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Are Indonesian High School Students Curious and Creative Enough? An Analysis of Science Curiosity and Creative Thinking Skills in the Merdeka Curriculum Context

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ABSTRACT: This study aimed to assess the levels of science curiosity and creative thinking skills (CreTS) among Grade XI students in state high schools (SMAN) across Sumedang Regency under the Merdeka curriculum. Using a quantitative survey design, data were collected from 210 students across three schools. Instruments included a 20-item Science Curiosity questionnaire ($\alpha = 0.82$) and a task CreTS essay rubric (inter-rater ICC = 0.78). Normality tests indicated non-normal distributions; therefore, non-parametric analyses were applied. Kruskal–Wallis tests revealed significant differences between schools for curiosity ($H = 10.92$, $df = 2$, $p = 0.004$) and CreTS ($H = 25.46$, $df = 2$, $p < 0.001$). Post-hoc Dunn tests further showed significant pairwise differences between School A and School B ($p = 0.01$). Descriptive statistics show that the average curiosity score of the three schools ranges from 3.38 to 3.51 on a 5-point Likert scale, reflecting a need for improvement. Likewise, creative thinking skills (CRETS) also have a low average score, with an average score of 46%. The findings highlight the need for more engaging, inquiry and project based learning approaches to enhance students' scientific curiosity and creative thinking. The study concludes by recommending improved instrument validation, extended response time for CreTS tasks, and deeper post-hoc analysis to better understand inter-school differences.

Keywords: creative thinking skills, merdeka curriculum, science curiosity, sumedang regency

ABSTRAK: *Penelitian ini bertujuan untuk menilai tingkat rasa ingin tahu sains dan keterampilan berpikir kreatif (Creative Thinking Skills/CreTS) siswa kelas XI SMA Negeri (SMAN) di Kabupaten Sumedang dalam konteks Kurikulum Merdeka. Penelitian menggunakan desain survei kuantitatif dengan melibatkan 210 siswa dari tiga sekolah. Instrumen penelitian meliputi kuesioner Rasa Ingin Tahu Sains sebanyak 20 butir ($\alpha = 0,82$) dan rubrik penilaian esai tugas CreTS dengan reliabilitas antarpenilai (ICC) sebesar 0,78. Uji normalitas menunjukkan bahwa data tidak berdistribusi normal, sehingga analisis non-parametrik digunakan. Uji Kruskal–Wallis menunjukkan adanya perbedaan yang signifikan antar sekolah baik pada rasa ingin tahu sains ($H = 10,92$, $df = 2$, $p = 0,004$) maupun keterampilan berpikir kreatif ($H = 25,46$, $df = 2$, $p < 0,001$). Uji lanjut Dunn menunjukkan perbedaan pasangan yang signifikan antara Sekolah A dan Sekolah B ($p = 0,01$). Statistik deskriptif menunjukkan bahwa skor rata-rata rasa ingin tahu siswa pada ketiga sekolah berkisar antara 3,38 hingga 3,51 pada skala Likert 5 poin, yang mengindikasikan perlunya peningkatan. Demikian pula, keterampilan berpikir kreatif (CreTS) menunjukkan skor rata-rata yang rendah, yaitu sebesar 46%. Temuan ini menegaskan perlunya penerapan pendekatan pembelajaran yang lebih menarik, berbasis inkuiri, dan berbasis proyek untuk meningkatkan rasa ingin tahu sains dan keterampilan berpikir kreatif siswa. Penelitian ini merekomendasikan peningkatan validasi* *instrumen, perpanjangan waktu pengerjaan tugas CreTS, serta analisis post-hoc yang lebih mendalam untuk memahami perbedaan antar sekolah secara lebih komprehensif.*

Kata kunci: *kabupaten sumedang, keterampilan berpikir kreatif, kurikulum merdeka, rasa ingin tahu sains*

INTRODUCTION

Curiosity is defined as an individual's tendency to seek new information and to make sense of scientific phenomena, driven by intrinsic interest and the desire to know (Hidi & Renninger, 2020) . Rather than a fleeting interest, curiosity represents a stable personal disposition that plays a pivotal role in fostering deep conceptual understanding. Meanwhile, Creative thinking skills (CreTS) refer to a set of cognitive abilities that enable individuals to generate multiple possible solutions to a problem based on available information. These skills involve the construction of ideas that emphasize fluency, flexibility, originality, and elaboration. They equip students with the capacity to solve problems, propose innovative ideas, and make informed decisions in diverse contexts, thereby supporting their self-actualization (Nasution et al., 2023). To sum up, curiosity and creative thinking skills (CreTS) represent interconnected cognitive and affective dimensions that drive learners to explore, generate, and refine ideas. As an integrated construct, they form the foundation for deeper understanding, problem-solving, and lifelong learning in scientific and educational contexts.

Biology plays a crucial role in shaping the future, particularly in preparing students to become critical, creative, and competitive individuals. In addition, learners must be able to solve problems and make accurate, timely decisions to remain resilient in a globalized era. Therefore, effective biology instruction requires not only a solid understanding of biological concepts but also the development of creative thinking skills (Handayani et al., 2021).

Creative thinking refers to the ability to generate original and valuable ideas to accomplish given tasks. This aligns with Torrance's (1998) framework for creative thinking assessment, which evaluates an individual's capacity to produce numerous and innovative responses to figural stimuli. Typically, the tasks and responses are presented in visual formats, while the value of the ideas is expressed concisely in written form (Orbeta, 2022). According to Torrance (1998), creative thinking comprises four key dimensions: fluency, flexibility, originality, and elaboration.

This study emphasizes the importance of a systematic approach to data inventory, processing, and reporting as the basis for high-quality research. The main focus of this study is to explore the state of science curiosity and creative thinking skills (CreTS) among high school students in Sumedang Regency. By applying a quantitative statistical approach, this research not only aims to identify major challenges in data collection and processing but also to design contextual strategies tailored to local needs. The findings of this study are expected to enrich the understanding of these two essential competencies among students and provide methodological guidance for other researchers in adapting learning strategies to real-world classroom challenges (Handayani et al., 2021).

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Although curiosity and creative thinking skills (CreTS) are essential for developing students' understanding and problem-solving in science, studies on these aspects in Indonesian high schools are still limited. Most previous research focused on university students or examined these skills separately. Therefore, this study explores and analyzes the levels of curiosity and creative thinking skills among senior high school students in Sumedang Regency. The results are expected to provide an overview of students' current abilities and serve as a basis for improving biology learning practices. Accordingly, the study is guided by the following research questions:

1. What obstacles arise during the stages of data collection, analysis, and reporting in the study of students' curiosity and creative thinking skills (CreTS) in Sumedang Regency?
2. What strategies and methodological approaches can be effectively applied to address the obstacles encountered in collecting, processing, and reporting data in the research on students' curiosity and creative thinking skills (CreTS) in Sumedang Regency?

RESEARCH METHOD

Research Design and Participants

This study employed a quantitative approach using a survey method to measure the levels of science curiosity and creative thinking skills (CreTS) among Grade XI students from three State Senior High Schools (SMAN) in Sumedang Regency, Indonesia. The participating schools SMAN 1 Cimalaka, SMAN 2 Sumedang, and SMAN 3 Sumedang were selected purposively based on their geographic representation, academic standing, and implementation of the Kurikulum Merdeka (Independent Curriculum). These schools also have adequate science learning facilities, making them representative of actual classroom conditions related to the development of curiosity and creative thinking. A total of 210 students participated in the study.

Instruments

Two main instruments were used: a Creative Thinking Skills (CreTS) essay test and a Science Curiosity questionnaire. The CreTS test, adapted from Torrance's framework, assessed four dimensions namely: fluency, flexibility, originality, and elaboration through written tasks. The Science Curiosity questionnaire, developed based on the Heart and Beall model, measured students' intrinsic motivation and interest in exploring scientific phenomena.

Instrument Validation

The validation process involved both expert judgment and empirical testing. Content validity was assessed by two biology education experts from Universitas Pendidikan Indonesia (UPI), focusing on the clarity, relevance, and representativeness of each item. A pilot test was then conducted with 30 students from a state senior high school in Sumedang to examine item clarity and initial

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reliability. Internal reliability, calculated using Cronbach's alpha in SPSS, yielded satisfactory results for both instruments: the Science Curiosity Scale (α = 0.83) and the CreTS essay rubric (α = 0.86). Each curiosity subscale Novelty, Lack of Clarity, Complexity of Stimulus, Surprise, and Bafflement showed acceptable internal consistency (α = 0.71–0.83). Due to the small pilot sample, factor analysis was not performed, but all items were reviewed for conceptual alignment and item discrimination.

The CreTS essays were evaluated using the developed rubric. Two trained raters independently scored the responses after a two-hour calibration session using eight sample essays. Inter-rater reliability, calculated with Cohen's kappa, was κ = 0.82, indicating a high level of agreement. Overall, the instruments demonstrated satisfactory reliability and conceptual validity, though future studies are recommended to use larger samples for factor analysis and stronger construct validation. The three selected schools represented approximately 20% of the total 16 public senior high schools in Sumedang. Although this purposive sampling ensured relevant and contextually rich data, it may limit the generalizability of the findings to other school settings. Research permission was obtained from the respective school administrations prior to data collection. Both students and their parents provided informed consent after receiving a clear explanation of the study's objectives and procedures. Participant anonymity and confidentiality were strictly maintained by assigning numerical codes, and all collected data were securely stored in password-protected files accessible only to the researchers.

Data Collection and Analysis

The main data were analyzed using SPSS version 30. Analytical steps included normality tests (Kolmogorov Smirnov and Shapiro Wilk), homogeneity tests (Levene's test), and the Kruskal Wallis test as a non-parametric alternative to identify differences in curiosity and CreTS levels among the three schools. Non-parametric testing was applied because the normality tests indicated that the data were not normally distributed. Descriptive statistics were used to present the mean, minimum, maximum, and distribution of scores through graphs and boxplots.

Additionally, semi-structured interviews were conducted with three biology teachers from the participating schools on November 9–10 to gather contextual insights regarding classroom practices and the development of students' curiosity and creative thinking skills.

RESULT AND DISCUSSION

Demographic Data of Research Sample

This study involved 210 students from three of the best state senior high schools in Sumedang Regency as research samples, namely SMAN 1 Cimalaka, SMAN 2 Sumedang, and SMAN 3 Sumedang. The selection of this research location was carried out with the aim of seeing the level of curiosity in science and CreTS in favorite schools in Sumedang Regency, so that the data obtained can provide a

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more representative picture for further research, especially in designing appropriate interventions to improve students' abilities in these variables. The number of students by gender is something that needs to be considered, because we can see the contribution of each gender to the research data. Samples based on gender can be seen in Figure 1.

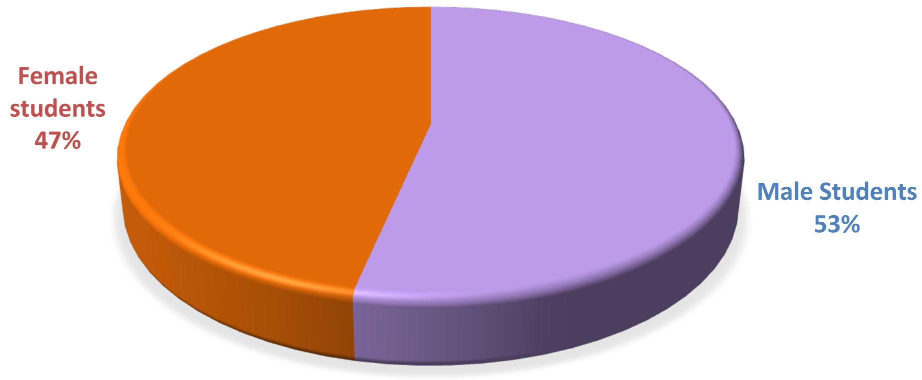

Figure 1. Number of Respondents by Gender

Furthermore, it is also necessary to see the distribution of the number of students from each school. This is to ensure balanced representation from each school in the study. This is important to provide a more comprehensive picture of curiosity and Creative Thinking Skills (CreTS) in the three State Senior High Schools in Sumedang Regency. With proportional representation, the results of the study are expected to identify patterns of curiosity and CreTS in various school environment contexts.

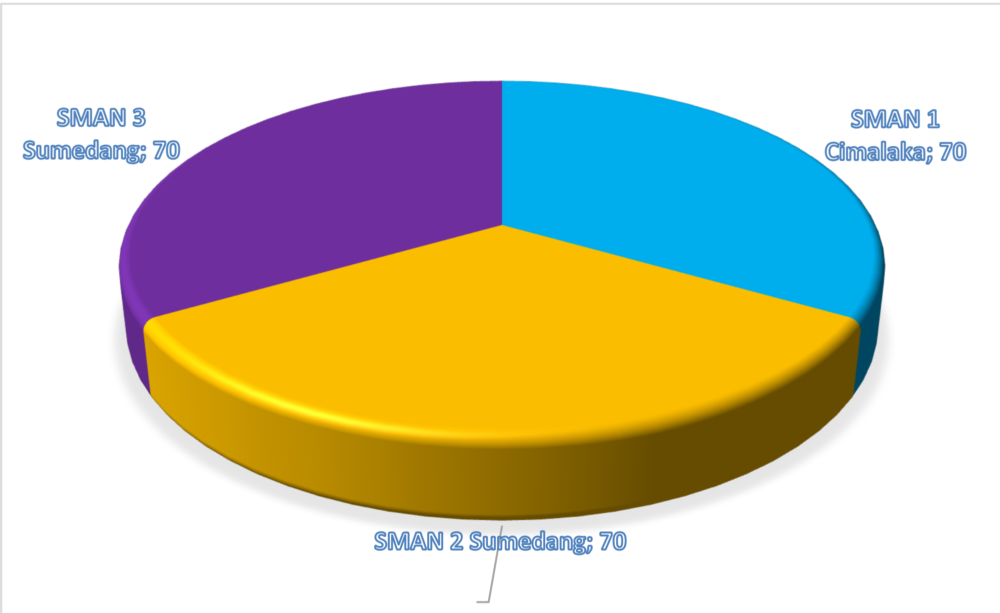

Figure 2. Number of Respondents by School

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Based on the figure above, the distribution of respondents by school shows that from a total of 210 students included in the study sample, each school contributed an equal number of respondents, namely 70 students. The participating schools were SMAN 1 Cimalaka, SMAN 2 Sumedang, and SMAN 3 Sumedang. Using an equal sample size from each school offers several methodological advantages. First, it ensures fair representation of each institution, preventing data dominance or bias from any single school. Second, it enhances the validity of the findings, as each school contributes equally to the dataset, making the conclusions more representative of the overall student population. Furthermore, equal sample sizes facilitate direct comparisons between schools, allowing differences or similarities in students' science curiosity and Creative Thinking Skills (CreTS) to be analyzed more accurately. This approach also helps control for respondent number as a variable, ensuring that any observed differences in outcomes are attributable to the research factors rather than sampling imbalance.

Descriptive Statistics Reporting

The analysis then continued by examining the descriptive statistics for each variable. For the science curiosity variable, a descriptive analysis was conducted for each school. The score results were summarized and visualized in the form of a graph, as presented in the following figure.

Table 1. Statistical Summary for SMA N 1 Cimalaka

Statistic	Value
Mean	3,4794 (Std. Error = ,03120)
95% CI for Mean (Lower Bound)	3,4171
95% CI for Mean (Upper Bound)	3,5417
5% Trimmed Mean	3,4698
Median	3,5000
Variance	,066
Std. Deviation	,25730
Minimum	3,07
Maximum	4,30
Range	1,23
Interquartile Range	,45
Skewness	,481 (Std. Error = ,291)
Kurtosis	,066 (Std. Error = ,574)

Table 2. Statistical Summary for SMAN 2 Sumedang

Statistic	Value
Mean	3,5087 (Std. Error = ,02802)
95% CI for Mean (Lower Bound)	3,4528
95% CI for Mean (Upper Bound)	3,5646
5% Trimmed Mean	3,5126
Median	3,5000

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Variance	,054
Std. Deviation	,23275
Minimum	2,90
Maximum	4,13
Range	1,23
Interquartile Range	,30
Skewness	-,187 (Std. Error = ,289)
Kurtosis	,571 (Std. Error = ,570)

Table 3. Statistical Summary for SMAN 3 Sumedang/ SMA Petang

Statistic	Value
Mean	3,3765 (Std. Error = ,02719)
95% CI for Mean (Lower Bound)	3,3222
95% CI for Mean (Upper Bound)	3,4307
5% Trimmed Mean	3,3806
Median	3,4000
Variance	,050
Std. Deviation	,22424
Minimum	2,87
Maximum	3,90
Range	1,03
Interquartile Range	,30
Skewness	-,313(Std. Error = ,291)
Kurtosis	-,002(Std. Error = ,574)

The descriptive statistics comparison among the three schools SMAN 1 Cimalaka, SMAN 2 Sumedang, and SMAN 3 Sumedang shows relatively similar science curiosity levels among students, with slight variations in central tendency and dispersion. SMAN 2 Sumedang recorded the highest mean score (3,5087), followed closely by SMAN 1 Cimalaka (3,4794) and SMAN 3 Sumedang (3,3765), indicating that students from SMAN 2 demonstrated slightly higher curiosity on average. The standard deviations across the three schools (ranging from 0.22 to 0.26) suggest that the data were moderately consistent within each group. All distributions were approximately normal, as shown by small skewness and kurtosis values near zero. Overall, while minor differences exist, the results indicate that students from the three schools share comparable levels of science curiosity, with SMAN 2 showing a marginally stronger tendency toward higher curiosity.

Based on the curiosity level data of grade XI students from three), the average value is in the range of 6.73 to 7.0. Referring to the Kashdan et al. (2009) scale, this value is included in the moderate curiosity category. This means that students have a fairly good curiosity, but are still not consistent or deep in exploring new knowledge. Although the students demonstrated an interest in learning, their efforts to explore the subject matter more deeply still need

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improvement. This suggests that learning approaches that promote greater exploration and active student engagement could enhance their curiosity to a higher level. To compare the distribution of students' curiosity across the three schools, a boxplot was used. Differences in curiosity levels among the schools can be visually observed, particularly in terms of value variation, the presence of outliers, and data consistency within each group. This visualization not only facilitates a clearer understanding of the data distribution patterns but also supports a more accurate interpretation prior to conducting more complex statistical analyses. The boxplot visualization of students' curiosity across the three schools is presented in the figure below.

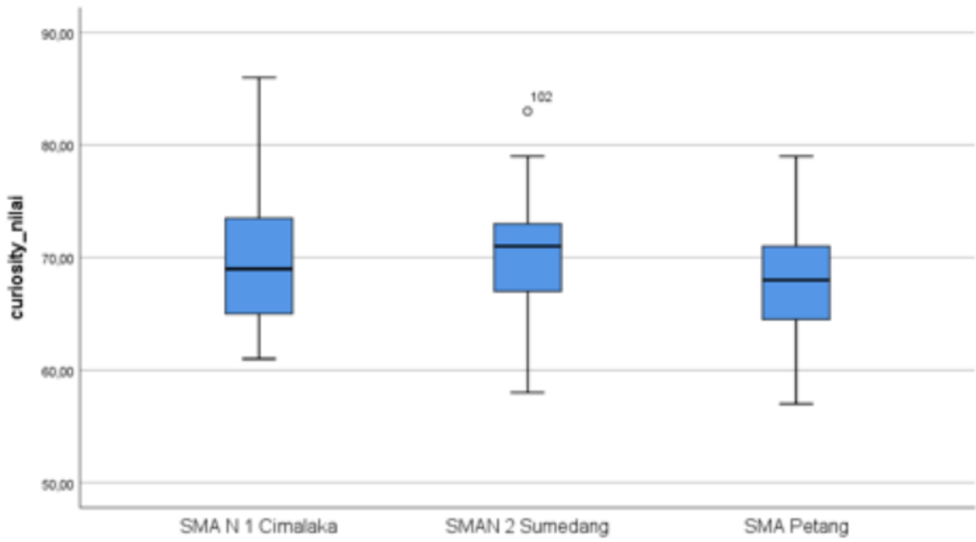

Figure 3. Curiosity Science Data Boxplot

The results of the boxplot analysis show that the highest median curiosity is found in SMAN 2 Sumedang with a value of 71, which indicates that in general students at this school have a higher level of curiosity compared to SMAN 1 Cimalaka and SMAN 3 Sumedang. This median is an indicator of the middle position of the distribution of student curiosity, reflecting the general tendency at the school. In terms of data distribution, SMAN 3 Sumedang has the smallest variation in curiosity values, indicating that the level of student curiosity at this school tends to be more uniform or homogeneous. In contrast, SMAN 1 Cimalaka has a wider distribution of values, reflecting a greater variation in curiosity among students, which may be caused by differences in individual characteristics or other factors. Interestingly, SMAN 2 Sumedang has one extreme outlier in the 102nd child with a curiosity value of 83. This value is much higher than the majority of students' curiosity values at the school and is not found in the other two schools. The presence of this outlier may reflect students with very high levels of curiosity, which could be the subject of further analysis to understand the factors that influence it. Overall, SMAN 3 Sumedang shows a more consistent and homogeneous distribution of curiosity scores compared to the other two schools, as seen from the smaller data distribution. This consistency may reflect a more

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uniform learning environment or the influence of effective educational policies in fostering student curiosity at the school. These differences provide important insights into the curiosity patterns in each school, which can be used to design appropriate learning strategies. The same thing was done for the CreTS data, descriptive statistical tests were also carried out. The data can be seen in the form of a graph in the following figure.

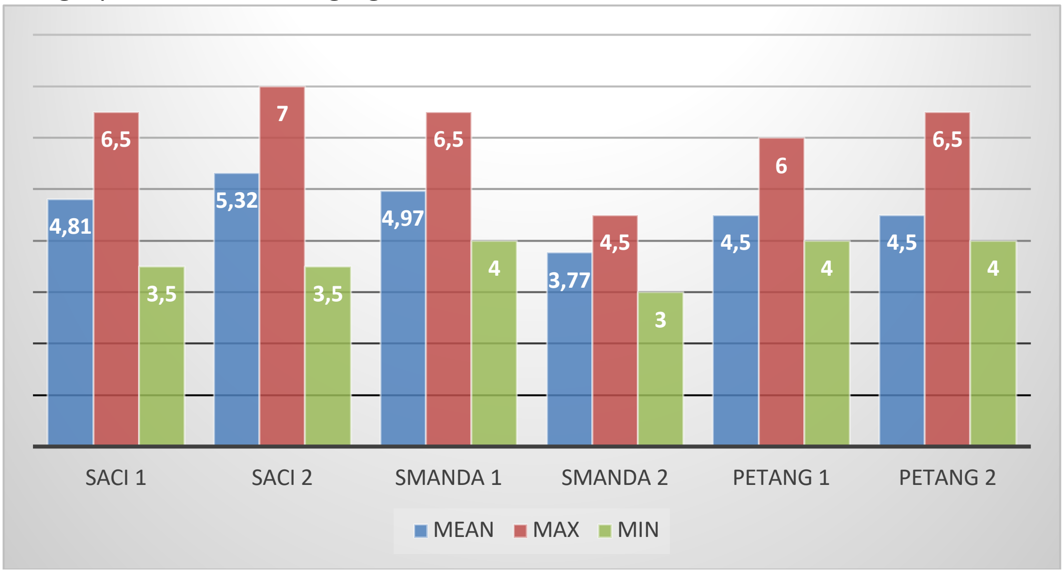

Figure 4. Comparison of max, min and average CreTS values

Rahayu et al (2022) classifies creative thinking skills based on three categories, creative is indicated by a scale of 68%-100%, quite creative 33%-67%, and less creative <33%. In the graph of creative thinking skills of grade XI students (CreTS), the average value (symbolized in blue) shows a value in the range of 4.2 to 4.8. The highest average value is seen in class SMANDA 1 with a number of 4.8, while the lowest value is in SACI 2 with a number of 4.2. This value indicates that the level of students' creative thinking skills is in the moderate category based on the Kashdan et al. (2009) scale. The small variation between the average values indicates a relatively consistent distribution, although there is still an opportunity to improve this ability in classes with lower averages. To compare the distribution of students' CreTS in three schools, you can use the Boxplot curiosity visualization of the three schools presented in the figure below.

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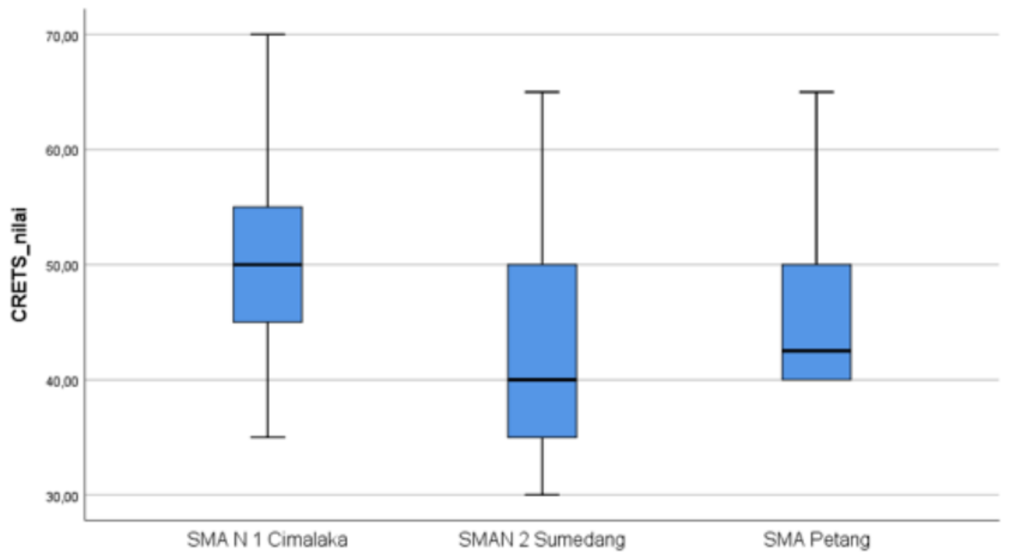

Figure 5. Boxplot of Creative Thingking Skills Data

The results of the CreTS (Creative Thinking Skills) boxplot analysis show differences in the distribution of scores in three schools: SMAN 1 Cimalaka has a median of around 50 with high value variation (large IQR), reflecting the diversity of student abilities; SMAN 2 Sumedang has a lower median (around 45) and a small IQR, but with the lowest minimum score, indicating challenges for very low-ability students; while SMAN 3 Sumedang has a similar median to SMAN 1 Cimalaka, but a smaller IQR and a more stable score distribution. These differences indicate the need for educational strategies that are appropriate to the characteristics of each school.

Homogeneity and Normality Test Results

The results of the statistical analysis showed that the homogeneity test using Levene's test confirmed that the variance of students' science curiosity data between the three groups met the assumption of homogeneity, with a significance value above 0.05. However, normality test using Kolmogorov-Smirnov and Shapiro-Wilk methods revealed that not all students' science curiosity data were normally distributed, especially at SMAN 2 Sumedang which showed abnormal results (Sig. = 0.03).

Table 4. Science Curiosity Normality Test Results

Tests of Normality							
	School	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Curiosity_skor	SMA N 1 Cimalaka	,095	68	,200*	,959	68	,025
	SMAN 2 Sumedang	,137	69	,003	,978	69	,272
	SMAN 3 Sumedang	,101	68	,085	,975	68	,186
Curiosity_nilai	SMA N 1 Cimalaka	,096	68	,197	,958	68	,024
	SMAN 2 Sumedang	,135	69	,003	,976	69	,217
	SMAN 3 Sumedang	,112	68	,034	,981	68	,393
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

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Accordingly, the Kruskal–Wallis nonparametric test was utilized to compare students' curiosity levels across schools, as this approach does not assume a normal distribution of data. Although the results indicated that the variances were homogeneous, the presence of non-normality in certain school groups necessitated the use of an alternative statistical procedure to ensure the accuracy and validity of the findings.

Likewise, in the CreTS data, the normality test results using Kolmogorov-Smirnov and Shapiro-Wilk methods showed that the distribution of CRETS scores and CRETS scores data in all three schools, namely SMAN 1 Cimalaka, SMAN 2 Sumedang, and SMAN 3 Sumedang (Petang), did not follow the normal distribution. At SMAN 1 Cimalaka, the significance value (Sig.) for Kolmogorov-Smirnov was 0.000 and for Shapiro-Wilk was 0.006, both below 0.05, indicating that the data were not normal. Similar results were seen at SMAN 2 Sumedang, with a significance value of 0.000 in both tests, indicating that the data were also not normal. Similarly, at SMAN 3 Sumedang (Petang), the significance value of 0.000 in both methods confirmed that the data were not normally distributed.

Table 5. Creative Thinking Skills (CreTS) Normality Test Results

Tests of Normality							
	School	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CreTS_skor	SMA N 1 Cimalaka	,173	68	,000	,947	68	,006
	SMAN 2 Sumedang	,207	69	,000	,929	69	,001
	SMAN 3 Sumedang	,297	68	,000	,788	68	,000
CreTS_nilai	SMA N 1 Cimalaka	,173	68	,000	,947	68	,006
	SMAN 2 Sumedang	,207	69	,000	,929	69	,001
	SMAN 3 Sumedang	,297	68	,000	,788	68	,000
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

In conclusion, these results show that not all data on both science curiosity and CreTS variables are normally distributed. Therefore, non-parametric statistical analyses such as Kruskal-Wallis are required for inferential tests.

Kruskal-Wallis Test Results

The Kruskal-Wallis test results showed significant differences in the levels of curiosity and creative thinking skills (CreTS) among students from the three schools, with H values of 10.923 and 11.507 for curiosity, and 25.456 for CreTS, all with significance below 0.05. This confirms that students' curiosity and CreTS levels differed overall across the three schools. However, since the Kruskal-Wallis test only identifies differences in general without indicating pairs of significantly different groups, post-hoc analyses, such as Dunn's test, are required to determine the specific groups with differences. These findings provide important insights for understanding the factors that influence science curiosity and CreTS in each school and serve as a basis for developing more effective educational strategies that suit students' needs.

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Tabel 6. Kruskal Wallis Test Results Science Curiosity and CreTS

	Curiosity_skor	Curiosity_nilai	CreTS_skor	CreTS_nilai
Kruskal-Wallis H	10,923	11,507	25,456	25,456
Df	2	2	2	2
Asymp. Sig	,004	,003	,000	,000

This finding provides an important overview of the levels of students' science curiosity and creative thinking skills (CreTS) in high-achieving schools. The results indicate that the average level of science curiosity remains within the moderate category, while the average CreTS score falls within the adequate category.

These findings reinforce the need for further research involving intervention studies that implement innovative learning strategies aimed at enhancing students' abilities in both variables. It is also essential to examine in greater detail the factors influencing science curiosity and creative thinking skills (CreTS) in each school, as this understanding can serve as a foundation for developing more effective and contextually relevant educational strategies aligned with students' needs.

Discussion

In conducting this study, the application of statistical procedures encompassed several stages, including data inventory, processing, and reporting. Throughout these stages, the researchers encountered certain methodological limitations and analytical challenges. Prior to elaborating on these constraints, a comparative analysis of previous studies related to science curiosity and creative thinking skills (CreTS) was undertaken to provide contextual grounding. The outcomes of this review are summarized in the following table.

Table 5. Analysis of Curiosity and CreTS Data Processing Weaknesses in Previous Research

No.	Title, Author, Year	Data Processing Weaknesses
1.	Exploring curiosity and critical thinking skills for prospective biology teacher.(Nurdiana et al., 2023)	The article uses descriptive statistics and analytical approaches to evaluate the contribution of gender to scientific curiosity and critical thinking skills. While these methods are important, there are no qualitative elements to support the quantitative results, such as interviews or observations to explain the findings in more depth.
2.	A Thirst for Knowledge: Grounding Curiosity, Creativity, and Aesthetics in Memory and Reward Neural Systems.(Kenett et al., 2023)	The article does not mention the use of longitudinal data to observe changes in curiosity or creativity over time. This approach is important to understand the dynamics of the variables in more depth.
3.	Cultivating an	Most data comes from self-report, which is prone

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No.	Title, Author, Year	Data Processing Weaknesses
	understanding of curiosity as a seed for creativity(Gross et al., 2020)	to respondent bias, and few explore more objective behaviour-based measures.
4.	A shared novelty-seeking basis for creativity and curiosity(Ivancovsky et al., 2024)	Most of the results come from laboratories or simulations, making them less relevant to real-world contexts.
5.	On educating, curiosity, and interest development (Hidi & Renninger, 2020)	The research focused on a specific educational context, making it difficult to generalise the results to different learning situations
6.	The Five-Dimensional Curiosity Scale: Capturing the bandwidth of curiosity and identifying four unique subgroups of curious people(Kashdan et al., 2018)	Although the scale was developed with a large sample, validation across different cultures and contexts is underrepresented
7.	Effectiveness of Hands-On Activities to Develop Chemistry Learners' Curiosity in Community Secondary Schools in Tanzania (Kibga et al., 2021)	The study involved only a few students from a specific school in Tanzania, so the results may not be relevant for a global context.
8.	The differences and similarities between curiosity and interest: Meta-analysis and network analyses(Tang et al., 2022)	The meta-analysis results showed high heterogeneity, which may obscure the true relationship between curiosity and interest
9.	Supporting curiosity in schools and classrooms (Peterson, 2020)	Analyses are limited to US education policy, making it difficult to apply outside of this context
10.	Teaching questioning fosters adolescent curiosity:Analyzing impact through multiple-group structural equation modeling(Clark et al., 2019)	Studies show that certain teaching methods have a negative impact on students' curiosity, but the reasons behind this effect are not sufficiently analysed
11	Managing Cognitive Resource Expenditure and Fostering Creative	The study was conducted on only 61 11th grade biology students, so generalisation of the results to a wider population is limited.

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No.	Title, Author, Year	Data Processing Weaknesses
	Thinking in Biology TeachingGuided by Instructional Message Design (Orbeta, 2022)	
12	The Effect Size of Different Learning on Critical and Creative Thinking Skills of Biology Students (Supratman et al., 2021)	Differences in sample size between groups may have affected the reliability of the results and the study used ANCOVA and LSD without exploring modern analytical approaches such as machine learning for more complex variable relationships
13	Relationship between Critical and Creative Thinking Skills and Learning Achievement in Biology with Reference to Educational Level and Gender (Nasution et al., 2023)	Study used regression to measure the relationship between critical and creative thinking skills and learning achievement, but did not explore more complex variable interactions such as moderation or mediation
14	Developing Scientific Attitude, Critical Thinking and Creative Intelligence of Higher Secondary School Biology Students by Applying Synectics Techniques(Hwang et al., 2023)	There was no control over external factors such as students' educational or socio-economic backgrounds that could affect the results
15	Effects of Worksheets Base the Levels of Inquiry in Improving Critical and Creative Thinking(Muskita et al., 2020)	The study involved only 80 students, which limits the generalisation of the results to a wider population
16	An investigation of the cognitive and neural correlates of semantic memory search related to creative ability(Ovando-Tellez et al., 2022)	Study was conducted on a limited sample and used a neurocognitive experimental approach that may not be applicable outside the laboratory context
17	Effects of divergent thinking training on students' scientific creativity: The impact of individual creative potential and domain knowledge (Sun et al.,	ANCOVA analysis used three covariate variables (pre-SCT, creative potential, and domain knowledge), but did not explore the possibility of more complex interactions between variables

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No.	Title, Author, Year	Data Processing Weaknesses
	2020)	
18	The Effect of Technology Integration in Education on Prospective Teachers' Critical and Creative Thinking, Multidimensional 21st Century Skills and Academic Achievements (Hujjatusnaini et al., 2022)	The use of a combination of quantitative and qualitative data (mixed-method) resulted in the complexity of the analyses, but it was not explained in detail how these two types of data were integrated to produce robust conclusions and the sample size was small and divided into subgroups (experimental and control), which may reduce the statistical power of the results.

In the CreTS data collection, for example, researchers faced great challenges mainly because the questions were in the form of essays that required longer processing time, so students found it difficult it takes a lot of time to do all the questions. In addition, students' moods and emotions were disturbed because they were rarely given high-quality questions. To overcome this, CreTS time should be given specifically and separately to support student concentration. The validation of the questions, which was only based on lecturer feedback, should be supplemented with small sample trials to test their reliability and validity. In addition, differences in student literacy led to challenges in uniform understanding of the questions. The questions should have a tiered level of difficulty to cover the diversity of students' abilities.

Likewise, in taking science curiosity data, there are a lot of statements that students have to read so that it greatly affects external factors, such as mood and fatigue. Therefore, test completion should be done at a convenient time with a conducive atmosphere and not all at once (parallel) to support student concentration. Another challenge is the variation in students' understanding of the questions given, which can be overcome by using contexts close to their lives and simple language. In addition, students may give inauthentic responses if they feel that their answers affect the judgement. It should be made clear from the outset that their answers are confidential and will not affect the evaluation.

At the data processing stage, both curiosity and CreTS data have some weaknesses that need to be considered. In CreTS, question validation is only done through input from lecturers without formal statistical tests, so that measurement accuracy is less than optimal. In addition, essay questions that require a long time are not supported by sufficient time allocation, making it difficult for students to provide representative answers. In curiosity, there is a need for analysis per aspect or there is analysis and exploration of each indicator of science curiosity. In addition, the limited number of students or teachers involved in the study reduced the overall representation of the population. Another shortcoming is that no further analyses, such as post-hoc tests, were conducted to identify significant differences between specific groups. These weaknesses indicate the importance of improvements in instrument design, data collection methods, and further analyses to increase the validity of the research results.

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CONCLUSION

The results of the study indicate that the levels of science curiosity and creative thinking skills (CreTS) among grade XI students at three state senior high schools in Sumedang Regency remain in a category that needs improvement. The Kruskal-Wallis test confirmed significant differences between schools in both aspects. However, since the Kruskal-Wallis test only reveals overall differences, a post-hoc test such as Dunn's Test is necessary to identify which specific pairs of schools differ significantly. Conducting such a test could be part of further research to deepen the analysis and provide a stronger basis for educational interventions.

The data collection and processing stages in this study faced several challenges. One of the main issues was suboptimal instrument validation, which relied solely on expert judgment without accompanying statistical tests such as construct validity or empirical reliability (e.g., Cronbach's Alpha). This may have affected the accuracy of the variable measurements. Additionally, the limited time allocated for completing the instruments, especially the essay questions for CreTS which prevented students from answering to their full potential. Variations in student literacy levels also led to inconsistent interpretations of the questions, which could impact data consistency.

The recommendations provided in this study are relevant to the context of educational development, but they should be described in more detail. For instance, teachers are encouraged to integrate innovative learning approaches such as project-based and inquiry-based learning, which can simultaneously enhance students' curiosity and creative thinking. The incorporation of educational technologies including interactive simulations, gamified assessments, and virtual laboratories can further strengthen student engagement and conceptual understanding. Curriculum designers should ensure adequate time allocation for open-ended learning activities and include authentic assessments that capture curiosity and creativity as essential learning outcomes. Future studies are recommended to involve larger and more diverse samples, employ statistically validated instruments, and perform advanced analyses such as post-hoc comparisons to produce more robust and generalizable results.

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