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Developing a Mathematical Curiosity Scale for Adolescents: Validity and Reliability Study

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Abstract

Curiosity offers opportunities for personal growth by instilling a desire to learn, explore, and investigate. Therefore, it is considered essential to encourage curiosity, especially in children and adolescents, for their future lives. Similarly, mathematical curiosity leads the individual to develop in mathematics by directing their desire to learn about mathematics toward discovery. In this context, the study aims to create a scale that provides accurate and reliable measurements that is a valid and reliable Likert-type scale of mathematical curiosity of secondary and high school students. 499 students participated in the exploratory factor analysis, 294 in the confirmatory factor analysis, and 91 in the test-retest analysis. As a result of the exploratory factor analysis, the scale structure with 3 factors and 20 items explains 57.95% of the total variance. The construct validity of the scale was examined through confirmatory factor analysis. The Cronbach alpha reliability coefficient of the scale was found to be 0.903. The reliability coefficients of the sub-dimensions of the scale are .838, .842, and .690, respectively.

Key Words

Curiosity • Mathematical curiosity • Scale development

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Introduction

There is a strong relationship between emotions and learning, therefore, affective characteristics should be taken into account in the learning process (Gömleksiz & Kan, 2012). Concepts such as student interest, attitude, love, fear, anxiety, bias, curiosity, motivation, excitement, self-efficacy perception, and self-confidence towards the course are affective characteristics (Etlioğlu & Tekin, 2020). Hence, the inclusion of affective characteristics in teaching programs is crucial for affective learning (Bacanlı, 2006). In particular, curiosity has been recognized as a critical motivation that constantly affects human behavior both positively and negatively throughout the life cycle (Loewenstein, 1994). It is known that at the core of curiosity are the concepts of recognizing, searching, and preferring the new (Kashdan & Silvia, 2009). However, curiosity needs to be nurtured. To do so, it is necessary to focus on student motivation, turn the lack of knowledge from a shameful concept to a form of curiosity about learning, and direct the student's curiosity cognitively to raise their intellectual level (Watson, Inan, Whitcomb, & Yigit, 2018).

A teacher who knows what it feels like to have a desire to learn is better equipped to nurture this desire in their students (Engel, 2015, p.1). In education, while a teacher's goal for their students may be for them to engage in certain behaviors or master specific skills, focusing not on the behaviors or skills themselves, but on students' underlying motivation, inspiring their curiosity, and working to nourish it, is one of the most effective ways to achieve that aim (Baehr, 2015). For instance, cognitive ability is required to solve arithmetic problems. However, what we truly desire is for the student to have a desire to understand why the answers are correct. In other words, students are expected to not just be knowledgeable about the answers to the questions, but also to ask questions at an intellectual level (Pritchard, 2015). Therefore, determining students' mathematical curiosity, especially, is deemed significant in guiding students. In the literature, different scales for mathematical curiosity (Usluoğlu & Toptaş, 2021), knowledge-based curiosity (Eren, 2009), scientific curiosity (Cındıl-Kopan, 2020), physics curiosity (Serin, 2010), and curiousness (Demirel & Coşkun, 2009) for different age groups are observed. However, it is striking that there is no scale to determine the level of mathematical curiosity of students receiving education at the secondary and high school levels. Therefore, a valid and reliable mathematical curiosity scale was aimed to be developed for secondary and high school students in this study. The development of this scale will not only meet this need in the field but will also serve as a resource for teachers and researchers in determining the curiosity of secondary and high school students towards mathematics and in allocating, directing and guiding students into fields.

Method

Research Model

This study aimed to develop a mathematical curiosity scale for students aged 14-16, and a survey model was used for this purpose. Survey models are models in which the opinions of large groups and various communities are taken, and their characteristics and attitudes are determined (Büyüköztürk et al., 2016).

Study Groups

The research was conducted with data collected from three different study groups.

Study Group 1

For the exploratory factor analysis, attention was paid to having a number of participants ten times the number of items in the scale (Bryman and Cramer, 2001). For the exploratory factor analysis (EFA), data were collected from 499 students studying in the 8th grade of secondary school, 9th and 10th grades of high school in public schools affiliated with the Istanbul National Education Directorate in the 2021-2022 academic year. (EFA) (Table 1)

Table 1

Demographic Characteristics of the EFA Study Group

	Groups	**F**	**%**
Gender	Female	249	49.8
	Male	250	50.2
Grade	8-th grade	140	28.1
	9-th grade	169	33.9
	10-th grade	190	38.1

As seen in Table 1, 249 (49.8%) of the participants in the study were female students, while 250 (50.2%) were male students. When examining the students' grade levels, 140 (28.1%) were 8th grade, 169 (33.9%) were 9th grade, and 190 (38.1%) were 10th grade students.

Study Group 2

For the confirmatory factor analysis (CFA), data were collected from 294 students in the 8th grade of secondary school and 9th and 10th grades of high school from public schools affiliated with Istanbul Provincial Directorate of National Education during the 2021-2022 academic year (Table 2).

Table 2

Demographic Characteristics of the Study Group Applied Confirmatory Factor Analysis

	Groups	**f**	**%**
Gender	Female	120	40.8
	Male	174	59.2
Grades	8-th grade	20	6.8
	9-th grade	142	48.3
	10-th grade	132	44.9

As seen in Table 2, 195 (%40.8) of the participants in the study were female students and 174 (%59.2) were male students. When looking at the grade levels, 20 (%6.8) were 8-th grade students, 142 (%48.3) were 9-th grade students, and 132 (%44.9) were 10-th grade students.

Study Group 3

For the test-retest application, data was collected from 91 students in 8-th grade of secondary school, and 9-th and 10-th grade of high school from public schools affiliated with the Istanbul Provincial Directorate of National Education during the 2021-2022 academic year (Table 3).

Table 3

Test-Retest Analysis Demographic Characteristics of the Study Group

	Groups	f	%
Gender	Female	47	51.6
	Male	44	48.4
Grade	8-th grade	45	49.5
	9-th grade	32	35.2
	10-th grade	14	15.4

As seen in Table 3, 47 (51.6%) of the participants were female students and 44 (48.4%) were male students. In terms of grade levels, 45 (49.5%) were 8-th grade students, 32 (35.2%) were 9-th grade students and 14 (15.4%) were 10-th grade students.

Data Collection Tools

Mathematical Curiosity Scale

The development of the scale started with a literature review. In the process of developing the scale, international studies related to the curiosity were examined and an item pool was created (Cındıl-Kopan, 2020; Collins, Litman & Spielberger, 2004; Demirel & Coşkun, 2009; Kashdan, Gallagher, Silvia, Winterstein, Breen, Terhar & Steger, 2009; Kashdan, Stiksma, Disabato, McKnight, Bekier, Kaji & Lazarus, 2018; Leherissey, 1971; Litman & Jimerson, 2004; Litman & Spielberger, 2003; Renner, 2006; Naylor, 1981; Serin, 2010; Usluoğlu & Toptaş, 2021). Simultaneously, the opinions of 10 mathematics teachers working at secondary and high school levels in Istanbul were received and these opinions were added during the creation of the item pool. The scale, which initially consisted of 131 items, was reduced to 32 items by removing the items that had the same meaning or were not related by taking the opinions of experts in mathematics education, especially in the affective domain (2), measurement and evaluation (1) and Turkish teacher (1). The 32-item scale's factor structure was first determined by exploratory factor analysis, and the model obtained in exploratory factor analysis was tested by confirmatory factor analysis.

The scale type was determined as a 5-point Likert scale: (1) Strongly Disagree, (2) Disagree, (3) Neither Agree nor Disagree, (4) Agree, (5) Strongly Agree. Likert scales enable individuals to indicate to what extent they agree with a given situation (Seçer, 2015). There are 14 positive and 6 negative items in the scale, with the negative items calculated by reverse coding.

Data Analysis

To determine whether the data were suitable for factor analysis, a normality test, Kaiser-Meyer-Olkin (KMO), and Bartlett's test of Sphericity were conducted. EFA is used to determine how many items in a draft measurement tool should be grouped and what the relationship between them is (Sönmez & Alacapınar, 2014). It was found that the data were suitable for factor analysis and a three-factor structure consisting of 20 items was revealed.

During the factor analysis, care was taken not to maintain the scale's content validity. After the exploratory factor analysis, the items were re-evaluated. Content validity refers to the ability of the items that make up a measurement tool to adequately represent the qualities the scale intends to measure (Seçer, 2015).

Subsequently, the correlation between item-total scores was calculated. Confirmatory factor analysis (CFA) was applied to test the structure that emerged. In order to conclude that the model was validated, fit values were taken into consideration. A ratio of the chi-square value (χ^2) to the degrees of freedom (df) of 2 or less indicates an ideal fit, while a ratio between 2 and 5 indicates an acceptable fit. A CFI (Comparative Fit Index) value of 1 indicates ideal fit, while a value between 0.90 and 0.99 is considered acceptable. An RMSEA (Root mean square error of approximation) value between 0.05 and 0.09 is considered an acceptable fit, while an SRMR (Root mean square residuals) value of 0 is considered ideal fit and a value between 1 and 5 is considered acceptable (Özdamar, 2016).

In the reliability analysis of the scale, Cronbach's alpha reliability coefficient and item-total correlation values were calculated, and the independent samples t-test (with a 27% upper-lower independent group) was applied to determine whether the items distinguish between upper and lower groups. To provide evidence of the scale's reliability in terms of stability, correlation coefficients of data obtained from test-retest were calculated.

Results

Validity-Related Findings

EFA and CFA were conducted to reveal the findings regarding the scale's validity. In this process, IBM SPSS 25 and AMOS 25 programs were used to analyze the data.

EFA is a technique used to determine the sub-factors of the items in the measurement tool and to identify the relationships between the items (Sönmez & Alacapınar, 2016, p.63). The Kaiser-Meyer-Olkin (KMO) test was used to determine the suitability of the data for factor analysis and the adequacy of the sample size. Bartlett's Sphericity Test was used to determine whether there was sufficient correlation between variables (Özdamar, 2016). The results obtained are presented in Table 4 below.

Table 4

KMO and Bartlett's Test of Sphericity Results of MCS

KMO and Bartlett's Test	Coefficiants	Values	Acceptable	Fine fit
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.953	$0.50 \leq KMO \leq 0.90$	$0.90 \leq KMO$
Bartlett's Test of Sphericity	χ^2 2/df	6811.944/496	$2 \leq \chi^2/\text{df} \leq 5$	$\chi^2/\text{df} \leq 2$
	Sig.	.000		

As seen in Table 4, the KMO value of the Mathematical Curiosity Scale (MCS) is above 0.50, and the Bartlett's test is also significant at the 0.05 level, indicating that the data is suitable for factor analysis. Özdamar (2016, p.150) emphasized that KMO values should be greater than 0.50, and as the value approaches 1, the scale will be highly competent in measuring the phenomenon. [(KMO=0.953), Bartlett's test (496) = 6811.944 p=.000)]. After determining that the data is suitable for factor analysis, a principal component analysis was conducted. The factors with eigenvalues above 1 in the first principal component analysis and the eigenvalues and ratios of the variance they explain are given in Table 5.

Table 5

Eigenvalues and Percentages of Variance Explained by Factors in Principal Component Analysis

Factors	**Eigenvalue**	**Variance**	**Cumulative Variance**
1	11.287	35.271	35.271
2	2.079	6.496	41.767
3	1.578	4.930	46.697
4	1.119	3.496	50.193
5	1.078	3.369	53.561

As seen in Table 5, there are 5 factors with an eigenvalue greater than 1. In addition, the distribution of the scale's factor structure was examined using the Scree Plot given in Figure 1.

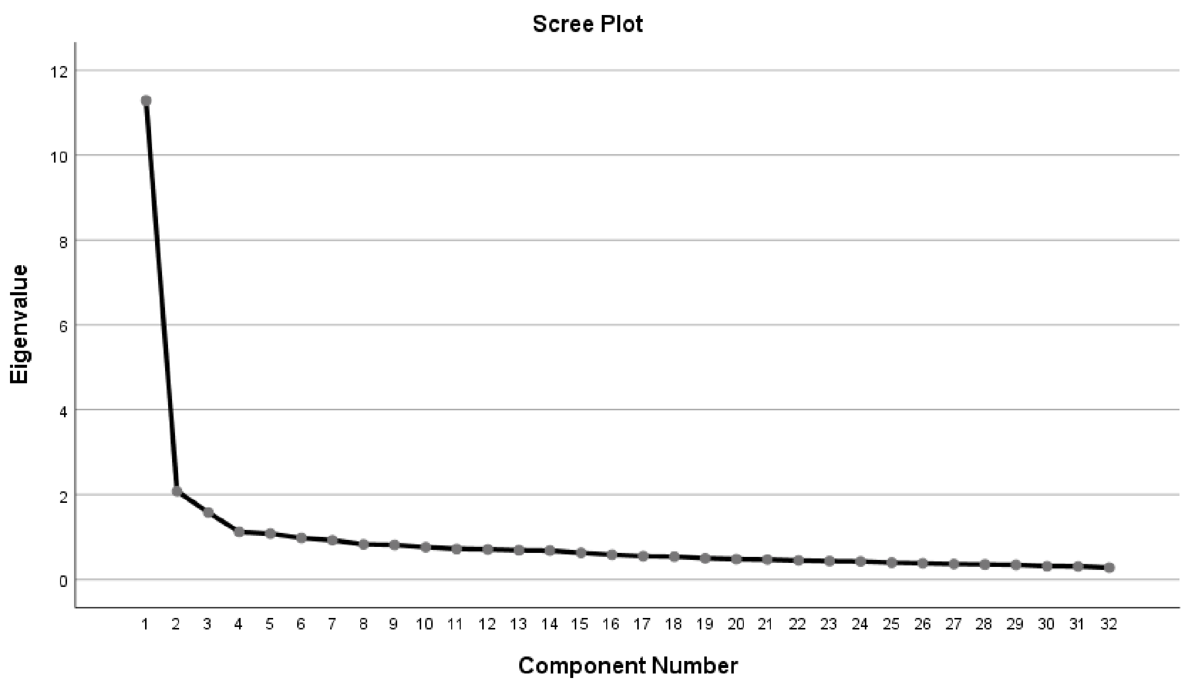

Figure 1. Scree plot

As seen in Figure 1, it can be said that the items are distributed into 3 factors.

In the principal component analysis, the item loading estimation point was accepted as .40 and above, items with multiple loading on different factors were removed one by one, and the analysis was repeated after each item removal. Table 6 presents the factors with eigenvalue greater than 1 and their corresponding variance ratios.

Table 6

Variance Ratios and Eigenvalues Explained by the Subfactors of the MCS

Factors	Eigenvalue	Variance	Cumulative Variance
1	7.339	43.171	43.171
2	1.444	8.495	51.667
3	1.068	6.284	57.951

As seen in Table 6, there are three factors with eigenvalues above 1. The eigenvalue for the first factor is 7.339, accounting for 43.171% of the variance; the eigenvalue for the second factor is 1.444, accounting for 8.495% of the variance; and the eigenvalue for the third factor is 1.068, accounting for 6.284% of the variance. The sub-factors of MCS account for a total of 57.951% of the variance. In addition, following the principal component analysis, the scale's factor structure was examined using the Scree Plot in Figure 2.

The variance eigenvalue explained by the first factor is 7.339 and the variance ratio is 43.171%; the variance eigenvalue explained by the second factor is 1.444 and the variance ratio is 8.495%; the variance eigenvalue explained by the third factor is 1.068 and the variance ratio is 6.284%. The sub-factors of MCS explain 57.951% of the total variance. In addition, the Scree Plot given in Figure 2 was examined for the scale's factor structure after the principal component analysis.

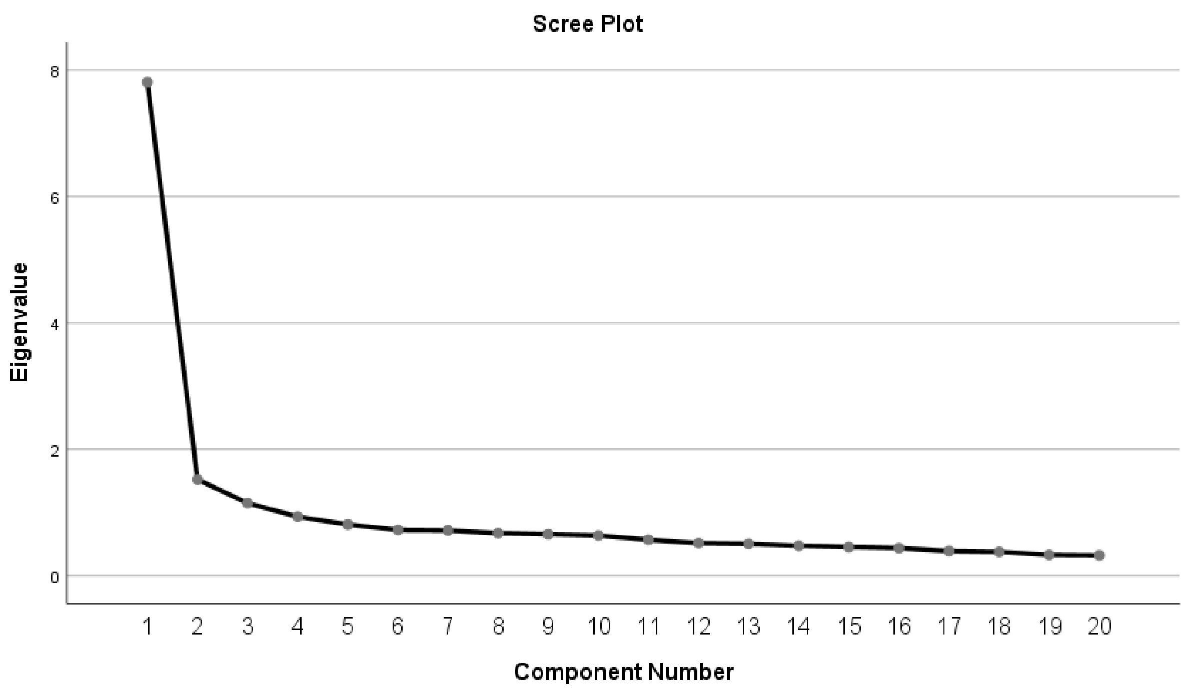

Figure 2. Scree plot

Twelve items with factor loadings below 0.40, with loadings on two or more factors, and with differences between factors less than 0.10 were removed (1, 12, 13, 16, 19, 22, 23, 25, 26, 28, 29, 31). As a result of this process, a scale consisting of 20 items was obtained. The factor loadings, variance ratios explained by the factors, and item numbers of the scale are presented in Table 7.

Table 7

Exploratory Factor Analysis Results

	Factor Loading Values		
Item No	**Will to learn mathematics (WLM)**	**Value-oriented mathematics curiosity (VOMC)**	**Applied mathematics curiosity (AMC)**
I7	0.715		
I5	0.698		
I3	0.651		
I11	0.642		
I17	0.634		
I21	0.623		
I15	0.526		
I9	0.509		
I20	0.452		
I4		0.763	
I2		0.728	
I6		0.701	
I8		0.693	
I18		0.650	
I10		0.618	
I32			0.699
I27			0.698
I24			0.627
I30			0.591
I26			0.485

When Table 7 is examined, it is seen that the items that make up the scale are grouped under 3 factors with eigenvalues greater than 1. The items belonging to the sub-dimensions were analyzed and the sub-dimensions were named. The "Will to learn mathematics" factor consists of 9 items (1, 2, 3, 4, 5, 6, 7, 8 and 9), "Value-oriented mathematics curiosity" factor consists of 6 items (10, 11, 12, 13, 14 and 15) and "Applied mathematics curiosity" factor consists of 5 items (16, 17, 18, 19 and 20). All items in the value-oriented mathematics curiosity factor were negative and reverse-coded.

The item-total correlation values and inter-factor correlation values of the MCS were calculated and presented in Table 8.

Table 8

Item-Total Correlation Values and Interfactor Correlation Values of the MCS

	Total	**WLM**	**VOMC**	**AMC**
I2	.611**	.486**	.739**	.335**
I3	.690**	.725**	.534**	.471**
I4	.636**	.465**	.773**	.412**
I5	.584**	.665**	.377**	.405**
I6	.712**	.579**	.809**	.434**
I7	.680**	.755**	.494**	.435**
I8	.672**	.563**	.787**	.354**
I9	.656**	.671**	.503**	.482**
I10	.561**	.415**	.662**	.382**
I11	.674**	.728**	.505**	.445**
I15	.557**	.619**	.368**	.402**
I17	.659**	.718**	.448**	.484**
I18	.617**	.481**	.739**	.363**
I20	.548**	.602**	.357**	.415**
I21	.761**	.781**	.583**	.555**
I24	.535**	.451**	.304**	.692**
I26	.630**	.534**	.431**	.716**
I27	.560**	.451**	.343**	.731**
I30	.614**	.508**	.406**	.740**
I32	.453**	.338**	.279**	.633**
WLM		1		
VOMC		.666**	1	
AMC		.652**	.504**	1
Total		.927**	.846**	.797**

N=499; **p<.01

As seen in Table 8, item-total correlation values ranged between 0.453 and 0.761. In addition, the correlation values between the factors ranged from .504 to .666, and the correlations between the scale total score and the factors ranged from .797 to .927 and were positively significant ($p<.01$). This finding was interpreted as a positive and significant relationship between the scale total score of the items and factors that make up the MCS. It can be said that the items and sub-dimensions as a whole measure MCS.

The structure consisting of 3 factors and 20 items in the exploratory factor analysis was confirmed by confirmatory factor analysis. CFA is an indispensable tool for the scale's construct validity (Brown, 2015, p.2). As a result of the confirmatory factor analysis, Figure 3 below has emerged.

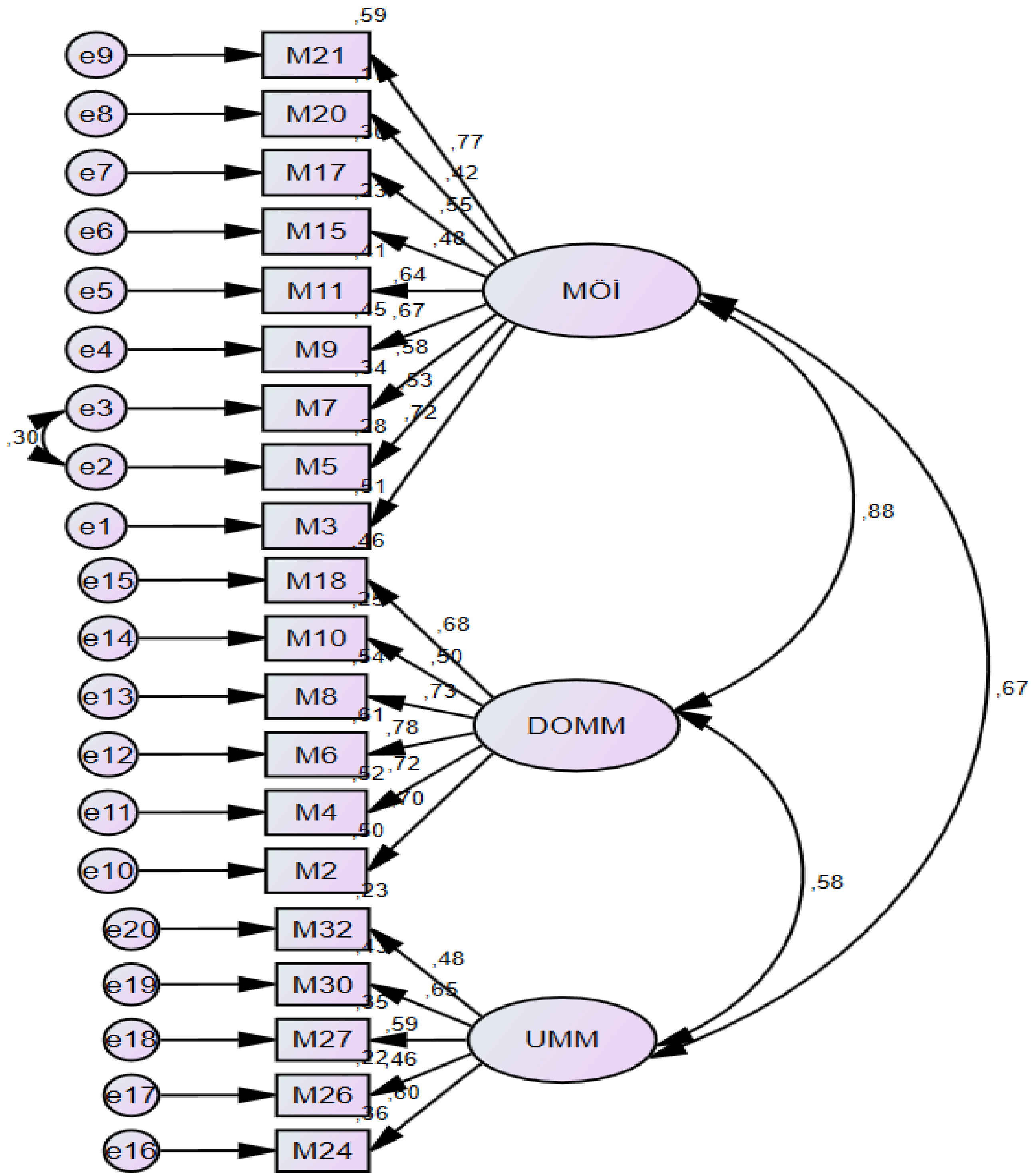

Figure 3. Confirmatory factor analysis

The fit indices of the CFA analysis are presented in Table 9.

Table 9

CFA Fit Indices

Fit Indices	Model values	Acceptable	Fine fit	Evaluation
x2/df	2.060	$3<\chi^2/df \leq 5$	$0\leq\chi^2/df \leq 3$	Fine
SRMR	.059	05<SRMR≤.08	0≤ SRMR≤.05	Acceptable
GFI	.889	90≤ GFI<95	95≤GFI≤1.0	Acceptable
IFI	.915	90≤ IFI<95	95≤IFI≤1.0	Acceptable
CFI	.914	90≤CFI<95	95≤CFI≤1.0	Acceptable
RMSEA	.060	.05≤RMSEA<.080	.0≤RMSEA<.080	Acceptable

χ^2=341.979; df=166; p=.000

Reference: Byrne, Shavelson & Muthen (1989), Jöreskog (2004), Kline (2011) & Sümer (2000)

According to Table 9, CFA fit indices confirm the 20-item and 3-factor structure obtained in EFA.

As a result of the studies and analyzes conducted for the validity of the scale, it can be concluded that the scale is a valid scale. In other words, it can be said that the scale is a scale that measures the mathematical curiosity of secondary and high school students.

Findings Related to Reliability

Firstly, Cronbach's Alpha values were calculated for the reliability of the MCS and given in Table 10.

Table 10

MCS Reliability Coefficients

	Cronbach	McDonald's	Spearman-Brown	Guttman	Item Numbers
WLM	.868	.869	.805	.783	9
VOMC	.846	.848	.833	.833	6
AMC	.744	.746	.718	.691	5
MCS Total	.918	.919	.878	.875	20

N=499

According to Table 10, after EFA, the reliability value of the will to learn mathematics (WMI) sub-dimension was .868, the reliability value of the value-oriented mathematics curiosity sub-dimension (VOMC) was .846, the reliability value of the applied mathematics curiosity sub-dimension (AMC) was .744, and the overall reliability value of the scale was calculated as .918. In addition, after CFA, the reliability value of the will to learn mathematics (WMI) sub-dimension was .838, the reliability value of the value-oriented mathematics curiosity sub-dimension (VOMC) was .842, the reliability value of the applied mathematics curiosity sub-dimension (AMC) was .690, and the overall reliability value of the scale was calculated as .903.

The findings of the independent samples t-test conducted to determine whether the scale items differentiated the lower and upper groups from each other are given in Table 11.

Table 11

Independent Groups t-Test

	Groups	N	M	Std.	t	df	p
I2	Lower group	135	2.34	1.160	-13.123	268	.000
	Upper group	135	4.07	1.005			
I3	Lower group	135	1.61	.947	-18.336	268	.000
	Upper group	135	3.82	1.036			
I4	Lower group	135	2.33	1.233	-14.199	268	.000
	Upper group	135	4.19	.902			
I5	Lower group	135	1.64	.988	-15.855	268	.000
	Upper group	135	3.64	1.082			
I6	Lower group	135	1.90	1.239	-20.184	268	.000
	Upper group	135	4.44	.769			
I7	Lower group	135	1.78	.975	-19.374	268	.000
	Upper group	135	4.06	.960			
I8	Lower group	135	1.81	1.169	-18.222	268	.000
	Upper group	135	4.21	.995			
I9	Lower group	135	1.69	.833	-17.818	268	.000
	Upper group	135	3.68	.997			
I10	Lower group	135	2.67	1.227	-11.596	268	.000
	Upper group	135	4.23	.962			
I11	Lower group	135	2.47	1.251	-15.166	268	.000
	Upper group	135	4.36	.739			
I15	Lower group	135	2.82	1.349	-11.446	268	.000
	Upper group	135	4.36	.777			
I17	Lower group	135	2.19	1.147	-15.588	268	.000
	Upper group	135	4.14	.899			
I18	Lower group	135	1.99	1.255	-15.260	268	.000
	Upper group	135	4.19	1.110			
I20	Lower group	135	3.04	1.307	-11.308	268	.000
	Upper group	135	4.52	.781			
I21	Lower group	135	1.75	.879	-22.485	268	.000
	Upper group	135	4.13	.859			
I24	Lower group	135	1.70	1.073	-11.884	268	.000
	Upper group	135	3.33	1.178			
I26	Lower group	135	2.04	1.239	-15.277	268	.000
	Upper group	135	4.16	1.021			
I27	Lower group	135	2.56	1.358	-11.099	268	.000
	Upper group	135	4.18	1.006			
I30	Lower group	135	2.06	1.202	-15.083	268	.000
	Upper group	135	4.07	.982			
I32	Lower group	135	2.90	1.506	-9.521	268	.000
	Upper group	135	4.34	.899			
WLM	Lower group	135	18.97	5.324	-30.567	268	.000
	Upper group	135	36.711	4.133			
VOMC	Lower group	135	13.044	4.729	-24.093	268	.000

	Upper group	135	25.34	3.576			
AMC	Lower group	135	11.2741	3.946	-20.892	268	.000
	Upper group	135	20.081	2.901			
Total	Lower group	135	43.296	9.937	-37.986	268	.000
	Upper group	135	82.133	6.509			

When Table 11 is analyzed, it is seen that the scale items, sub-factors and the total score of the scale significantly differentiate the lower and upper groups (p<.01). In other words, the scale items, sub-factors and the total score of the scale differentiate the lower and upper groups.

Table 12

MCS Test-Retest Correlation Coefficients

Dimension	**Group**	**N**	**r**	***p***
WLM	First application	91	.845	.000
	Last application	91		
VOMC	First application	91	.793	.000
	Last application	91		
AMC	First application	91	.844	.000
	Last application	91		
MCS Total	First application	91	.882	.000
	Last application	91		

*p<.01

As seen in Table 12, the correlation values between the scale sub-dimensions ranged between r=.793 and =.882 as a result of the MCS test-retest application.

Discussion, Conclusion & Suggestions

Curiosity leads individuals to seek new challenges, ask questions and solve problems (Hardy, Ness, & Mecca, 2017). People who are curious about mathematics often enjoy mathematical puzzles, abstract thinking, and solving complex problems (Peterson & Cohen, 2019). Mathematical curiosity is a fundamental quality for mathematicians as it helps individuals make connections between different mathematical concepts and find new solutions to problems (Kartika, Pujiastuti, & Soedjoko, 2019). In addition, a love of mathematics can inspire individuals to pursue careers in science, engineering, finance, and technology, where mathematical knowledge and skills are highly valued (Cass, Hazari, Cribbs, Sadler, & Sonnert, 2011; Wang & Degol, 2017). To nurture and develop mathematical curiosity, engaging in activities that challenge and stimulate the mind is vital. This can include solving mathematical puzzles and problems, reading books on mathematical topics, attending lectures and workshops, and participating in mathematical competitions (Rumack & Huinker, 2019). In addition, exploring the history of mathematics and learning about the people and ideas that have shaped the field can also help develop curiosity about the subject (Bell, 2012). Determining individuals' curiosity towards mathematics is essential for changing and improving their attitudes toward mathematics. When the literature in Turkey is examined, it is seen that different data collection tools have been developed for the concept of curiosity (Cındıl-Kopan, 2020; Demirel & Coşkun, 2009; Eren, 2009; Serin, 201;

Usluoğlu & Toptaş, 2021). However, it was determined that there was no measurement tool to determine the mathematics curiosity of secondary and high school students.

KMO (.953) and Bartlett's Test of Sphericity (x2=6811.944, $p<.01$) values were examined to determine whether the data obtained from the draft form were suitable for factor analysis. According to Tabachnick and Fidell (2007), in order to conduct factor analysis, the KMO value should be at least 0.60 and above and Bartlett's test should be significant. According to the values obtained, it was determined that the data were suitable for factor analysis. While determining the factor structure of the scale with Exploratory Factor Analysis, the factor loading value was taken as the lower limit of 0.40, and 12 items with item loadings below 0.40 and overlapping items were removed. In determining the factors, the condition of having an eigenvalue greater than 1 was sought (Özçifçi, 2020). Thus, the scale was finalized with 3 factors with eigenvalues greater than 1 and 20 items. The scale explains 57.951% of the total variance. In social sciences, a total explained variance above 40% is considered sufficient (Özdamar, 2016). It was determined that there was a positive and significant relationship between the factors that make up MCS and factor-total scale scores. CFA was conducted to test the construct validity of the 3-factor MCS scale (χ^2/sd= 2.060; SRMR==.059; GFI= .889; IFI=.915; CFI=.914; RMSEA= .060) and it was seen that the structure of the scale met the criteria recommended in the literature (Byrne, Shavelson, & Muthen, 1989; Jöreskog, 2004; Kline, 2011; Sümer, 2000). Scale item-total correlation values were calculated and found to show a significant relationship ($p<.05$). This analysis provides an idea about the relationship between the items of the scale and the trait to be measured (DeVellis, 2014). This finding shows that the items and sub-dimensions as a whole measure mathematics curiosity.

Cronbach's alpha reliability coefficients were calculated to determine the reliability of the scale and it was found that the overall reliability coefficient of the scale was 0.903. It was determined that the internal consistency of the items in the scale was high (Tezbaşaran, 2008). Independent groups t-test was calculated to provide evidence for the discriminative feature of the items (Büyüköztürk, Akgün, Kahveci, & Demirel, 2004), and it was concluded that the scale items were able to distinguish the affect of mathematical curiosity of the lower and upper groups from each other. For reliability, test-retesting is recommended to show the consistency of the measurement tool, that is, its invariance over time and the external consistency of the measurements (Gözüm & Aksayan, 1999; Karadağlı & Ecevit-Alpar, 2017). In the test-retest correlation analysis, it was found that the correlation coefficients were significant and high ($r= .882$, $p=.00$). According to these results, the reliability of the scale was found to be at a high level. As a result of the validity and reliability studies and analyses, the factors and item distributions of the (MCS) are given below:

Will to Learn Mathematics: 1, 2, 3, 4, 5, 6, 7, 8, 9

Value Oriented Mathematical Curiosity: 10, 11, 12, 13, 14, 15

Applied Mathematics Curiosity: 16, 17, 18, 19, 20

The scale aims to measure the mathematical curiosity of students between the ages of 14-16. In future studies, calculating and presenting values for the validity and reliability of the scale may increase the validity and reliability of the scale. Since there is no Turkish mathematical curiosity scale developed on a similar sample group in the literature, an analysis of criterion validity could not be conducted. It is predicted that reporting the relationships between the MCS and other variables in future studies will provide evidence of criterion validity. The scale can be used to assess individual differences in students' mathematics curiosity, to understand how mathematical curiosity levels contribute to academic achievement, and to see the effect of educational interventions designed to nurture mathematics curiosity in students.

Ethic

This study was ethical approved by Istanbul Sabahatttin Zaim University Graduate Education Institute (Date:06/04/2022, Approval Number: E-20292139-050.01.04-25492 and Istanbul Governorship, Istanbul Provincial Directorate of National Education (date:21/04/2022, Approval Number: 48270374)

Author Contributions

First author: Literature rewiev, process of creating scale items, results and conclusions

Second author: Methodology, data analysis and results.

Third author: Data collection process.

Fourth author: Literature rewiev and process of creating scale items.

Conflict of Interest

The authors declare that they have no conflict of interest.

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References

Bell, E. T. (2012). *The development of mathematics*. Courier Corporation. Retrieved from: http://www.math.chalmers.se/~ulfp/Review/devmath.pdf

Büyüköztürk, Ş., Akgün, Ö. E., Kahveci, Ö., & Demirel, F. (2004). Güdülenme ve öğrenme stratejileri ölçeğinin Türkçe formunun geçerlik ve güvenirlik çalışması [The validity and reliability study of the Turkish version of the motivated strategies for learning questionnaire]. *Kuram ve Uygulamada Eğitim Bilimleri*, *4*(2), 207-239. Retrieved from https://www.researchgate.net/profile/Oezcan-Akguen/publication/279175043_Gudulenme_ve_Ogrenme_Stratejileri_Olceginin_Turkce_Formunun_Gecerlik_ve_Guvenirlik_Calismasi/links/5c248bea458515a4c7fb2fae/Gueduelenme-ve-Oegrenme-Stratejileri-Oelceginin-Tuerkce-Formunun-Gecerlik-ve-Guevenirlik-Calismasi.pdf

Byrne, B. M., Shavelson, R. J.,& Muthen, B. (1989). Testing for the equivalence of factor covariance and mean structures: The issue of partial measurement in variance. *Psychological Bulletin, 105,* 456-466. Retrieved from: http://www.statmodel.com/bmuthen/articles/Article_027.pdf

Cass, C. A., Hazari, Z., Cribbs, J., Sadler, P. M., & Sonnert, G. (2011, October). Examining the impact of mathematics identity on the choice of engineering careers for male and female students. In *2011 Frontiers in Education Conference (FIE)* (pp. F2H-1). IEEE. Retrieved from: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6142881&casa_token=BNy-XD_7aBQAAAAA:D2l9T1VBTJrLugBpq-V5hXK8Oz1VlMFXeDMj-s6PspQbsT1eLWAQvSCyKB-SV_ep8e8R9HEKCElpbw&tag=1

Cındıl-Kopan, T. (2020). *Ortaokul öğrencilerinin bilimsel merak düzeylerinin çeşitli değişkenler açısından incelenmesi [Investigation of scientific curiosity levels of secondary school students in terms of various variables]* [Yüksek Lisans Tezi]. Trabzon Üniversitesi, Trabzon. https://tez.yok.gov.tr/UlusalTezMerkezi/

Collins, R. P., Litman, J. A., & Spielberger, C. D. (2004). The measurement of perceptual curiosity. *Personality and Individual Differences*, *36*(5), 1127-1141. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0191886903002058?casa_token=EK8JH_dwtLUAAAAA:W4N7fBx-G7XY4AvL4OYOdmxZ7cYWW4MbezP_2kyvWy6d7HysvS31je7ShQoPu1gBMxv9QWzIYhGD

Demirel, M., & Coşkun, Y. D. (2009). Üniversite öğrencilerinin meraklılık düzeylerinin bazı değişkenler açısından incelenmesi [Investigation of curiosity levels of university students in terms of some variables]. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, (18), 111-134. Retrieved from: https://dergipark.org.tr/en/download/article-file/181284

DeVellis, R. F. (2014). *Ölçek geliştirme: kuram ve uygulamalar* **[***Scale development: theory and applications]* **(**A.Bakioğlu, N. Dilek & T. Totan, Çev. Ed.). Nobel.

Engel, S. (2015). *The hungry mind: The origins of curiosity in childhood*. Harvard University Press. Retrieved from: https://books.google.com/books/about/The_Hungry_Mind.html?id=nmDFBgAAQBAJ

Eren, A. (2009). Examining the relationship between epistemic curiosity and achievement goals. *Eurasian Journal of Educational Research*. *36*, 129-144. Retrieved from: http://acikerisim.ibu.edu.tr/xmlui/bitstream/handle/20.500.12491/1601/altay-eren.pdf?sequence=1

Gözüm, S., & Aksayan, S. (1999). Öz-etkililik-yeterlik ölçeği'nin türkçe formunun güvenilirlik ve geçerliliği [The reliability and validity of Turkish form of the self-efficacy scale]. *Anadolu Hemşirelik ve Sağlık Bilimleri Dergisi*, *2*(1), 21-34. Retrieved from: https://dergipark.org.tr/en/download/article-file/29103

Hardy III, J. H., Ness, A. M., & Mecca, J. (2017). Outside the box: Epistemic curiosity as a predictor of creative problem solving and creative performance. *Personality and Individual Differences*, *104*, 230-237. http://dx.doi.org/10.1016/j.paid.2016.08.004 0191-8869

Jöreskog, K. G. (2004). *On chi-squares for the ındependence model and fit measures in Lisrel.* Retrieved from http://www.ssicentral.com/lisrel/techdocs/ftb.pdf

Karadağlı, F., & Ecevit-Alpar, Ş. (2017). Bir ölçek geliştirme çalışması: Kemoterapi uygulanan hastalarda özbakım yetersizliği kuramına gore özbakım davranışları ölçeği [A Scale development study: scale of self-care behaviors according to the theory of self-care deficiency in patients who were administered chemotherapy]. *Mersin Üniversitesi Sağlık Bilimleri Dergisi*, *10*(3), 168-181. Retrieved from: https://dergipark.org.tr/en/download/article-file/384535

Kartika, Y. K., Pujiastuti, E., & Soedjoko, E. (2019). The effectiveness of project based learning with creative mind-map tasks for improving mathematical connection ability and student curiosity. *Unnes Journal of Mathematics Education*, *8*(2), 145-151. https://doi.org/10.15294/ujme.v8i2.31937

Kashdan, T. B., & Silvia, P. J. (2009). Curiosity and interest: The benefits of thriving on novelty and challenge. In S. J. Lopez & C. R. Snyder (Eds.), *Oxford handbook of positive psychology* (pp. 367–374). Oxford University Press. Retrieved from: https://www.researchgate.net/profile/Todd-Kashdan/publication/232709031_Curiosity_and_Interest_The_Benefits_of_Thriving_on_Novelty_and_Challenge/links/09e41508d50c5af6d3000000/Curiosity-and-Interest-The-Benefits-of-Thriving-on-Novelty-and-Challenge.pdf

Kashdan, T. B., Stiksma, M. C., Disabato, D. J., McKnight, P. E., Bekier, J., Kaji, J., & Lazarus, R. (2018). The five-dimensional curiosity scale: Capturing the bandwidth of curiosity and identifying four unique subgroups of curious people. *Journal of Research in Personality*, *73*, 130-149. https://doi.org/10.1016/j.jrp.2017.11.011

Kline, R. B. (2011). *Principles and practice of structural equation modeling*. Guilford publications. Retrieved from: https://pdfs.semanticscholar.org/9f61/4aefcc38de8aa425a190560055dff40fabed.pdf

Leherissey, B. L. (1971). The development of a measure of state epistemic curiosity. Retrieved from: https://files.eric.ed.gov/fulltext/ED053549.pdf

Litman, J. A., & Jimerson, T. L. (2004). The measurement of curiosity as a feeling of deprivation. *Journal of personality assessment*, *82*(2), 147-157. https://doi.org/10.1207/s15327752jpa8202_3

Litman, J. A., & Spielberger, C. D. (2003). Measuring epistemic curiosity and its diversive and specific components. *Journal of personality assessment*, *80*(1), 75-86. https://doi.org/10.1207/S15327752JPA8001_16

Naylor, F. D. (1981). A state-trait curiosity inventory. *Australian Psychologist*, *16*(2), 172-183. https://doi.org/10.1080/00050068108255893

Özçifçi, V. (2020). Sosyal medyanın tüketicilerin satın alma niyeti üzerindeki etkisi [The impact of social media on consumers' purchase intention]. *Ahi Evran Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *6*(1), 206-223. https://dergipark.org.tr/en/download/article-file/1027222

Özdamar, K. (2016). *Eğitim, sağlık ve davranış bilimlerinde ölçek ve test geliştirme yapısal eşitlik modellemesi [Scale and test development structural equation modeling in education, health and behavioral sciences]*. Eskişehir: Nisan.

Peterson, E. G., & Cohen, J. (2019). A case for domain-specific curiosity in mathematics. *Educational Psychology Review*, *31*, 807-832. https://doi.org/10.1007/s10648-019-09501-4

Pritchard, D. (2015). Intellectual virtue, extended cognition, and the epistemology of education. In *Intellectual virtues and education* (pp. 113-127). Routledge.

Renner, B. (2006). Curiosity about people: The development of a social curiosity measure in adults. *Journal of Personality Assessment*, *87*(3), 305-316. https://doi.org/10.1207/s15327752jpa8703_11

Rumack, A. M., & Huinker, D. (2019). Capturing mathematical curiosity with notice and wonder. *Mathematics Teaching in the Middle School*, *24*(7), 394-399. Retrieved from https://www.jstor.org/stable/10.5951/mathteacmiddscho.24.7.0394

Semerci, Ç. (2004). İlköğretim Türkçe ve matematik ders kitaplarini genel değerlendirme ölçeği [A scale for general evaluation of Turkish and mathematics textbooks about elementary education]. *CÜ Sosyal Bilimler Dergisi Mayıs*, *28*(1), 49-54. Retrieved from https://tr-scales.arabpsychology.com/wp-content/uploads/pdf/ilkogretim-turkce-ve-matematik-ders-kitaplarini-genel-degerlendirme-olcegi-toad.pdf

Serin, G. (2010). İlköğretim 7. sınıf öğrencilerin fene karşı meraklarının incelenmesi [Investigation of 7th grade elementary students' science curiosity]. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *7*(13), 237-252. Retrieved from https://dergipark.org.tr/en/download/article-file/183263

Sümer, N. (2000). Yapısal eşitlik modelleri: Temel kavramlar ve örnek uygulamalar [Structural equation modeling: basic concepts and applications]. *Türk Psikoloji Yazıları*, *3*(6), 49-74. Google Scholar

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics (5th ed.).* Allyn and Bacon.

Tezbaşaran, A. (2008). Likert tipi ölçek hazırlama kılavuzu [Likert-type scale preparation guide]. https://www.academia.edu/1288035/Likert_Tipi_Ölçek_Hazırlama_Kılavuzu adresinden edinilmiştir

Usluoğlu, B., & Toptaş, (2021). Sınıf öğretmenleri ve öğretmen adaylarına yönelik matematiksel merak ölçeği: geçerlik ve güvenirlik çalışması [Mathematical curiosity scale for primary school teachers and teacher candidates: validity and reliability study]. *International Primary Education Research Journal*, *5*(1), 18-28. DOI:10.38089/ekuad.2022.120

Wang, M. T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational psychology review*, *29*, 119-140. https://doi.org/10.1007/ s10648-015-9355-x

Watson, L. (2018). Educating for curiosity. *The Moral Psychology of Curiosity*, 293-309. Retrieved from https://www.academia.edu/download/55850414/Watson_2018_Educating_for_Curiosity.pdf