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The Influence of High School Students' Mathematical Curiosity on Interest in STEM Learning

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Abstract: The study had explored the influence of high school students' mathematical curiosity on their interest in STEM (Science, Technology, Engineering, and Mathematics) learning. Using a quantitative approach, the study had involved 271 students from various high schools, who had filled out a questionnaire regarding their level of mathematical curiosity and interest in STEM learning. Regression analysis had been conducted to identify the relationship between the two variables. The study's results had revealed a significant relationship between mathematical curiosity and interest in STEM learning, with a p-value of <0.05. This finding had indicated that students' mathematical curiosity had simultaneously influenced students' interest in STEM learning with several indicators that had significantly affected interest in STEM learning, namely the desire to detail information and enthusiasm for learning. The implications of these results had highlighted the importance of designing teaching strategies that could trigger students' mathematical curiosity to increase their engagement in STEM fields.

Keywords: interest; mathematical curiosity; STEM

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A. Introduction

Curiosity is an important cognitive aspect that motivates individuals to explore and understand their surroundings. Curiosity is also a desire to know that is accompanied by positive emotions, increased blood flow, and exploratory behavior (Peterson & Cohen, 2019). Mathematical curiosity refers to students' internal drive to explore and understand mathematical concepts in mathematics education. Curiosity can be directed to improve understanding of mathematical concepts through several ways related to the components of curiosity (Anderson & Dean, 1963; Peterson & Cohen, 2019). Curiosity theory, as explained by Piaget and Vygotsky, emphasizes the important role of curiosity in the learning process. Piaget argued that curiosity is a primary driver in cognitive development, where individuals continue to adapt and build mental structures through interactions with their environment. In contrast, Vygotsky highlighted the importance of social and cultural interactions in facilitating the development of curiosity and cognitive abilities (Rabindran & Madanagopal, 2020; Wardani et al., 2023). In mathematics, curiosity can be recognized through several signs, such as questions in-depth understanding of mathematical concepts, a desire to explore topics beyond the curriculum, and creativity in solving problems. Intrinsic motivation theory suggests that students with high mathematical curiosity tend to be more active in learning because they feel challenged and motivated to dig deeper into knowledge. They seek answers to existing questions, continually ask new questions, and seek innovative solutions (Peterson & Cohen, 2019).

Mathematics curiosity is influenced by various factors, including attitudes toward mathematics, previous experiences, and support from teachers and peers. Students with positive experiences in mathematics and support from the learning environment usually show higher levels of curiosity. Mathematics curiosity in students is influenced by a variety of complex factors. One of the most significant factors is the influence of inspirational teachers. A study conducted in the 1960s showed that students who had inspirational teachers in mathematics or science tended to have higher levels of curiosity. Inspirational teachers not only provide academic knowledge but also motivate students to ask questions, form hypotheses, and test hypotheses. This can be seen from a survey showing that 83.41% of Kansas High School students interviewed felt that they had inspirational teachers, and 17.36% of them had inspirational teachers in science. Awareness of knowledge gaps is also an important factor in increasing mathematics curiosity. Students aware of knowledge gaps in mathematics will be more likely to find and understand concepts they do not yet know. This can encourage them to seek information and understand deeper concepts. In addition, increased blood flow or a sense of urgency also plays an important role. Students who feel increased blood flow will be more motivated to explore mathematical concepts, such as asking questions and testing hypotheses. Exploratory behavior is also important in increasing mathematical curiosity (Anderson & Dean, 1963; Ulya & Hayati, 2020; Zetriuslita & Ariawan, 2021).

Curious students can demonstrate exploratory behaviors such as forming and testing hypotheses and connecting current questions to prior knowledge. This can help them understand mathematical concepts more deeply and broadly. In addition, the development of epistemic beliefs is also very important. Students with better beliefs about mathematics will be more motivated to explore and understand mathematical concepts. Strategic educational interventions can also increase mathematical curiosity. Teachers can use strategic learning strategies to increase students' curiosity. Mathematical curiosity can generally be identified by several indicators, including asking about the information or problems/questions given, wanting to know things in detail, being enthusiastic/passionate about learning, seeking information from various sources, and trying alternatives to solving problems or questions (Zetriuslita & Ariawan, 2021). Teachers can give challenging assignments that can be completed with the help of available learning resources. This can encourage students to explore and understand mathematical concepts more deeply. Research also shows that mathematical curiosity can be increased through teaching methods emphasizing exploration, discussion, and interesting and challenging problem solving, such as the use of technology in today's digital age (Torbeyns et al., 2015). Project-based learning is one of the learning methods that is considered to emphasize exploration, discussion, and problem-solving, one of which, in this digital era, is STEM learning (Rahmawati et al., 2020).

STEM learning, which encompasses science, technology, engineering, and mathematics, has become a major focus in modern education due to the importance of these skills in addressing global challenges and evolving technologies. The STEM concept emphasizes the interdisciplinary integration of these four areas to develop practical skills and complex problem-solving. As proposed by Jean Piaget and Lev Vygotsky, constructivist theory suggests that STEM learning involves an active process in which students construct their understanding through practical experiences and social interactions (Miles et al., 2018). Effective approaches to STEM education often involve several key elements, including project-based learning, collaboration, technology integration, and hands-on experimentation. Project-based learning allows students to apply theory to real-world situations, enhancing their understanding and skills. Collaboration in groups develops communication and teamwork skills, while technology integration gives students access to sophisticated tools and data analysis. Hands-on experiments allow students to apply theory to real-world contexts and hone their technical skills (Cheng et al., 2022). Good STEM learning approaches also encourage the development of critical and creative thinking skills. Students are encouraged to evaluate multiple solutions, identify problems, and develop innovative solutions. STEM learning models often involve real-life problems, which can increase student motivation and engagement. In practice, mathematical curiosity can be enhanced through various teaching methods that involve exploration and problem-solving. For example, challenging mathematical projects can stimulate students' curiosity and encourage them to find creative solutions. Technology and digital tools in mathematics learning can also expand students' exploration and provide access to additional resources (A. Roberts & Cantu, 2012; Zayyinah et al., 2022).

At the high school level, instruction involving challenging tasks and relevant problem situations can foster mathematical curiosity. This approach helps students understand mathematical concepts more deeply and enhances critical and analytical thinking skills. Project-based learning, complex problem-solving, and independent exploration can create a supportive learning environment that stimulates students' curiosity. In STEM education, applying constructivist principles and interdisciplinary approaches is key. Problem-based projects involving science, technology, engineering, and mathematics allow students to apply theory in practical contexts. These projects often involve challenging tasks relevant to real life, increasing student engagement and motivation (Gómez-Chacón et al., 2021; Rahmawati et al., 2020; Sitorus, 2022).

Group collaboration is also an important element in STEM learning. Working together on STEM projects helps students develop communication, collaboration, and problem-solving skills. Integrating technology into STEM learning allows students to use sophisticated tools and analyze data more effectively, while hands-on experiments help students apply theory in real-world contexts. Constructive evaluation and feedback are also important in STEM learning practices. Continuous assessment and effective feedback help students identify areas for improvement and refine their approaches to completing STEM tasks. Understanding the relationship between mathematical curiosity and STEM learning is essential to designing effective learning experiences. By leveraging mathematical curiosity as a driver in STEM learning and implementing curiosity-inducing teaching approaches, educators can help students develop deeper understanding and the skills needed to succeed in STEM fields (Hariyanti & Lestari, 2023; Li & Schoenfeld, 2019; Ulya & Hayati, 2020). Therefore, further research in this area may provide insights valuable for the development of more effective curriculum and teaching strategies, preparing students to face future challenges in the STEM field. So the researcher will conduct a study on the influence of high school students' mathematical curiosity on their interest in STEM learning.

B. Methods

This is quantitative research. Quantitative research, according to the guidelines provided by John W. Creswell, represents a systematic approach to compiling, collecting, and analyzing data in the form of numbers or statistics. Quantitative research begins by formulating the problem, identifying the phenomenon to be studied, and establishing research questions (Creswell, 2014). The next step is to determine the purpose of the research and choose an appropriate research design. The data collection process is carried out through validated instruments. The collected data is then analyzed using appropriate statistical methods. The results of the data analysis are interpreted by considering practical and theoretical implications. Finally, the research findings are organized in a research report according to a scientific structure, clearly explaining the methods, findings, and interpretations. The report contributes to knowledge in the relevant research field (Creswell, 2013).

This study will analyze the influence of high school students' mathematical curiosity on their interest in STEM learning. In this study, the researcher acts as a planner, implementer, data collector, data interpreter, and reporter of research results. Activities carried out by the researcher include creating instruments in the form of online forms, collecting data through online forms for students, analyzing data, making conclusions, and making research reports. The subjects used in this study were high school students in Indonesia. The subjects selected were 200 high school students.

Research Instruments are tools used by researchers to collect data (Creswell, 2013). The instrument used in this study was an online form of student interest in three-dimensional media and STEAM. The research instrument contains a choice of students' mathematical curiosity levels based on five criteria, namely never, rarely, sometimes, often, and always, which are described in 5 indicators of mathematical curiosity, namely asking about mathematical information or problems given, wanting to know mathematical things in detail, being enthusiastic about learning mathematics, seeking information from various mathematical sources, and trying alternatives to solving mathematical problems (Zetriuslita & Ariawan, 2021). Meanwhile, the level of interest in STEM learning includes those who are interested and those who are not. Furthermore, the research hypothesis will be tested using SPSS-assisted logistic regression analysis. This aims to answer the research question, namely the influence of two or more independent variables on the independent variable. Before conducting a hypothesis test, the prerequisite test must first be met, namely the overall model test (overall model fit) model feasibility test based on the Hosmer and Lemeshow Test results. Furthermore, in the hypothesis test, the Wald test (t) shows how far the influence of the independent variable is partially in explaining the dependent variable. To find out the Wald test value, the significance level is 5%. The decision-making criteria are as follows: If the p-value> 0.05, then H0 is accepted, meaning that one of the independent variables does not affect the dependent variable, but if the p-value < 0.05, then H0 is rejected, meaning that one of the independent variables affects the dependent variable (Andrade, 2019).

Five hypotheses can be formulated in this research, namely:

1. The influence of asking about mathematical information or problems on interest in STEM learning.
2. The influence of wanting to know mathematical matters in detail on interest in STEM learning.
3. The influence of enthusiasm in learning mathematics on interest in STEM learning.
4. The influence of seeking mathematical information from various sources on interest in STEM learning.
5. The effect of trying alternatives to solving mathematical problems on interest in STEM learning.

C. Results and Discussion

The data that has been successfully collected is 271 respondents consisting of high school students in Indonesia. The data contains the respondents' mathematical curiosity and their interest in STEM-based learning. The analysis presented is related to the influence of high school students' mathematical curiosity on their interest in STEM learning. The analysis was conducted using SPSS-assisted logistic regression tests, as follows:

1. Case Processing Summary

Tabel 1. Case Processing Summary

Case Processing Summary			
Unweighted Cases[a]		**N**	**Percent**
Selected Cases	Included in Analysis	271	100.0
	Missing Cases	0	.0
	Total	271	100.0
Unselected Cases		0	.0
Total		271	100.0

a. If weight is in effect, see classification table for the total number of cases.

The case processing summary was used to assess the accuracy and integrity of the data. Referring to Table 1, the data obtained in this study was 271, and there were no missing cases or data, so all data could have been processed and used in this research.

2. Classification Table

Tabel 2. Classification Table

Classification Table[a,b]					
	Observed		**Predicted**		
			STEAM		Percentage Correct
			Tidak Tertarik	Tertarik	
Step 0	STEAM	Tidak Tertarik	0	66	.0
		Tertarik	0	205	100.0
	Overall Percentage				75.6

a. Constant is included in the model.

b. The cut value is ,500

Table 2 obtained the overall percentage before the *variable* independent was entered, namely 75.6%. Based on this, 75.6% of students are interested in STEM learning, amounting to 205 students, and 24.4% are not interested in STEM learning, amounting to 66 students.

3. Iteration History

Tabel 3. Iteration History Book

Iteration		-2 Log likelihood	Coefficients					
			Constant	Ask for Information	Want to Detail Information	Enthusiastic to Learn	Searching for information	Trying Alternatives Solution
Step 1	1	278.139	-.6.580	.059	.291	.291	-.049	.077
	2	274.263	-9.916	.072	.375	.428	-.062	.125
	3	274.187	-10.580	.072	.385	.455	-.062	.136
	4	274.187	-10.599	.072	.385	.456	-.062	.136
	5	274.187	-10.599	.072	.385	.456	-.062	.136

Iteration History[a,b,c,d]

a. Method: Enter

b. Constant is included in the model.

c. Initial -2 Log Likelihood: 300.880

d. Estimation terminated at iteration number 6 because parameter estimates changed by less than ,001.

Referring to Table 3 above, which is a table of iteration history when the independent variables are not included (in block 1), the value of -2 Log Likelihood is obtained: 300.880. When compared with the Chi-Square value when the degrees of freedom DF = N - Number of Independent Variables = 271 - 5 = 266 and the probability is 0.05, then the value of -2 Log-Likelihood: 300.880 < Chi-Square value: 305.5. This shows that after the independent variables are entered, the model fits the data.

4. Omnibus Test

Tabel 4. Omnibus Test

Omnibus Tests of Model Coefficients				
		Chi-square	**Df**	**Sig.**
Step 1	Step	26.693	5	.000
	Block	26.693	5	.000
	Model	26.693	5	.000

Based on Table 4, a significance value of <0.05 was obtained, which means that the model can be said to be fit or in other words, the addition of independent variables has a real influence on the model.

5. Hosmer and Lemeshow Test

Tabel 5. Hosmer and Lemeshow Test

Hosmer and Lemeshow Test			
Step	Chi-square	Df	Sig.
1	10.637	8	.223

Based on the data in Table 5, the Chi SquareHosmer and Lemeshowtest value is obtained: 10.637 > Chi-Square table value: 15.507 (when df 8 and probability P = 0.05). This can also be seen from the significance value in the table: 0.223 > 0.05, which means there is no significant difference between the model and its observations, so the hypothesis test can be carried out.

6. Classification Results

Tabel 6. Classification Results

Classification Table[a]

Observed			Predicted: STEM_Interest Not interested	Predicted: STEM_Interest Interested	Percentage Correct
Step 1	STEM Interest	Not interested	8	58	12.1
		Interested	2	203	99.0
	Overall Percentage				77.9

a. The cut value is ,500

Based on Table 6, after the independent variables are entered, the results show that students are not interested in STEM learning are 66 students, with a classification of 8 students who are indeed not interested and 58 students who should not be interested but are interested. Then, students interested in STEM learning are 205 students with a classification of 203 students who are indeed interested and two people who should be interested but are not interested in STEM learning. Based on Table 6, the accuracy of the research model is also obtained at 77.9%.

7. Logistic Regression Model and Hypothesis Testing

The output in SPSS had produced the following coefficient output results:

Tabel 7. Output SPSS Variables in the Equation Logistic Regression

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Ask for Information	.072	.183	.156	1	.693	1.075
	Want to Detail Information	.385	.168	5.280	1	.022	1.470
	Enthusiastic to Learn	.456	.181	6.374	1	.012	1.578
	Searching for information	-.062	.165	.142	1	.706	.940
	Trying Alternatives Solution	.136	.182	.559		.455	1.146
	Constant	-10.599	4.525	5.486	1	.019	.000

a. Variable(s) entered on step 1: Asking for Information, Wanting to Detail Information, Enthusiastic to Learn, Seeking Information, Trying Alternative Solutions.

a. The First Hypothesis on X1(Asking for Information)

H_0 : There is no effect of asking about information on interest in STEM learning.

H_1 : There is an influence of asking about information on interest in STEM learning.

Referring to Table 7, the p-value (0.693) > 0.05 is obtained so that H0 is accepted, which means that there is no effect of asking for information on interest in STEM learning. Based on these results, asking for information does not always directly affect students' interest in STEM learning. Although asking for information is integral to the learning process, this activity focuses more on understanding the material than on triggering significant interest and interest in STEM learning. In addition, asking questions is a foundational skill for developing other skills (Waruwu et al., 2023).

b. The First Hypothesis on X2(Want to Detail Information)

H_0 : There is no influence of wanting to know mathematical things in detail on interest in STEM learning.

H_1 : There is an influence of wanting to know mathematical things in detail on interest in STEM learning.

Based on Table 7, the p-value (0.022) < 0.05 is obtained, so it is rejected, which means that wanting to know mathematical things in detail influences interest in STEM learning. Based on these results, it was found that when students have a deep curiosity about the details of mathematical concepts, they are actively involved in learning and have an interest in learning. In addition, students can explore mathematical concepts in depth and relate them to practical applications in learning, such as those found in STEM learning (Belecina & Ocampo, 2016; Torbeyns et al., 2015).

c. The First Hypothesis on X3(Enthusiastic to Learn)

H_0 : There is no influence of enthusiasm in learning mathematics on interest in STEM learning.

H_1 : There is an influence of enthusiasm in learning mathematics on interest in STEM learning.

Based on Table 7, the p-value (0.012) < 0.05 is obtained, so H0 is rejected, which means that enthusiasm for learning mathematics influences interest in STEM learning. Based on these results, enthusiasm for learning significantly influences students' interest in STEM learning. Students showing enthusiasm for learning can encourage students to be more involved in STEM experiments and projects, which develop critical and collaborative skills. Thus, enthusiasm for learning can be a way to increase participation and interest in media learning, such as in STEM learning (Asria et al., 2021; Fitriyana et al., 2024; T. Roberts et al., 2018).

d. The First Hypothesis on X4(Searching for Information)

H_0 : There is no influence of seeking mathematical information from various sources on interest in STEM learning.

H_1 : There is an influence of seeking mathematical information from various sources on interest in STEM learning.

Referring to Table 7, the p-value (0.706)> 0.05 was obtained, so H0 was accepted, which means that there is no influence of seeking mathematical information from various sources on interest in STEM learning. Based on these results, seeking mathematical information from various sources does not always significantly influence students' interest in STEM learning. Although access to external sources of information such as books, scientific articles, or websites can enrich students' understanding of mathematical concepts, this process does not necessarily lead to more significant mathematical curiosity or engagement in STEM learning. Without contextual learning experiences or clear relevance between mathematics and its real-world applications, information-seeking alone is insufficient to increase students' mathematical curiosity in learning as it does in STEM learning (Puspitasari et al., 2024). In addition, contextualised mathematics or realistic mathematics education will also make mathematics more representative and students' curiosity and confidence will improve (Hidayat & Novikasari, 2023; Najah, 2024).

e. The First Hypothesis on X5(Trying Alternative Solutions)

H_0 : There is no effect of trying alternatives to solving mathematical problems on interest in STEM learning.

H_1 : There is an influence of trying alternatives to solving mathematical problems on interest in STEM learning.

Based on Table 7, the p-value (0.455) > 0.05 is obtained so that H0 is accepted, which means there is no effect of trying alternatives to solving mathematical problems on interest in STEM learning. Based on these results, although alternative strategies in problem-solving can provide variation and support understanding of mathematical concepts, not many students have this ability, and not all students respond to it with interest in learning mathematics, including in STEM learning (Papilaya et al., 2023) Based on Table 7, a logistic regression model was also obtained in terms of the variables significant independent influence:

$$Logit(\frac{\pi}{1-\pi}) = -10{,}599 + 0{,}385X_2 + 0{,}456X_3$$

From the findings obtained, it was found that the data successfully analyzed was mathematical curiosity data and interest data in STEM learning. The final results of the logistic regression test showed an accurate model of 77.9%. This shows that students' mathematical curiosity classified into specific mathematical curiosity indicators affects students' interest in STEM learning. This confirms that students' mathematical curiosity, classified into several specific indicators, has a significant effect on students' level of interest in the context of STEM learning. This is in line with several studies. It is stated that mathematical curiosity drives project learning, including STEM, which emphasizes many STEM projects (Belecina & Ocampo, 2016; Torbeyns et al., 2015; Wicaksana, 2018).

D. Conclusion

This study concluded that the study had shown the influence of mathematical curiosity, which focused on wanting to detail information and being enthusiastic about STEM learning. The final result of the accurate model regression test was 77.9%. This indicated that education should have focused on developing mathematical curiosity through an exciting and relevant approach to create a learning environment that supported and increased students' interest in

STEM learning. Thus, learning that had facilitated and stimulated this curiosity could have created a more exciting and in-depth learning experience and encouraged students to be more actively involved in the learning process. Therefore, integrating teaching methods that prioritized mathematical curiosity in the STEM curriculum had been essential to developing students' interest and motivation.

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