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A scale for seventh and eighth grade students' attitudes towards skill-based mathematics questions

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ABSTRACT The aim of this study is to develop a theoretically sound, valid, and reliable scale to examine seventh and eighth grade students' attitudes towards so-called skill-based mathematics questions (SBMQ). The sample of the study was 820 seventh and eighth grade students at three different middle schools in Etimesgut District of Ankara Province. A draft item pool was crafted after a detailed literature review and the scale was finalized for the implementation after receiving expert opinions. This version of scale was administered shortly before the national examination which included skill-based questions in the 2022-2023 academic year. Exploratory and confirmatory factor analysis methods were used to examine the construct validity of the scale. The analysis resulted in 16 items in three factors (affective, cognitive, and motivational) which explained 46% of the total variance. Cronbach's alpha and composite reliability scores were above .70 for each factor and whole scale. The results indicated that the Attitudes Towards SBMQ Scale developed for seventh and eighth grade students is valid and reliable.

Keywords: *Attitude, Scale development, Seventh and eighth grade students, Skill-based mathematics questions*

Yedinci ve sekizinci sınıf öğrencileri için beceri temelli matematik sorularına yönelik tutum ölçeği

ÖZ Bu çalışmanın amacı, yedinci ve sekizinci sınıf öğrencilerinin beceri temelli olarak isimlendirilen matematik sorularına yönelik tutumlarının incelenmesi amacıyla, kuramsal temeli olan, geçerli ve güvenilir bir ölçek geliştirmektir. Öğrencilerin beceri temelli matematik sorularına karşı tutumları bilişsel, duyuşsal ve motivasyonel boyutlar bağlamında incelenmiştir. Tarama modeline göre gerçekleştirilen bu çalışmanın örneklemi, Ankara İli Etimesgut İlçesinde bulunan üç farklı ortaokulda öğrenim gören 820 yedinci ve sekizinci sınıf öğrencilerinden oluşmaktadır. Geliştirilen ölçekteki maddeler için öncelikle detaylı alan yazın taraması yapılmış ve taslak madde havuzu oluşturulmuştur. Uzman görüşleri alındıktan sonra nihai ölçek maddeleri 2022-2023 öğretim yılı ikinci yarıyılında, Liselere Geçiş Sistemi kapsamındaki merkezi sınavdan önce olmak koşuluyla, öğrencilere uygulanmıştır. Ölçeğin yapı geçerliğini incelemek için açımlayıcı ve doğrulayıcı faktör analizi yöntemleri kullanılmıştır. Analiz sonuçlarına göre ölçek, üç faktörlü (duyuşsal, bilişsel, motivasyonel) ve toplam varyansın %46'sını açıklamaktadır. Tüm ölçeğe ve alt boyutlara ilişkin hesaplanan Cronbach α iç tutarlılık katsayısı ve bileşik güvenilirlik değerleri .70'in üzerindedir. Sonuç olarak, yedinci ve sekizinci sınıf öğrencileri için geliştirilen Beceri Temelli Matematik Sorularına Yönelik Tutum Ölçeğinin geçerli ve güvenilir bir ölçme aracı olduğu söylenebilir.

Anahtar Sözcükler: *Beceri temelli matematik soruları, Ölçek geliştirme, Tutum, Yedinci ve sekizinci sınıf öğrencileri*

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INTRODUCTION

Contemporary education is based on the idea of providing individuals with professional and life skills such as problem solving, critical thinking, creativity, information management, communication, and effective use of technology, which are considered 21st century skills (Hu, 2023). Critical thinking, problem solving and reasoning are among the most emphasized of these skills as indicators of the quality of the educational system. These skills are also addressed in international comparison studies and used in restructuring educational policies (She et al., 2018). In international comparative studies, education systems are consistently rated according to their effectiveness in promoting these cognitive skills (Nortvedt, 2018). The integration of critical thinking and problem solving into curriculum provide learners who are capable of not only understanding information but also synthesizing it and asking relevant questions and developing creative solutions, with the ability to do so (Falloon, 2024).

Large-scale assessment and evaluation studies conducted at the international level (e.g. Programme for International Student Assessment (PISA), and Trends in International Mathematics and Science Study (TIMSS), and Progress in International Reading Literacy Study (PIRLS)) have provided useful comparative information about the education levels of countries to educators and decision makers (Erden, 2020; She et al., 2018; Yüksel, 2022). PISA results have influenced the education policies of many countries and what they prioritized (Kanes et al., 2014). The results obtained from the PISA studies give valuable insight as to the efficiency of the education systems of different countries and highlight strengths and weaknesses (Cantley, 2019; She et al., 2018). Considering these findings and the low average achievement among OECD countries of Turkish students in comparative studies (Tortop et al., 2022), the Ministry of National Education (MoNE, 2018a) has taken initiatives to increase student achievement since 2018 (Ünsal & Kaba, 2022). One of the initiatives is the introduction of so-called "skill-based mathematics questions (SBMQ)" (MoNE, 2019) in the national examination within the scope of the Transition to High School System (LGS). This examination, a fundamental component of the education system in Türkiye, is intended to test students' high-level cognitive abilities in addition to their academic knowledge. In this assessment, the skill-based questions are of critical importance in terms of assessing students' reading comprehension, interpretation, inference making, and problem-solving (MoNE, 2018b). These questions are designed to help students transform real life situations into mathematical expression (Şad & Aydın, 2023). The structure of skill-based questions is different from regular questions as they require executing higher level cognitive skills and drawing conclusions without memorizing information or formulas (Ünsal & Kaba, 2022).

With these changes, problems that require reasoning and aim to measure students' ability to relate mathematics to daily life, as targeted in international exams, have become more important for students. However, this question type, which focuses on cognitive skills and requires the ability to solve problems related to situations given in daily life contexts, brings difficulties for students (Kertil et al., 2021; Tortop et al., 2022). Both students and teachers evaluate the form of questions as long, containing shapes or visuals, and story-type (Kablan & Bozkuş, 2021). On the other hand, teachers think that curriculum and textbooks are not sufficient to provide effective guidance on skill-based questions (Erden, 2020) and continue to solve objective-based questions. If teachers incorporate skill-based questions into their teaching practices, students may develop favorable attitudes towards them, deal with these questions more easily, and acknowledge their significance in academic performance.

Students' attitudes towards skill-based questions may facilitate their approach to these questions patiently and carefully but may also cause them to not even read the questions. Knowing students' attitudes can help teachers to predict students' approaches to questions and make recommendations that facilitate the process of solving these questions (Tarım & Dinç Artut, 2016). Therefore, it has become important to determine students' attitudes that may affect their approaches to these so-called "skill-based" or "new generation" questions. For this reason, this study aimed to develop a valid and reliable measurement tool with a solid theoretical basis to determine the attitudes of seventh and eighth grade students regarding "skill-based questions" in mathematics.

Research on Views About Skill-Based Questions

Many countries around the world have recognized the importance of developing skills such as critical thinking, creativity and analytical thinking in addition to subject knowledge based on the PISA frameworks and results (She et al., 2018; Kanes et al., 2014). Although the specific terminology may vary, many educational systems have focused on improving these skills by adopting new policy actions, national outcomes, and practices (Kanes et al., 2014) such as new national assessment frameworks and tasks (Neumann et al., 2012). The term "skills-based questions" or "new generation questions" may be specific to the educational terminology in Türkiye. However, the concept of including questions that assess higher-order thinking skills, problem-solving skills and real-world applications is not unique to Türkiye. For example, Norwegian national examination mathematics questions were structured to require students use their mathematical competencies to solve problems in real-life contexts (Nortvedt, 2018; Pettersen & Braeken, 2019).

Research on PISA results has been generally on the interpretations rather than on the tasks, mostly with focus on the policies and/or the relationships between certain affective, socioeconomic and cognitive variables that could explain the results for specific countries. One of the reasons for low performance in PISA mathematics tasks is identified as the lack of congruence between the country's mathematics curriculum and the PISA's emphasis on mathematical literacy (Cantley, 2019). In one study about the tasks, teachers in Serbia were asked how students would perceive two specific PISA tasks (Radišić & Baucal, 2018). Teachers believed that the tasks were difficult for students because they place mathematics in a context, which was different from the mathematics tasks presented in the classrooms (Radišić & Baucal, 2018). An Italian study indicated that female students performed higher in tasks that required high level reading comprehension skills, whereas male students performed higher in tasks that demanded low reading comprehension skills (Ajello et al., 2018). In the context of Scandinavia, students from countries that emphasized pure mathematics at schools tended to perform better at PISA tasks (Costa & Chen, 2023).

Despite the recent attention on skill-based questions in Türkiye, research is scarce in this field (Kedikli & Katrancı, 2022). Studies have focused mostly on students' and teachers' opinions on skill-based questions (e.g., Erden, 2020; Kablan & Bozkuş, 2021; Tortop et al., 2022). Kablan and Bozkuş (2021) have found that teachers and students are of the opinion that high-level cognitive abilities, such as reasoning and analysis, are needed to solve LGS questions which include real-world scenarios and contain mathematical concepts and information presented in a specific structure. In another study, teachers have indicated that skill-based questions in LGS measure high-level thinking skills, require reading comprehension skills, are about real-life situations, and require the application of knowledge (Kertil et al., 2021). Teachers have indicated that students, especially with low and medium knowledge-skill levels, have difficulty solving these questions (Kertil et al., 2021; Tortop et al., 2022).

The appearance of skill-based questions in LGS, however, brings doubts for the teachers about the alignment of SBMQ with the national curriculum objectives and resources. Turkish and mathematics teachers indicated that skill-based questions are not compatible with the objectives of curriculum in Turkish and mathematics courses and textbooks are not sufficient to provide effective guidance on skill-based questions (Erden, 2020). They have the view that mathematics textbooks are insufficient in terms of SBMQ examples and that professional development opportunities are needed regarding SBMQ (Kertil et al., 2021).

These findings align with findings from other countries expressed above and address that SBMQ have a different structure than the questions that students encounter in textbooks and solve in mathematics lessons, and require different skills to deal with them. Students' approaches to SBMQ may also be different because these questions are different than the questions they are used to solving. Teachers have observed that low and medium knowledge-skill level students' attitudes towards mathematics were negatively affected because they could not even understand the SBMQ and decided that they would not be able to solve any SBMQ (Tortop et al., 2022). On the other hand, higher level students tended to

think that SBMQ were challenging and enjoyable despite being difficult and were more eager to solve them (Tortop et al., 2022). Considering that middle school students' attitudes towards mathematics are positively related to their performance in non-routine problem solving (Öztürk et al., 2020), it is reasonable to indicate that students' attitudes towards SBMQ can positively or negatively affect their approach to solving these questions.

Attitudes Towards SBMQ

The nature of affective variables in mathematics education have been extensively researched due to their effects on teaching and learning (Andrà et al., 2023). Hannula (2011) compiled these studies and stated that there is a need to look at multiple aspects when examining affect constructs because these constructs have affective, cognitive, and motivational dimensions, they can be state or trait, and that they have psychological, sociological, and physiological components. However, he added that all these aspects cannot be examined in a single study. Aiken (2002, p.3) had a similar argument about the attitude construct and defined attitude as "cognitive, affective, and behavioral predispositions to respond positively or negatively to certain objects, situations, institutions, concepts or persons." By examining the narratives of approximately 1600 Italian students describing their relationship with mathematics, Di Martino and Zan (2010) found that attitudes towards mathematics have three components: feelings about mathematics (emotions-affective), opinions about mathematics (beliefs-cognitive), and perceptions of own mathematics skills (behaviors-also indicate their motivation for mathematics). These three components affect each other, but this effect may not be straightforward. For example, students may believe that mathematics is necessary and may engage in negative emotions and ineffective mathematics study behaviors at the same time (Di Martino & Zan, 2011). For this reason, instead of evaluating attitudes as positive/negative, focusing on the relationships among their components may give us the opportunity to better understand students' mathematics experiences (Di Martino & Zan, 2011).

Considering these characteristics of attitudes, students may think that solving SBMQ is necessary and useful (belief), but when they encounter SBMQ, they may start to feel anxious (emotion) and try to delay the action of solving SBMQ under the influence of this anxiety (motivation/behavior). Similarly, students may believe that solving SBMQ is only necessary for the LGS exam and does not contribute to their mathematics skills (belief), they may get bored when they see SBMQ (feeling), but they may try to solve SBMQ to be successful in the LGS exam (motivation/behavior). Therefore, attitudes towards SBMQ should be examined on the basis of its components and the relationship between them in the context.

Students' attitudes towards SBMQ have been an issue of interest among the researchers in Türkiye (in addition to the ones cited above, for example, Bayrak & Baki, 2023, Çifter & Çekmez, 2023). However, there is only one study (see Kılcan, 2021) that developed a scale to investigate students' attitudes towards SBMQ in the accessible literature. The mentioned study documented the development of a scale in order to determine the attitudes of middle school students towards "new generation mathematics questions", which the present study addressed as SBMQ. The analysis of data obtained from 399 middle school students resulted in a scale with 17 items with 3 factors. However, the mentioned study did not depend on a theoretical model that explains the attitude constructs, its elements, and its relation to students' learning. The finalized scale did not address the affective, cognitive, and motivational/behavioral components of attitudes explicitly except for an affective component and did not discuss what information the scale would provide for the teachers and researchers especially in terms of the three factors and their relationship to students' learning.

Understanding students' attitudes towards SBMQ with its components can help mathematics teachers identify students' needs and design practices that will help students develop favorable attitudes. Those attitudes may have the potential to guide students in their efforts to solve SBMQ (Öztürk et al., 2020; Yavuz Mumcu & Cansız Aktaş, 2020). Therefore, there is a need to develop a tool that will help teachers and researchers investigate students' attitudes towards SBMQ within cognitive, affective, and motivational/behavioral components. Therefore, this study aimed to develop a valid and reliable scale

to address seventh and eighth grade students' attitudes towards skill-based questions. Our goal was to provide teachers and researchers with a well-grounded scale that will help them identify and target students' attitudes in more effective ways to support students' dealing with and learning from SBMQ. The research questions that guided the study are as follows:

Is the scale developed to determine the attitudes of seventh and eighth grade students towards "skill-based mathematics questions" a valid and reliable scale?
a) What are the results of the exploratory factor analysis of the Students' Attitudes Towards Skill-Based Mathematics Questions (SBMQ) Scale?
b) What are the confirmatory factor analysis results of the SBMQ scale?
c) What are the reliability analysis results of the SBMQ scale?

METHOD

The study was designed as a scale development study based on the survey design which aims to identify the characteristics of and/or distribution of variables in a population (Fraenkel et al., 2011). In the process of scale development, descriptive analyses, exploratory and confirmatory factor analysis, item analysis, and reliability analysis of factors and whole scale were carried out.

Study Process

A total of 820 students (360 from the seventh grade and 460 from the eighth grade) from conveniently selected middle schools in Etimesgut district of Ankara in the 2022-2023 academic year participated in the study. Data collected started after all necessary ethical procedures within the scope of "Higher Education Institutions Scientific Research and Publication Ethics Directive" were completed (Başkent University Ethics Committee, approval no 17162298.600-50) and administrative permissions were ensured. The gender and grade level of the students in the study are presented in Table 1. These grade levels were selected because we assumed that they are more familiar with the SBMQ and they already have developed certain attitudes towards SBMQ as they deal with them in their preparation for LGS. The first author implemented the scale to all volunteer students.

Table 1.
Distribution of Students by Gender and Grade Level

Gender	Grade Level	
	Seventh grade	Eighth grade
Female	176	210
Male	184	250
Total	360	460

Tabachnick and Fidell (2013) suggested that a sample of at least 300 participants will help researchers be confident in their analysis for scale development studies. As we planned to use different samples for exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), we decided to reach at least double of this value. Therefore, we aimed to gather data from at least 800 participants to be used separately in both EFA and CFA. Data were collected from 889 volunteer students 69 of which were excluded from the study due to missing data. Thus, the study was conducted with data from 820 students.

Scale Development Procedure

Item Pool Development

First, a detailed literature review was conducted with focus on the studies that investigated the opinions, thoughts, suggestions, and expectations of middle school students and teachers regarding skill-based

questions (such as Erden, 2020; Kablan & Bozkuş, 2021; Kılcan, 2021; Tortop et al., 2022). We also revised studies about students' attitudes towards mathematics and problem solving in order to have a comprehensive view (such as Çanakçı & Özdemir, 2011; Katrancı & Şengül, 2019; Yavuz Mumcu & Cansız Aktaş, 2020). We tried to include items that reflect students' general views on BTMS, describe the emotions they feel when they encounter BTMS, and express their perseverance to solve BTMS. We took into consideration that (approximately) three times the target number of items should be generated in a scale development process because there may be items that do not serve the purpose and be removed from the scale (Baykul, 2010). Based on the literature review, a total of 52 possible attitude statements that might reflect the components of students' attitudes towards SBMQ were written. A five-point Likert-type rating scale was employed to express the level of agreement with the items from "strongly disagree (1)" to "strongly agree (5)".

Validity and Reliability

Content Validity (Expert Opinion): The 52-item draft version of the scale was revised by several experts to ensure the content validity. First, two mathematics education researchers and two researchers in measurement and evaluation in education provided their comments and suggestions for the items. Then, three mathematics teachers were asked to review the draft version. An evaluation form was prepared for the experts on which they can comment on the suitability of the items for the purposes of the study and for the seventh and eighth grade students by labeling the items with one of the "appropriate", "not suitable for the theme", "not suitable for middle school students", "not meaningful", or "not comprehensible" alternatives and writing their comments and/or suggestions. The evaluation form also asked if they would like to suggest items to determine students' attitudes towards SBMQ that were not included in the draft version. A draft of the form was shared with an eighth-grade public school student and the student was asked to comment on the comprehensibility of the words in the items and whether there were any items that were unclear and may be perceived in different ways. In the draft item pool, some items that were not included or reflected the attitude towards SBMQ and its subcomponents cognitive, affective, and motivational dimensions were removed from the scale. Experts stated that some of the items indicated the views about the characteristics of the SBMQ such as "SBMQ are long", "SBMQ are difficult", and "SBMQ are complex". They also addressed that some items reflected the opinions of the students about the teaching process rather than their attitudes such as "What we do in the mathematics lesson helps me to solve SBMQ", "We solve SBMQ in every mathematics subject", and "I can solve SBMQ with what I learnt in the lesson". Therefore, these and similar items were removed. Accordingly, the 52-item version of the scale was reduced to a 38-item scale after considering all the suggestions and comments. The minimum possible score in this version of the scale was 38 and the maximum score was 190.

The scale was administered to the students in the conveniently selected schools in the Spring semester of the 2022-2023 academic year, before the national LGS examination, as a written form in approximately 20-25 minutes.

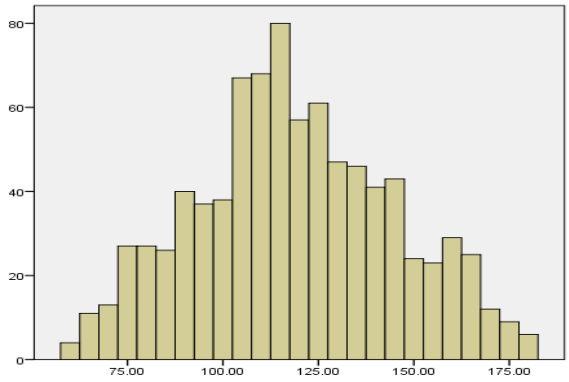
Construct Validity (Exploratory Factor Analysis and Confirmatory Factor Analysis): The raw data obtained from the scale were first transferred to the SPSS 22.0 program and descriptive analyses were conducted. Exploratory and confirmatory factor analysis were employed to examine the construct validity of the scale. In this study, firstly, EFA was used to determine the factor structure of the scale, and then the factor structure determined by EFA was subjected to confirmatory factor analysis (CFA) with the AMOS 20.0 program. EFA was conducted with a randomly selected 410 of the total 820 data and CFA was conducted with the remaining 410.

Reliability Studies: Cronbach alpha internal consistency coefficients were calculated for the reliability of the factors revealed by EFA and confirmed by CFA.

FINDINGS

Before starting the related analyses, the skewness and kurtosis coefficients of each item and the total score obtained from the scale were examined to determine whether the data showed a normal distribution. The skewness and kurtosis values were distributed between -1 and +1 which can be considered as evidence of normal distribution (Tabachnick & Fidell, 2013). In addition, histogram graphs for each item and for the total score resembled a normal distribution. The distribution of total scores is presented in Figure 1.

Figure 1.
The Histogram of Total Score

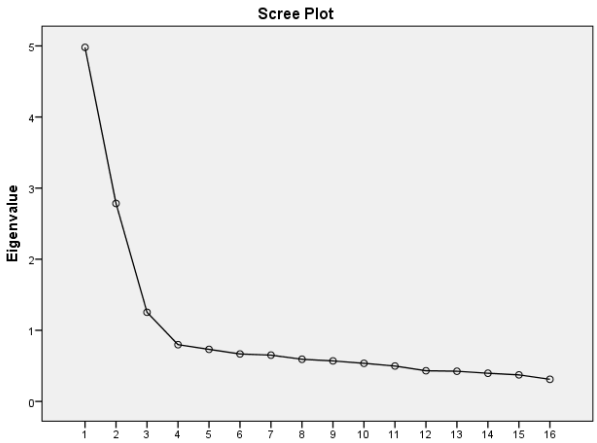


Exploratory Factor Analysis (EFA)

In order to determine the suitability of the data for EFA, the results of Kaiser Meyer-Olkin (KMO) and Barlett sampling adequacy tests were examined (Pallant, 2016). The KMO value (.881) and Bartlett test ($p<.05$) results of the 38 items in the data collection tool were found to be significant so that the data of this study was suitable for EFA.

The maximum likelihood analysis and Varimax method were used without determining the number of factors for the EFA which revealed six factors with eigenvalues greater than one. Considering the criteria that these factors should be consistent in terms of content and meaning and that each item should not be collected under more than one factor, some of the items were removed from the analysis and analysis was repeated. While removing items, the items with factor loadings below .4 and the items that has close factor loadings in more than one factor was removed and the factor analysis procedures was re-runed repeatedly. The final number of items was reduced to 16. The scree plot in Figure 2 and the explained total variance in Table 2 of the 16-item scale are presented below.

Figure 2.
Scree Plot



The scree plot and Table 2 show that the scale consists of three factors and 46% of the total variance can be explained by these factors. The first factor explains 27.8%, the second factor explains 14.1%, and the third factor explains 4.5% of the total variance.

Table 2.
Table of Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.979	31.120	31.120	4.446	27.790	27.790	3.645	22.780	22.780
2	2.784	17.403	48.522	2.264	14.148	41.937	2.017	12.608	35.387
3	1.253	7.833	56.355	.719	4.494	46.432	1.767	11.044	46.432
4	.798	4.989	61.344						
5	.733	4.580	65.924						
6	.668	4.173	70.097						
7	.651	4.069	74.166						
8	.593	3.705	77.872						
9	.570	3.559	81.431						
10	.536	3.351	84.782						
11	.498	3.111	87.893						
12	.431	2.697	90.590						
13	.425	2.654	93.244						
14	.397	2.478	95.722						
15	.373	2.334	98.056						
16	.311	1.944	100.000						

Extraction Method: Maximum Likelihood.

Table 3 shows the rotated components matrix and the items in the 16-item scale. As seen in the table, the scale items had acceptable factor loadings (from .459 to .769). The items are translated by the authors.

Table 3.
Rotated Components Matrix

	Factor		
	1	2	3
I 36. I feel uneasy when I see SBMQ.	.769		
I 17. I get scared when I encounter SBMQ.	.766		
I 15. I get stressed when I see SBMQ.	.713		
I 31. I get confused when I see SBMQ.	.710		
I 18. Seeing SBMQ makes me unhappy.	.658		
I 24. When I see SBMQ I'm not sure I can figure it out.	.635		
I 7. I feel anxious when I see SBMQ.	.622		
I 11. I would like SBMQ to be included in mathematics classes.		.751	
I 20. More SBMQ should be solved in mathematics lessons.		.690	
I 23. I would like to be informed about SBMQ.		.524	
I 22. Solving SBMQ is important for my future.		.520	
I 25. It is unnecessary to solve SBMQ.		.459	
I 19. I try every method to solve SBMQ.			.693
I 28. When I see SBMQ, I definitely try to solve it.			.600
I 2. I struggle until I find the result while solving SBMQ.			.577
I 9. I am patient while solving SBMQ.			.509

Extraction Method: Maximum Likelihood.
Rotation Method: Varimax with Kaiser Normalization.

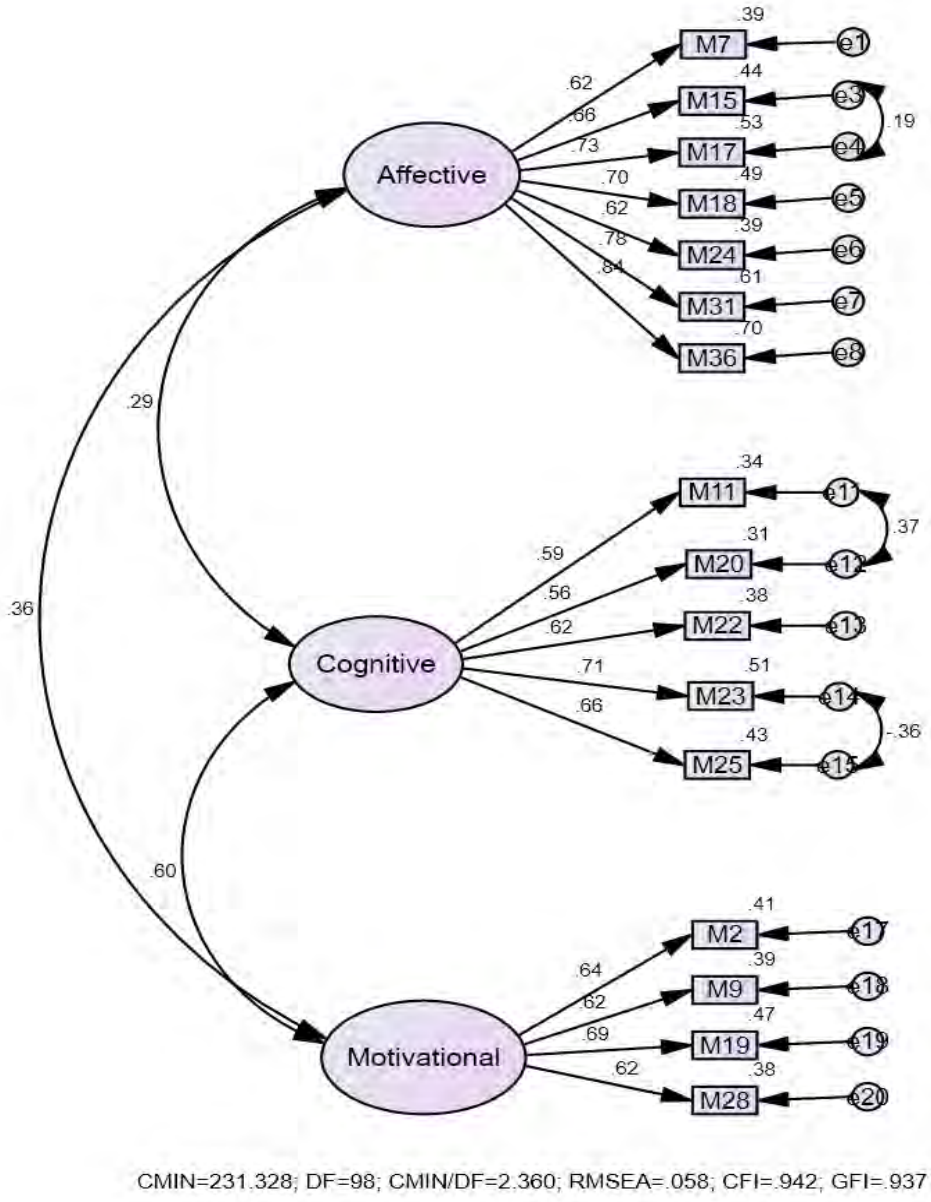
The factors were named in line with the framework, considering the characteristics of the items included in the factors that represent the attitude components. In this context, the first factor is named as the "affective component of attitudes towards SBMQ", the second is the "cognitive component of attitudes

towards SBMQ", and the third factor is the "motivational/behavioral component of attitudes towards SBMQ".

Confirmatory Factor Analysis (CFA)

In the next step, CFA was performed to determine whether the fit indices of the scale resulting from EFA were acceptable. The model analyzed in the confirmatory factor analysis is presented in Figure 3. Maximum likelihood estimation was utilized in CFA.

Figure 3.
Confirmatory Factor Analysis Model



In the following table (Table 4), reference values for the fit indices as summarized by Schermelleh-Engel et al. (2003, p. 52) were given. The fit indices in Table 4 indicate that the scale with three factors

has acceptable values. Overall, it can be concluded that the three-factors model of the scale was validated with CFA.

Table 4.
Fit Indices for the Scale

Fit Indices	Good Fit	Acceptable Fit	Value found in the analysis
chi-square/sd	0 < x2/sd < 2	2 < x2/sd < 3	2.36 (Acceptable)
RMSEA	0 < RMSEA < .05	.05 < RMSEA < .08	.058 (Acceptable)
NFI	.95 < NFI < 1	.90 < NFI < .95	.904 (Acceptable)
CFI	.97 < CFI < 1	.95 < CFI < .97	.942
GFI	.95 < GFI < 1	.90 < GFI < .95	.937 (Acceptable)
AGFI	.95 < AGFI < 1	.90 < AGFI < .95	.912 (Acceptable)

In addition, the correlation matrix showing the inter-item correlations within the CFA dataset was provided in Appendix 1.

Reliability

Following the EFA and CFA, Cronbach's alpha and Composite Reliability coefficients were calculated for the entire scale and the factors of the scale. While computing composite reliability of factors, the factor loadings in CFA were used. Table 5 presents that the reliability coefficients of the entire scale and each factor are acceptable and indicate good reliability (Hair et al., 2009; Pallant, 2016).

Table 5.
Cronbach's Alpha Coefficients for the Factors of the Scale

Scale	# of items	Cronbach's alpha	Composite Reliability
Factor 1 (Affective)	7	.84	.87
Factor 2 (Cognitive)	5	.76	.76
Factor 3 (Motivational/Behavioral)	4	.74	.73
Total	16	.85	.87

In addition, as seen in Table 6, the correlation of each item with both the factor to which it belongs and the whole scale is above .30 and at acceptable levels (Pallant, 2016).

The documented analyses indicated that the final version of the Students' Attitudes Towards Skill-Based Mathematics Questions Scale consists of three factors and it is a valid and reliable tool to determine students' attitudes. The lowest score that can be obtained from the entire scale is 16 and the highest score is 80. A high score from the scale means that students have favorable attitudes towards SBMQ and their emotions, beliefs and motivations have the potential to support them more when they solve SBMQ. A low score from the scale means that students' attitudes may not help them when they try to solve SBMQ or may even lead them towards not attempting. Scores in the three factors should be evaluated within the context of students' mathematics teaching and learning practices. The final version of the scale (in English and in Turkish) is given in Appendix 2.

Table 6.
Item-Total Correlations

Item	Corrected Item-Total Correlation	Cronbach's alpha if Item Deleted	Item - Factor Correlation	Factor Cronbach's alpha if Item Deleted
I 7	.431	.840	.571	.832
I 15	.514	.835	.651	.822
I 17	.560	.833	.705	.815
I 18	.599	.830	.633	.824
I 31	.543	.834	.665	.821
I 36	.520	.835	.688	.818
I 24	.435	.840	.594	.830
I 11	.459	.839	.607	.688
I 20	.373	.843	.559	.707
I 22	.400	.842	.537	.715
I 23	.304	.847	.490	.731
I 25	.561	.832	.454	.744
I 2	.455	.839	.534	.680
I 9	.441	.839	.494	.704
I 19	.417	.840	.578	.656
I 28	.427	.840	.527	.684

CONCLUSION, DISCUSSION, AND RECOMMENDATIONS

The purpose of this study was to develop a scale that would assist in identifying the seventh and eighth grade students' attitudes towards SBMQ. For this purpose, a preliminary 52-item scale was developed as a draft version before presenting the experts' opinions. After receiving expert opinions, 52 items were reduced to 38 items. Following the EFA, 22 items were removed from the scale because they did not match the required standards. A structure with 16 items with three factors was discovered as a consequence of EFA. With the use of the CFA, this 16-item scale with three factors was found to be consistent and coherent within the new data set. Lastly, the calculated Cronbach's alpha coefficients for the whole scale and three factors indicated high internal consistency and composite reliability scores were above the cut-of value .70. As a result, it can be concluded that a valid and reliable scale reflecting the theoretical structure of attitudes towards skill-based mathematics questions was developed.

According to the results of the EFA, the scale has three factors, namely: affective, cognitive, and motivational/behavioral, and 46% of the total variance can be explained by these three factors. While determining the number of factors in EFA, the eigenvalues of the factors and items' factor loadings were considered. According to Çokluk et al. (2012), a scale that can explain 40%-60% of the total variance can be considered as effective. Therefore, this calculated percentage indicated that this scale is useful to explain the variability in students' attitude towards SBMQ. When each factors' contribution to this explained variance is considered, it can be seen that each factor has a meaningful unique contribution. As a part of the EFA, when the Rotated Components Matrix is investigated, it can be seen that the scale items had factor loadings ranging from .459 to .769. These factor loadings indicated also that each item in the scale has a meaningful relation with its corresponding factor.

In addition, for the whole scale, both the Cronbach's alpha coefficient and composite reliability was found to be greater than .85. These values are adequate to show the reliability of the scale in assessing seventh and eighth school students' attitudes towards SBMQ. Given that each of the scale's three factors has an internal consistency coefficient between .74 and .84, and composite reliability scores between .73 and .87, this scale can be considered quite dependable. These results were corroborated by the outcomes of the CFA. Every model data fit index exceeds the threshold of .90 and the model's RMSA value is .058 (Schermelleh-Engel et al., 2003).

A previous study that reported the development of an attitude scale for SBMQ resulted in three factors:

(i) new generation questions from an affective perspective, (ii) consultation in solving new generation questions, and (iii) difficulty in solving new generation questions (Kılcan, 2021). The structure and content of these factors did not explicitly address the three components of attitudes, except for the affective component; and it did not discuss the final structure of the scale in relation to the theory, which was not mentioned in the study. We are not aiming for an item-by-item comparison of the scale in the mentioned study and the scale in the present study. However, we would like to indicate that the present study provides an alternative tool for teachers and researchers who would like to address seventh and eighth grade students' attitudes towards SBMQ with theoretical components of attitude.

The scale provides mathematics education researchers and mathematics teachers with multiple perspectives about seventh and eighth grade students' attitudes towards SBMQ. It is important that researchers and teachers focus on scores from each factor and also the relationship between the different components rather than a positive/negative dichotomy (Di Martino & Zan, 2011; Hannula, 2011). For example, teachers may observe negative emotional reactions among their students when they ask SBMQ. However, the students may have more favorable beliefs about the benefits of working on SBMQ and may even attempt for a solution. If teachers (and researchers) can identify these different reactions and tendencies, then they may develop strategies to decrease students' negative emotions and direct students' favorable beliefs and motivation towards effectively supporting students' solution strategies.

The scale developed in this study can be used as an essential tool for exploring the different components of attitude to support teachers and students in solving SBMQ. Future studies using this scale may aim to reveal student profiles based on these three components. Our intention for future research is to find and explore these profiles. These profiles may also provide teachers with potential factors that affect students' achievement in solving SBMQ. We recommend that the scale be tested with the students at the fifth and sixth grades in order to see its adequateness for these grades. The scale can be also be tested for different samples based on variables such as gender, socio-economic status, and school type for examining measurement invariance.

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APPENDICES

Appendix 1: Inter-Item Correlation Matrix

	M2	M5	M7	M9	M11	M15	M17	M18	M19	M20	M22	M23	M24	M25	M28	M31	M36
M2	1.000	.159	.125	.422	.270	.209	.209	.246	.452	.205	.125	.216	.171	.256	.372	.283	.257
M5	.159	1.000	.055	.219	.325	.119	.120	.219	.203	.239	.347	.281	.100	.374	.179	.203	.161
M7	.125	.055	1.000	.143	.161	.453	.438	.417	.108	.089	.077	-.001	.410	.108	.103	.477	.526
M9	.422	.219	.143	1.000	.279	.152	.181	.258	.424	.216	.165	.271	.142	.249	.355	.237	.220
M11	.270	.325	.161	.279	1.000	.208	.165	.277	.208	.578	.389	.438	.081	.325	.296	.188	.141
M15	.209	.119	.453	.152	.208	1.000	.581	.485	.115	.161	.083	.069	.340	.292	.067	.525	.549
M17	.209	.120	.438	.181	.165	.581	1.000	.553	.084	.091	.119	-.003	.440	.296	.132	.546	.614
M18	.246	.219	.417	.258	.277	.485	.553	1.000	.187	.169	.199	.119	.412	.403	.191	.543	.563
M19	.452	.203	.108	.424	.208	.115	.084	.187	1.000	.279	.217	.297	.097	.253	.449	.157	.139
M20	.205	.239	.089	.216	.578	.161	.091	.169	.279	1.000	.337	.419	.107	.330	.272	.158	.089
M22	.125	.347	.077	.165	.389	.083	.119	.199	.217	.337	1.000	.446	-.013	.424	.230	.133	.089
M23	.216	.281	-.001	.271	.438	.069	-.003	.119	.297	.419	.446	1.000	-.109	.279	.334	-.002	.009
M24	.171	.100	.410	.142	.081	.340	.440	.412	.097	.107	-.013	-.109	1.000	.258	.049	.501	.556
M25	.256	.374	.108	.249	.325	.292	.296	.403	.253	.330	.424	.279	.258	1.000	.272	.331	.323
M28	.372	.179	.103	.355	.296	.067	.132	.191	.449	.272	.230	.334	.049	.272	1.000	.185	.078
M31	.283	.203	.477	.237	.188	.525	.546	.543	.157	.158	.133	-.002	.501	.331	.185	1.000	.653
M36	.257	.161	.526	.220	.141	.549	.614	.563	.139	.089	.089	.009	.556	.323	.078	.653	1.000

Appendix 2: Final Version of the Scale

Final Version of the Scale (English)

1. When I see SBMQ, I definitely try to solve it.
2. I struggle until I find the result while solving SBMQ.
3. I feel anxious when I see SBMQ.
4. I am patient while solving SBMQ.
5. I would like SBMQ to be included in mathematics classes.
6. I get stressed when I see SBMQ.
7. I get scared when I encounter SBMQ.
8. Seeing SBMQ makes me unhappy.
9. I try every method to solve SBMQ.
10. More SBMQ should be solved in mathematics lessons.
11. Solving SBMQ is important for my future.
12. I would like to be informed about SBMQ.
13. When I see SBMQ, I'm not sure I can figure it out.
14. It is unnecessary to solve SBMQ.
15. I get confused when I see SBMQ.
16. I feel uneasy when I see SBMQ.

Ölçeğin Son Hali (Türkçe)

1. BTMS gördüğümde çözmeyi mutlaka denerim.
2. BTMS çözerken sonucu bulana kadar uğraşırım.
3. BTMS görünce kaygı duyarım.
4. BTMS çözerken sabırlı davranırım.
5. BTMS'nin matematik derslerinde yer almasını isterim.
6. BTMS görünce strese girerim.
7. BTMS ile karşılaşınca korkarım.
8. BTMS görmek beni mutsuz eder.
9. BTMS çözmek için her yöntemi denerim.
10. Matematik derslerinde daha çok BTMS çözülmelidir.
11. BTMS çözmek geleceğim için önemlidir.
12. BTMS ile ilgili bilgilendirilmek isterim.
13. BTMS gördüğümde çözebileceğimden emin olamam.
14. BTMS çözmek gereksizdir.
15. BTMS gördüğümde kafam karışır.
16. BTMS gördüğümde tedirgin olurum.

TÜRKÇE GENİŞLETİLMİŞ ÖZET

Uluslararası düzeyde yapılan ölçme-değerlendirme çalışmaları (örneğin, Uluslararası Öğrenci Değerlendirme Programı (PISA), Uluslararası Matematik ve Fen Eğilimleri Araştırması (TIMSS) ve Uluslararası Okuma Becerilerinin Gelişimi Projesi (PIRLS)) eğitimcilere ve karar vericilere ülkelerin eğitim düzeyleri hakkında karşılaştırmalı işlevsel bilgiler sağlamaktadır (Yüksel, 2022). Bu sınavlarda Türk öğrencilerin başarı ortalamalarının düşük ortalama düzeylerinde kaldığı belirtilmektedir (Tortop vd., 2022). Bu noktada, 2018 yılından itibaren Millî Eğitim Bakanlığı (MEB), öğrencilerin başarılı olmalarına yardımcı olmak amacıyla bir dizi değişiklik yapmıştır (Ünsal & Kaba, 2022). Bu değişikliklerden biri, liseye geçiş merkezi sınavında "beceri temelli" (MEB, 2019) soru tipinin kullanılmaya başlanmasıdır. İşlemsel beceriden farklı olarak kavramsal becerilere odaklanan, günlük yaşam bağlamları içinde verilen durumlara ait problemleri çözme becerisini gerektiren bu soru tipinin öğrenciler için zorluk getirdiği bilinmektedir (Kertil vd., 2021; Tortop vd., 2022). Öğrencilerin beceri temelli sorulara yönelik tutumları onların bu sorulara karşı sabırlı ve dikkatli yaklaşmalarını sağlayabileceği gibi soruları okumama veya çözmeme yoluna gitmelerine de sebep olabilir. Öğrencilerin tutumlarının bilinmesi ile öğretmenler öğrencilerin sorulara yaklaşımlarını tahmin edebilir ve bu soruları çözme süreçlerini kolaylaştırıcı tavsiyelerde bulunabilir (Tarım & Dinç Artut, 2016). Dolayısıyla, öğrencilerin “beceri temelli” veya “yeni nesil” olarak isimlendirilen uygulamalarla ilgili bu sorulara yaklaşımlarını etkileyebilecek tutumlarını belirlemek önem kazanmıştır.

Hannula (2011), duyuşsal olguları incelerken çok yönlü bakmamız gerektiğini, olguların duyuşsal, bilişsel ve motivasyonel bileşenlerinin olduğunu, anlık olabildiği gibi kişilik özelliği de olabileceğini ve psikolojik, sosyolojik ve fizyolojik boyutlarının olduğunu belirtmiş; ancak, tek bir çalışma ile bütün bu yönlerinin incelenemeyeceğini de eklemiştir. Tutumları olumlu/olumsuz şeklinde değerlendirmek yerine bileşenlerinin birbirleriyle ilişkilerine odaklanarak değerlendirmek öğrencilerin matematik deneyimlerini daha iyi anlamamıza fırsat verebilir (Di Martino & Zan, 2011). Tutumun bu özellikleri düşünüldüğünde öğrenciler beceri temelli matematik soruları (BTMS) çözmenin gerekli ve yararlı olduğuna inanabilir (inanış) ancak BTMS ile karşılaştığında kaygı duymaya başlayıp (duyuş) bu kaygının etkisiyle BTMS çözme eylemini geciktirmeye çalışabilir (motivasyon/davranış). Benzer bir şekilde, öğrenciler BTMS çözmenin sadece sınav için gerekli olduğuna ve matematik becerisine bir katkısı olmadığına inanabilir (inanış), BTMS gördüğünde sıkılabilir (duyuş) ancak LGS sınavında başarılı olmak için BTMS çözme eylemini gerçekleştirebilir (motivasyon/davranış). Bu şekilde düşünüldüğünde, BTMS’ye yönelik tutumların bileşenleri temelinde incelenmesi gerektiği ortaya çıkmaktadır. Bu nedenle, bu çalışmada ortaokul 7. ve 8. sınıf öğrencilerinin matematik dersi özelinde “beceri temelli sorularla” ilgili tutumlarının belirlenmesine yönelik kuramsal temeli olan geçerli ve güvenilir bir ölçme aracı geliştirilmesi hedeflenmiştir.

Bu çalışmada şu araştırma sorusuna yanıt aranmıştır: Yedinci ve sekizinci sınıf öğrencilerinin beceri temelli matematik sorularına yönelik tutumlarını belirlemek için geliştirilen ölçek geçerli ve güvenilir bir ölçek midir? Araştırma, tarama modeline göre gerçekleştirilen bir ölçek geliştirme çalışmasıdır. Betimsel analizler, açımlayıcı ve doğrulayıcı faktörlerin analizi, madde analizi, faktörlerin güvenirliği analizi ve faktörler arasındaki ilişkilerin belirlenmesi, yöntemin geliştirilmesi sürecinde gerçekleştirilen aşamalardır.

Araştırmanın örneklemi, 2022-2023 eğitim-öğretim yılı ikinci döneminde Ankara İli Etimesgut İlçesinde bulunan 3 farklı ortaokulda öğrenim gören 820 ortaokul yedinci ve sekizinci sınıf öğrencilerinden oluşmaktadır. Araştırmada geliştirilen ölçekteki maddeler için öncelikle detaylı bir alanyazın taraması yapılmıştır. Alan yazından elde edilen bilgiler ışığında ölçekte yer alması planlanan kategoriler belirlenmiş ve çalışmanın madde havuzu oluşturulmuştur. Sonuç olarak, öğrencilerin BTMS’ye ilişkin genel görüşlerini yansıtan, BTMS ile karşılaştıklarında hissettikleri duyguları tasvir eden, BTMS çözmek için sahip oldukları azmi ifade eden ve BTMS çözmeye dair özgüvenlerini belirlemeyi hedefleyen maddelere yer verilmeye çalışılmıştır. Bu bağlamda araştırmacıların belirledikleri kategoriler (dayanıklılık, özgüven, tutum gibi bilişsel ve duyuşsal alanlar) ve alan yazın

taraması sonucunda edilen bilgiler doğrultusunda 52 maddelik bir öncül madde havuzu hazırlanmıştır.

Madde havuzunda yer alan 52 taslak madde ile ilgili olarak uzman görüşleri alınmıştır. Uzman görüşleri sonrası gerekli düzenlemeler de yapıldıktan sonra 52 madde 38 maddeye indirilmiştir. Ölçek, belirlenen okullardaki öğrencilere 2022-2023 eğitim-öğretim yılı ikinci yarıyılında Liselere Geçiş Sistemi (LGS) kapsamındaki merkezi sınavdan önce olmak koşuluyla uygulanmıştır. Ölçek, yazılı form olarak yaklaşık 20-25 dakika süresinde uygulanmıştır.

Ölçekten elde edilen ham veriler ilk olarak SPSS 22 programına aktarılmış ve betimsel analizler yapılmıştır. Ölçeğin yapı geçerliğini incelemek için açımlayıcı faktör analizi (AFA) ve doğrulayıcı faktör analizi (DFA) yöntemleri kullanılmıştır. Ölçeğin güvenirlik analizi kapsamında AFA ile ortaya konan ve DFA ile doğrulanan alt boyutlara ilişkin Cronbach alfa ve bileşik güvenilirlik katsayıları hesaplanmıştır.

İlk AFA çalışmasında En Çok Olabilirlik Tahmin Analizi ve Varimax yöntemi kullanılarak faktör sayısı belirlenmeden işlem yapılmış ve özdeğeri 1'den büyük 6 faktör ortaya çıkmıştır. Bu faktörlerin içerik ve anlam açısından tutarlı olması ve her bir maddenin birden fazla faktör altında toplanmaması ölçütleri dikkate alınarak bazı maddelerin çıkarılmasına karar verilmiştir. Yürütülen analizler sonucunda madde sayısı 16'ya indirilmiştir. Sonuç olarak, ölçeğin üç faktörden (duyuşsal, bilişsel ve motivasyonel) oluştuğu ve toplam varyansın %46'sını açıkladığı görülmektedir. AFA sonucunda ortaya çıkan üç boyutlu ölçeğin uyum indekslerinin yeterli olup olmadığını belirlemek ve yapı geçerliğini destekleyecek bir kanıt daha bulmak için DFA yapılmıştır. Doğrulayıcı faktör analizi bulgularına göre uyum indeksi değerlerinin iyi uyuma ve mükemmel uyuma işaret ettiği görülmektedir.

Geçerlik çalışmalarının ardından, ölçeğin AFA ile ortaya çıkan ve DFA ile veri setine uygunluğu gösterilen alt boyutlarının ve ölçeğin tümünün güvenirlik çalışmaları yapılmıştır. Bu kapsamda tüm ölçeğin ve her bir alt boyutun Cronbach alfa ve bileşik güvenilirlik değerleri hesaplanmıştır. Bu değerler ölçeğin bütünü için .85'in, her bir alt boyut için de .70'in üzerindedir. Bu değerler ölçeğin bütünün ve alt boyutlarının güvenilir olarak kullanılabileceğini göstermektedir. Duyuşsal, bilişsel ve motivasyonel boyutları ölçeğin faktörlerini oluşturmaktadır. Ölçeğin tamamı için en düşük puan 16, en yüksek puan 80'dir. Ölçekten yüksek bir puan alınması öğrencilerin BTMS'ye yönelik olumlu tutumlarının ve BTMS çözmeye dair motivasyonlarının, duyuşsal yatkınlıklarının yüksek olması şeklinde yorumlanabilir. "Beceri Temelli Matematik Sorularına Yönelik Tutum Ölçeği"nin yapılan analizler ve sonuçlara göre güvenilir ve geçerli bir ölçme aracı olduğu söylenebilir.