the regression model used is valid and significant. Thus, it can be concluded that there is a significant and very strong relationship between the affective and cognitive aspects of scientific curiosity and students' conceptual knowledge as a whole.

DISCUSSION

The findings of this study indicate a significant and positive relationship between the affective aspect of scientific curiosity and students' conceptual knowledge, with a Pearson correlation coefficient of 0.988. Rather than merely acting as a passive trait, emotional engagement functions as an active driver of cognitive processing. Students with a high level of affective interest in science materials tend to be more focused and have a strong drive to seek in-depth explanations. This finding is supported by Wardana et al. (2025), which confirms that students with high levels of scientific curiosity possess a more solid foundation of conceptual scientific knowledge. Furthermore, Herianto & Wilujeng (2020) state that curiosity has a positive relationship with generic science skills, which are crucial in helping students process

concepts systematically. Thus, it can be concluded that the affective aspect of scientific curiosity has a significant and very strong relationship with the conceptual knowledge of seventh-grade students.

Similarly, the cognitive aspect of scientific curiosity has a significant and positive relationship with conceptual knowledge, demonstrating a coefficient of 0.973. The cognitive dimension involves the persistence to seek answers, ask in-depth questions, and resolve conceptual conflicts. Students who possess cognitive curiosity do not merely ask simple questions; they formulate critical questions demanding further explanation of a scientific concept. This intellectual drive allows them to find logical connections underlying every topic they study. This finding is empirically consistent with research by Zakirah & Widowati (2024), which states that students with high scientific curiosity tend to have better conceptual knowledge because they are motivated to explore and connect scientific phenomena with their prior knowledge. Aryani & Sartika (2024) also note a positive correlation between curiosity and science literacy, reinforcing that comprehensive conceptual understanding is an integral part of this cognitive persistence.

Based on the correlation analysis, it was found that the Pearson correlation coefficient for the affective aspect ($r = 0.988$) was higher than that for the cognitive aspect ($r = 0.973$). This distinction can be explained by examining how students at the seventh-grade level naturally process information. For early adolescents, a sense of joy and interest in scientific phenomena acts as an initial trigger that subsequently spurs the emergence of cognitive effort. As Litman (2008) described, the "Interest-Type" (affective excitement) must often precede the "Deprivation-Type" (the cognitive need to close an information gap). Before these seventh-grade students exert significant intellectual effort to bridge information gaps, they require strong emotional stimuli as the primary motivator. The dominance of the affective aspect suggests that students' intrinsic emotional interest plays a more decisive initial role in building their conceptual knowledge than their autonomous cognitive problem-solving skills.

Furthermore, the simultaneous analysis yielded a multiple correlation coefficient (R) of 0.989 and an R-square of 0.978, indicating that the affective and cognitive aspects together explain 97.8% of the variance in conceptual knowledge. The unusually high magnitude of this correlation can be attributed to the specific focus of the instruments. In this study, both scientific curiosity and conceptual knowledge were measured tightly around a specific scientific topic, namely the concept of heat (kalor), rather than general science knowledge. When both the psychological drive to understand a topic and the cognitive test measuring that exact topic are highly aligned, the statistical relationship naturally emerges as very strong.

Ultimately, both dimensions operate interdependently in the learning process. Theoretically, emotional engagement such as interest and enthusiasm must be supported by cognitive processes through questioning and exploration so that conceptual understanding can develop optimally. A systematic review by Hunaepi et al. (2024) states that well-managed curiosity helps students maintain concentration on complex material for longer periods. Therefore, science learning should prioritize models that begin with the presentation of unique phenomena to naturally spark students' affective curiosity, which will sequentially drive their cognitive effort toward a deeper mastery of conceptual knowledge.

CONCLUSION

Based on the results of the data analysis and discussion, it can be concluded that there is a significant and positive relationship between the affective and cognitive aspects of scientific curiosity, both partially and simultaneously, and the conceptual knowledge of seventh-grade students at SMPN 2 Ponorogo. The simultaneous analysis yielded an R-square of 0.978. This confirms that 97.8% of the variance in the conceptual knowledge of seventh-grade students at SMPN 2 Ponorogo is explained by the variable of scientific curiosity, while the remaining 2.2% is accounted for by other factors not examined in this study. However, this study is subject

to certain limitations, particularly its correlational design and specific focus on a single science topic (heat) within one demographic, which restrict causal inferences and broader generalizability. Therefore, future research is recommended to employ a longitudinal design or incorporate mediating variables, such as student motivation or specific instructional models, to further investigate the mechanisms underlying conceptual knowledge development.

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