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FOUR DOMINANT FACTORS INFLUENCING STUDENTS' MATHEMATICAL CURIOSITY

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Abstract

Curiosity is a crucial aspect of mathematics learning, as it encourages exploration, deep understanding, and active engagement. However, existing instruments for measuring students' mathematical curiosity are still limited and rarely tested for construct validity using robust statistical methods. This gap indicates a need for a valid measurement tool that can capture the multidimensional nature of mathematical curiosity. This study aims to develop and validate a measurement instrument for students' mathematical curiosity through an exploratory factor analysis (EFA) approach. However, there are still few instruments that have been systematically developed and tested for construct validity in this context. This study involved 177 students from the Department of Mathematics at Universitas Negeri Padang, spanning the 2022 to 2024 intake. Data were collected through a questionnaire containing 14 statement items arranged on a Likert scale. The results of the EFA analysis revealed the formation of four main factors, with a KMO value of 0.805 and a Bartlett's Test significance of 0.000. The four factors are called Reflective Thinking Curiosity, Routine Challenge Curiosity, Analytical Pattern Curiosity, and Active Exploration Curiosity. These findings suggest that the developed instrument is statistically valid and capable of capturing the multidimensional aspects of mathematical curiosity. The implications of this study contribute theoretically to the understanding of the construct of students' mathematical curiosity and practically to the development of learning strategies and curriculum development that can foster and manage students' curiosity more effectively.

Keywords: Curiosity; exploratory factor analysis; mathematics learning

Abstrak

Rasa ingin tahu merupakan aspek krusial dalam pembelajaran matematika, karena mendorong eksplorasi, pemahaman mendalam, dan keterlibatan aktif. Namun, alat ukur yang ada untuk mengukur rasa ingin tahu matematika siswa masih terbatas dan jarang diuji validitas konstruknya menggunakan metode statistik yang kuat. Kesenjangan ini menunjukkan kebutuhan akan alat ukur yang valid untuk menangkap sifat multidimensional dari rasa ingin tahu matematika. Penelitian ini bertujuan untuk mengembangkan dan memvalidasi alat ukur rasa ingin tahu matematika siswa melalui pendekatan Analisis Faktor Eksploratori (EFA). Namun, masih sedikit alat ukur yang telah dikembangkan secara sistematis dan diuji validitas konstruknya dalam konteks ini. Penelitian ini melibatkan 177 siswa dari Program Studi Matematika Universitas Negeri Padang, yang mencakup angkatan 2022 hingga 2024. Data dikumpulkan melalui kuesioner yang berisi 14 item pernyataan yang disusun pada skala Likert. Hasil analisis EFA menunjukkan pembentukan empat faktor utama, dengan nilai KMO sebesar 0,805 dan signifikansi Uji Bartlett sebesar 0,000. Keempat faktor tersebut disebut Reflektif Thinking Curiosity, Routine Challenge Curiosity, Analytical Pattern Curiosity, dan Active Exploration Curiosity. Temuan ini menunjukkan bahwa instrumen yang dikembangkan secara statistik valid dan mampu menangkap aspek multidimensional dari keingintahuan matematika. Implikasi penelitian ini secara teoritis berkontribusi

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pada pemahaman konstruksi keingintahuan matematika siswa dan secara praktis pada pengembangan strategi pembelajaran dan kurikulum yang dapat memupuk dan mengelola keingintahuan siswa secara lebih efektif.

Kata kunci*: Rasa ingin tahu; analisis faktor eksploratori; pembelajaran matematika*

INTRODUCTION

Curiosity is a mental trait that is pretheoretically used to explain why individuals actively seek information (Goupil & Proust, 2023). In the context of mathematics education, curiosity plays a crucial role, as it influences students' engagement in learning activities and contributes significantly to their understanding of mathematical concepts (Zetriuslita & Ariawan, 2021). Moreover, curiosity is considered one of the essential affective attitudes that encourage students to be actively involved in the mathematics learning process (Zetriuslita et al., 2024). It is also clari-fied that when students have curiosity, they tend to engage deeply with the material, participate actively in lessons, and show perseverance in facing challenges (Brod & Breitwieser, 2019; Verdeflor et al., 2024). According to Peterson and Cohen (2019), curiosity consists of three main components: the knowledge gap, increased passion, and exploration. However, despite its recognized importance, research on the development and structure of curiosity, particularly in the domain of mathematics, remains limited (Peterson & Cohen, 2019).

Many studies have discussed curi-ousity in the context of mathematics but have not revealed the dominant factors that shape it. Belecina and Ocampo (2016) examined the impact of curiosity on psychomotor aspects, while Pramiasari et al. (2022) focused on the influence of learning models. Rahmawati et al. (2021) linked curiosity to students' numerical abilities, and Bistari et al. (2024) linked it to self-regulated learning. Kundu and Bej (2022) reported on the comparative pedagogy of three popular learning modes: face-to-face, online, and blended in terms of their potential to stimulate students' curiosity. When teachers are enthusiastic about a subject, it creates a positive classroom environ-ment that fosters curiosity and engage-ment (Carmichael et al., 2017; Doño & Mangila, 2021). Mee et al. (2020) and Septiawan et al. (2023) studied students' curiosity about the application of gamification in learning. Usluoğlu and Toptaş (2025) examine the impact of artificial intelligence on increasing curiosity. However, no study explicitly discusses or analyzes the factors that drive mathematical curiosity.

Two commonly used factor analysis methods are Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). EFA is utilized to uncover the underlying structure among a set of variables or indicators by summarising these variables are reduced to a smaller set of factors that capture the primary underlying constructs (Peterson, 2017; Watson, 2017). This method is chosen because it enhances the interpretability of the resulting factor structure (Carrizosa et al., 2020). Meanwhile, CFA is used to test and confirm the validity of the factor structure previously identified through EFA (Harlow, 2023; Umar & Nisa, 2020). Therefore, EFA should be conducted first as an exploratory step

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before CFA is used as a confirmatory step.

Previous studies have used Exploratory Factor Analysis (EFA), but it still has limitations in the context of mathematical curiosity. Jaison et al. (2021) applied EFA outside the field of mathematics, namely introductory engineering and sketching courses, so it is not directly relevant. Meanwhile, although the studies by Akgul and Kahveci (2016) and Putra et al. (2022) were conducted in the context of mathematics, their focus was not on mathematical curiosity but on learning difficulties, mathematical dispositions, and learning interest.

Only one study focusing on mathematical curiosity using a factor analysis approach was found, conducted by Herwin and Nurhayati (2021). However, this study did not use EFA but directly applied CFA. Herwin and Nurhayati (2021) did not generate new factors but instead verified existing factors without explaining whether these factors were previously obtained through exploratory factor analysis (EFA). Additionally, several other studies also used CFA without prior EFA or did not specify the theoretical basis for factor naming (Hashim et al., 2023; Herwin & Nurhayati, 2021; Karbono et al., 2023). This inconsistency constitutes a common methodological weakness in factor analysis research. This aligns with Howard (2023) findings, which indicate that many researchers fail to provide detailed explanations of the factor analysis procedures they employed, thereby reducing the clarity and validity of their research results.

Based on the previous description by Jaison et al. (2021), Akgul and Kahveci (2016), and Putra et al. (2022), and Herwin and Nurhayati (2021), research related to the factor analysis of mathematical curiosity remains limited, with several limitations, particularly in the application of the Exploratory Factor Analysis (EFA) method. Therefore, the purpose of this study is to overcome these limitations by applying EFA to data from a questionnaire on students' mathematical curiosity, aiming to identify valid and dominant factors as indicators of curiosity in mathematics learning. The results of this study will likely provide a theoretical contribution in the form of new insights into the construct of students' mathematical curiosity. This study offers theoretical insights into the factors that influence students' mathematical curiosity. It offers practical guidelines for designing more effective instructional strategies and curricula to nurture and support students' curiosity in mathematics learning.

METHODS

This study uses a quantitative approach. The purpose of this study is to group questionnaire items to produce a statistically valid questionnaire instrument that truly measures students' mathematical curiosity through exploratory factor analysis (EFA). The research began by developing a mathematical curiosity measurement instrument. The instruments that have been developed are validated using exploratory factor analysis (EFA). After obtaining the results, they are analyzed, and a valid mathematical curiosity instrument is obtained.

The study's subject comprises 177 students from the Department of Mathematics, specifically those enrolled in the mathematics and mathematics education programs from the 2022 to 2024 cohorts at Universitas Negeri Padang. The instrument used in this research was a curiosity questionnaire

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consisting of 14 items presented in the form of statements and measured using a Likert scale.

The data analysis technique applied in this study was Exploratory Factor Analysis (EFA). The procedure for conducting EFA includes identifying the variables to be analyzed, testing assumptions, computing the correlation matrix through Bartlett's Test of Sphericity and evaluating the Measure of Sampling Adequacy (MSA), performing the extraction or factoring process, determining the number of factors, applying factor rotation, and interpreting the resulting factors. The factor analysis utilized the Principal Component Analysis (PCA) method combined with Varimax rotation.

RESULTS AND DISCUSSION

This study aims to identify the factor structure of the curiosity instrument, which consists of 14 statements (X1–X14). Factor analysis was carried out using the Principal Component Analysis method with Varimax rotation. The test results, obtained using SPSS 25 for Windows, are as follows.

KMO and Bartlett's Test

The Kaiser-Meyer-Olkin (KMO) Test and Bartlett's Test are crucial initial steps in exploratory factor analysis (EFA) to assess the suitability of the data used. The KMO value measures the adequacy of the sample and the suitability of the data for analysis using factor techniques. The outcomes of the KMO and Bartlett's tests are shown in Table 1.

Table 1. KMO test and *Bartlett's test*

Testing		Value
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,805
Bartlett's Test of Sphericity	Approx. Chi-Square	558,524
	Df	91
	Sig.	,000

Based on Table 1, an Measures of Sampling Adequacy (MSA) value of 0.805, which is greater than 0.5, was obtained, indicating that the data used had good sample adequacy for factor analysis. The value of KMO above 0.8 indicates that the data are very suitable for analysis using EFA. Furthermore, Bartlett's Test of Sphericity produced a Chi-Square value of 558.524 with 91 degrees of freedom and a significance level of 0.000 ($p < 0.05$), indicating that the correlations among variables are statistically significant. Therefore, since the MSA value exceeds 0.5 and the significance level of Bartlett's Test of Sphericity is less than 0.05, the dataset is considered suitable for factor analysis.

Anti Image Correlation

The Anti-Image Correlation analysis revealed that all variables had sufficient MSA values, supporting the validity of the data for conducting factor analysis. The Anti-Image Correlation matrix is shown in Table 2.

Table 2. *Anti-Image Correlation*

Variable	*Anti-Image Correlation*	Reference Values	Conclusion
X1	0,769	0,50	MSA Values Fulfilled
X2	0,756		
X3	0,796		
X4	0,793		
X5	0,802		
X6	0,736		
X7	0,774		
X8	0,868		
X9	0,781		
X10	0,858		
X11	0,831		
X12	0,869		
X13	0,790		
X14	0,745		

Based on Table 2 the MSA value of all variables is > 0.5, all are included in the factor analysis.

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Communalities

In Exploratory Factor Analysis (EFA), communalities represent the proportion of each variable's variance that is accounted for by the extracted factors. These values reflect the extent to which each variable contributes to the development of the underlying factors within the dataset. The communalities results are displayed in Table 3.

Table 3. *Communalities*

	Initial	*Extraction*
X1	1,000	,565
X2	1,000	,339
X3	1,000	,502
X4	1,000	,511
X5	1,000	,599
X6	1,000	,627
X7	1,000	,626
X8	1,000	,560
X9	1,000	,533
X10	1,000	,632
X11	1,000	,664
X12	1,000	,542
X13	1,000	,598
X14	1,000	,695

Extraction Method: Principal Component Analysis.

Based on Table 3. Of the 14 variables used, the X2 variable has a communalities value of 0.339, which means that only about 33.9% of the variance of this variable can be explained by the factors formed. In this study, the variable with a communalities value of < 0.5 was removed. Thus, the variable X2 is not included in the factor analysis. For variables X1, X3-X14, the communalities values are greater than 0.5, so they can be included in the factor analysis.

Total Variance

The total variance explained by the factors formed is one of the leading indicators in assessing the quality of the factor model resulting from the EFA analysis. If the total initial eigenvalue is greater than 1, then the factor can explain the indicator well, so it needs to be included in the formation of the indicator. The results of the total variance explained value are described in Table 4.

Table 4. Total variance explained

Com-ponent	***Initial Eigenvalues***			***Extraction Sums of Squared Loadings***			***Rotation Sums of Squared Loadings***		
	Total	**% of Variance**	**Cumula-tive %**	**Total**	**% of Variance**	**Cumu-lative %**	**Total**	**% of Variance**	**Cumu-lative %**
1	3,907	27,907	27,907	3,907	27,907	27,907	2,600	18,570	18,570
2	1,741	12,435	40,341	1,741	12,435	40,341	2,054	14,668	33,238
3	1,285	9,181	49,522	1,285	9,181	49,522	1,825	13,037	46,276
4	1,059	7,563	57,086	1,059	7,563	57,086	1,513	10,810	57,086
5	,985	7,036	64,121						
6	,733	5,239	69,360						
7	,704	5,028	74,388						
8	,655	4,681	79,069						
9	,608	4,340	83,409						
10	,559	3,991	87,401						
11	,520	3,714	91,115						
12	,495	3,537	94,652						
13	,382	2,726	97,377						
14	,367	2,623	100,000						

Extraction Method: Principal Component Analysis.

Based on Table 4, four components have an eigenvalue greater than 1. Thus, there are four factors formed from the 14 variables analyzed.

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Rotate Component Matrix

The Rotated Component Matrix is the result of a factor rotation process that aims to facilitate the interpretation of the factor structure formed in the EFA analysis. This study employed the Varimax rotation with Kaiser Normalization, which is the most commonly used orthogonal rotation method due to its ability to produce simpler and clearer factor structures. The results of the Rotated component factor are presented in Table 5.

Table 5. Rotated component matrix

Var	*Component*			
	1	**2**	**3**	**4**
X10	,789			
X11	,719	,135	,343	,103
X8	,714	,191		
X12	,631	,179		,334
X9	,576	,422	,110	-,103
X14	,154	,816		
X13	,292	,713		
X7		,701	,324	.171
X1			,748	
X4	,133	,131	,686	
X3	,207		,655	,172
X6			,140	,778
X5	,145			,753
X2	,166	,319	,284	,359

Based on Table 5, it is shown that the analyzed variables are distributed across four main components. The variables X8, X9, X10, X11, and X12 have a high loading factor in Component 1, with loading values exceeding 0.5, indicating that these variables contribute significantly to the first factor. Variables X7, X13, and X14 have high loading factors in Component 2, with loading values exceeding 0.5, indicating that these variables contribute significantly to the second factor. Variables X1, X3, and X4 have a high loading factor on component 3, with loading values exceeding 0.5, indicating that these variables contribute significantly to the third factor. Variables X5 and X6 have a high loading factor on component 4, with a loading value exceeding 0.5, indicating that these variables contribute significantly to the fourth factor.

Component Transformation Matrix

The Component Transformation Matrix shows how the initial component is transformed into a rotated component using Varimax rotation. The correlation values between the components before and after rotation are presented in Table 6.

Table 6. Component transformation matrix

Component	**1**	**2**	**3**	**4**
1	,703	,492	,408	,311
2	-,207	-,548	,629	,511
3	-,673	,666	,319	,049
4	-,100	,118	-,580	,800

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

As shown in Table 6, component 1 has a correlation of 0.703, component 2 shows a correlation of 0.629, component 3 has a correlation of 0.666, and component 4 displays a correlation value of 0.8. Since all correlation values exceed 0.5, the four extracted factors adequately represent the 14 variables analyzed. The subsequent step after identifying the factors is assigning appropriate labels or names to each of them. The naming of factors that have been formed is subjective, but it is usually based on the loading factor. It must be able to represent the fundamental properties of the variables that comprise the factor. The factor names derived from the analysis results are shown in Table 7.

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Table 7. Naming of latent factors

Variable	Statement	Name
X8	I am not interested in drawing conclusions based on facts or evidence in mathematics.	*Reflective Thinking Curiosity*
X9	I would rather accept the mathematical formulas that exist than try to find out where they came from or prove them.	
X10	I am not interested in identifying important information in math problems.	
X11	I do not care if some patterns or rules apply in general in various example problems.	
X12	When facing obstacles in solving math problems, I tend to choose only a few ways before deciding on the next step.	
X7	I am enthusiastic about solving the math problems given, especially problems that are not routine or unusual in class.	*Routine Challenge Curiosity*
X13	When faced with obstacles in solving math problems, I choose only a few available ways before deciding on the next step.	
X14	I was excited to solve problems that were routine or typically assigned in class.	
X1	I want to find logical (reasonable) conclusions based on facts and evidence in mathematics.	*Analytical Pattern Curiosity*
X3	I always want to know the core of the problem in math before trying to solve it.	
X4	I enjoy searching for patterns or general principles that apply to various math problems.	
X5	I will ask if there is any information on the material or if there are questions that are not well understood.	*Active Exploration Curiosity*
X6	If I encounter problems with solving math problems, I try various alternative way	

These four curiosity factors complement each other in an effective learning process. Reflective Thinking Curiosity encourages students to think deeply and critically about the problem at hand, rather than just looking for quick answers. Reflective learning helps students understand concepts more thoroughly and improve their problem-solving skills (Rapti et al., 2025). Mwamakula (2020) emphasizing that active learning methods that foster exploratory curiosity make students more motivated and creative in learning. Further This factor describes a person's tendency to think deeply and reflectively in the face of problems, especially in the context of mathematics learning. Curiosity encourages exploration and active attention to new stimuli, which are the basis for further learning and knowledge development (Bazhydai & Westermann, 2020). This reflective thinking process is the basis for creativity because children not only receive information passively but also develop new ideas and creative solutions to the problems at hand. In other words, curiosity, when driven by active exploration and thoughtful reflection, enhances one's capacity for critical and creative thinking.

The second factor is named the Curiosity Challenge Routine. When students encounter routine or repetitive problems, the Curiosity Routine Challenge helps them resist giving up easily and continue to seek effective solutions. Enjoyment and motivation are aspects of curiosity and intrinsic

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interest in mathematics that indirectly contribute to increased perseverance and resilience in learning (Mazana et al., 2018). Too repetitive routines can cause boredom and reduce students' curiosity, thereby decreasing their motivation to learn and explore new things (Liu et al., 2024). Next, Analytical Pattern Curiosity is the curiosity that drives a person to recognise patterns, relationships, and logical structures within the information or data encountered. This curiosity is significant in learning, especially in the fields of mathematics and science, because it helps students develop critical and analytical thinking skills systematically. Developing curiosity in the context of mathematics learning through active learning strategies (Vale & Barbosa, 2023).

Active Exploration Curiosity plays a role in encouraging students to actively seek new information and try various approaches to solving problems. emphasizing that active learning methods that foster exploratory curiosity make students more motivated and creative in learning (Liu et al., 2024).

Overall, these four curiosity factors form a dynamic learning cycle: students think reflectively to understand problems, actively explore solutions, persist in the face of routine challenges, and use analytical skills to recognize patterns and draw logical conclusions.

The findings of this study carry significant implications for the field of education, especially in mathematics learning. With the discovery of the four factors of mathematical curiosity through exploratory factor analysis, educators now have a stronger foundation for identifying and understanding the affective aspects of students that influence the mathematics learning process. The instruments developed can be used to assist teachers and lecturers in developing learning strategies that encourage exploration, critical thinking, and students' perseverance in facing mathematical challenges. In addition, the results of this study serve as a reference for the development of a more comprehensive curriculum and assessment, involving the curiosity aspect as one of the important indicators of mathematics learning success.

CONCLUSIONS AND SUGGESTIONS

From the research findings and discussion, students' mathematical curiosity can be validly measured through four main factors identified using exploratory factor analysis, namely reflective thinking curiosity, routine challenge curiosity, analytical pattern curiosity, and active exploration curiosity. These four factors represent a crucial dimension in an effective mathematics learning process. Therefore, further research is recommended to involve more diverse populations and different educational levels so that the structure of the identified factors can be further tested and strengthened. The use of confirmatory analysis (CFA) is also important to retest the reliability of the derived factor structure. In the long term, curiosity can be integrated into mathematics learning assessment and become an important indicator in the comprehensive evaluation of learning success.

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