CONTENT VALIDITY OF THE TEST OF MATHEMATICAL TALENT

Şeyma ŞENGİL AKAR

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PREFACE

This book is a translation of my master's thesis into English to reach a wider audience. During my master's process, I was one of the first teachers of UYEP, which provides education to gifted students affiliated to Eskişehir Anadolu University Gifted Research and Application Center, and one of the first researchers in the first establishment phase. Therefore, I contributed to the development of this test from the question writing stage in the development process of the TMT test. I contributed to the first item analysis of this test, I made the first applications of this test, and finally we turned this study into a master's thesis by making the content validity of the test with the request of my esteemed professor Uğur Sak. Since Uğur Sak left the university for a short time at the last stage of our study, we completed this study with İbrahim Halil Diken. I am grateful to both of them for paving the way. With this study, I finished my master's thesis. The gifted students we identified with this test are now in different parts of the world and have successfully continued their careers. For example, one of our students (we spoke the other day) is about to complete her PhD at Cambridge University. This is proof that we have done the right thing in identifying successful, bright and intelligent students. This test proved itself as these children grew up to become world-renowned scientists. As a teacher and an academic, I am honored that the bonds we established in those days are continuing. I hope this work will reach a wider audience. It will inspire other studies.

ABSTRACT

CONTENT VALIDITY STUDY OF THE TEST OF MATHEMATICAL TALENT FOR 6th AND 7th GRADE STUDENTS

Şeyma Şengil AKAR

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The Test of Mathematical Talent (TMT) is a test developed to identify 6th and 7th grade students who are gifted in mathematics. During the development process of the test, item properties, reliability and criterion validity were focused on. In this study, the content validity of the test was examined. With the data obtained through expert opinions, the strengths and weaknesses of the test in terms of content validity were tried to be revealed and comments were made on the adequacy of the test.

Mathematics teachers and academicians working on mathematics education and mathematics science at the faculties of education of universities and mathematics teachers who were selected through convenient sampling participated in the study. The reliability of the five-point Likert-type scale used as a data

collection tool was found to be .72. The data obtained were analyzed in terms of frequency and percentage distribution and interpreted according to content validity ratios based on these data.

When we interpreted the data obtained as a result of the study according to the content validity index, it was seen that the test was generally well structured and sufficient in terms of content validity. However, when some subtests were evaluated in terms of content validity, their adequacy was found to be moderate and below the expected value.

CONTENTS

1. INTRODUCTION

1.1. Problem

Identification of gifted students is the process of reaching the student who is wanted. According to Richert (1987), in the process of identifying gifted students, there may be some gaps between theoretical knowledge and practice. An approach, a scale or an accepted definition that is thought to be useful on the basis of theoretical knowledge may produce results contrary to expectations. The pre-designed identification process may not work as well as expected. This situation one result as emptiness, often

Determination process It may deviate from its purpose. The difficulties encountered in the identification process and the mistakes made in identification/determination a r e what we encounter in this gap situation (Budak, 2008).

Psychometric measurement tools such as aptitude/intelligence tests and studies on measuring intelligence using these tools have always been controversial from the past to the present and continue to be the subject of intense debate today (Sak, 2004b). Although they are based on the literature, indirect measurement of a psychological construct that cannot be measured directly may not produce the expected results. Therefore, the extent to which the tests developed for ability/intelligence measurements measure the behavior they aim to measure should be supported by scientific means and psychometric properties of the test. In other words, such tests need to be supported by evidence that they measure the condition or behavior they aim to measure. Part of this supporting or proving work is to establish the validity of these tests/measurement tools.

The Mathematics Aptitude Test (TMT) is designed to identify gifted students in mathematics at the second level of primary education (6th and 7th grade students) and to determine the mathematical ability levels of primary school students at the second level of primary education.

It is a test that is being developed to determine the level of mathematical ability. In this respect, the test can be considered as a diagnostic test and a test for determining the level of mathematics ability. Unlike the adaptation tests used to determine the levels of mathematics ability in Turkey, the test is the first mathematics aptitude test developed by taking into consideration the general structure of education in Turkey, the developmental levels of primary school students, and the renewed primary school curriculum in

2005. All the studies carried out during the development stages of the test revealed important findings, making the test more functional and minimizing the errors in diagnostic and/or placement studies using the test.

In the first stage of the test development process, problem examples were developed gradually and in accordance with the theoretical infrastructure of the test. The difficulty levels of the problem examples were tried to be adjusted in four stages from easy to difficult. Some questions were revised or removed from the question pool by the expert team within the pool. The subtests consisting of four questions deemed appropriate by the experts who developed the test were evaluated by three teachers working in primary schools and the first version of the test was created in line with their feedback. In the second stage of the test development, the test was piloted and the items of the test were analyzed. The test focused on item properties, reliability and criterion validity (Sak, Karabacak, Şengil, Demirel, Akar, Türkan, 2008, 2009). Simultaneously with this stage, the test had to be evaluated and reconsidered by experts other than the team of experts who developed the test, hence the need to focus on content validity studies. Because content validity is one of the most important studies showing the adequacy of a test. Content validity refers to the degree to which the test or scale items selected as a sample represent the conceptual main mass for the purpose. The selected sample items have content validity to the extent that they represent the conceptual main mass (Şencan, 2005; 746).

In content validity, whether the measurement tool measures the construct it wants to measure or not is left to expert decisions, not to the developers themselves (Şencan, 2005;747). In this sense, content validity studies are also useful in shaping a test with expert opinions. No matter how much a test is developed by a team of experts, the viewpoints of another expert group will always differ. may show. These differences can be used as cornerstones in strengthening the validity of the test. The fact that the reliability and criterion validity studies of the mathematics aptitude test have been conducted, but the content validity of the test has not yet been conducted, raises questions about how comprehensively the test measures the mathematics aptitude domain. The extent to which the test measures analytical, creative, and domain knowledge in mathematics, as theoretically proposed, and the extent to which the subtests of the test are appropriate to the developmental structure of the test need to be revealed.

1.2. Objective

The purpose of this study is to investigate the content validity of the Mathematics Aptitude Test (TMT) for 6th and 7th grade students. The following research question was tried to be answered in the study.

> What is the content validity of the math aptitude test (TMT)?

1.3. Importance

Accurate Identify and guidance, which is one of the principles of special education, is the first step in terms of the development and education of the individual. Accurate identification of individuals in accordance with the structure of diagnostic tests and determination of their level of ability, and therefore orientation in accordance with this determination is important for the education of the individual as well as for our education system. Measurement tools that are used in the identification process but cannot measure or predict the behavior or ability that is expected to be measured, the sub-abilities related to this ability; measurement tools that measure different characteristics than those expected to measure can often lead to misIdentify of students. This situation can have irreparable consequences for individuals and educational programs. The TMT is a guiding tool for talented students in mathematics to receive education in appropriate programs by determining their ability levels. From this point of view, in order for the test to serve its purpose as a diagnostic tool in mathematics, it is necessary and important to conduct reliability and validity studies.

TMT differs in some respects from adaptive tests or measurement tools used to determine the level of mathematics ability. TMT differs from intelligence tests, individual performance tests, and achievement tests in terms of level, content, theoretical background, and the fact that it is designed for only one ability area. These differences increase the importance of the mathematics aptitude test individually.

The findings from the content validity study of the TMT test developed for the identification of gifted students in mathematics can be used to determine the extent to which this test measures general mathematical ability, analytical ability in mathematics, creative ability in mathematics, and content knowledge in mathematics. In other words, the extent to which this test measures what it aims to measure can be determined.

The TMT test is evaluated by a large number of experts in this study. Experts evaluate the whole test and subtests in terms of their structure and the findings obtained in this study reveal the strengths and weaknesses of the test on the basis of subtests and/or holistically. These findings obtained as a result of the experts' evaluation of the test also shed light on the development of the validity of the test and help the test to make more qualified measurements. Since the TMT, which is designed as a diagnostic test, is a test in the development stage, it is thought that each correct Identify to be made after the completion of the validity studies of the test will be an effective contribution to the correct and appropriate education of the students.

1.4. Assumptions

- Participants filled in the measurement tools given to them in a way that reflected their own thoughts.
- Academics working on mathematics education and mathematical science in the faculties of education of universities and mathematics teachers teaching 6th and 7th grades in primary schools are the subject area experts.

- Subject matter experts have enough conceptual knowledge to evaluate the test.

1.5. Limitations

- The research was conducted with the participation of 6th and 8th graders working in primary schools in Eskisehir province.

7th grade mathematics teachers, each with at least two years of teaching experience, and academics working on mathematics education and/or mathematics field in the faculties of education of state universities in Ankara, Eskişehir and İzmir.

- The findings of the research are limited to the answers given by the participants to the measurement tool.

1.6. Definitions

TMT (Test of Mathematical Talent): It is an aptitude test used in the identification of 6th and 7th grade students who are gifted in mathematics and consists of a total of twelve subtests, four of which are mathematics learning domains (Sak et al., 2008, 2009).

Content validity: Content validity is the ability of the content of the measurement tool to exemplify the set of behaviors or characteristics measured (Tezbaşaran, 2008; 51).

2. WRITE FIELD

2.1. The Nature of Mathematical Ability

In this section, definitions in the literature on the nature of mathematical ability and the sub-dimensions of mathematical ability are given and these definitions are explained and discussed.

2.1.1. What is Math Ability?

Mathematics is a system of ideas (structures) and relations developed in the process of abstractions and generalizations in the human mind (New South Wales Department of Educational Research, 1972). These structures or systems formed by the human mind also form the basis of science.

Scientists from different disciplines have different definitions of mathematical ability. In the literature, mathematical giftedness is defined as academic giftedness or intellectual giftedness (Lupkowski- Shoplik, Benbow, Assouline, Brody; 2003). While mathematicians define mathematical ability in terms of the core structure of mathematics or mathematical thinking, researchers interested only in the field of intelligence have developed their definitions around psychometric values. Educators, on the other hand, have defined mathematical ability in terms of learning capacity (Sak, 2004b).

In the first known definitions, mathematical ability was generally defined as mathematical superiority, being successful in mathematics achievement tests and being born superior to other individuals in general intelligence. Therefore, in order to identify mathematically gifted students, experts first tried to measure achievement in mathematics (Wagner & Zimmermann, 1986). However, mathematical ability in mathematics

It can also be thought of as understanding mathematical structures and reasoning about these structures rather than getting good grades on tests (Miller, 1990).

Gardner (1999) mentioned seven different intelligences in his theory of multiple intelligences and described logical-mathematical intelligence as the ability to analyze problems, perform mathematical operations within problems, and solve problems. At this point, this definition has aspects that differ from the general intelligence section. In this definition, Gardner distinguished mathematical intelligence from other intelligences. According to Oral (2004), who brought many definitions together, mathematical thinking includes behaviors such as using numbers effectively, generating scientific solutions to problems, distinguishing the relationship or patterns between concepts, classifying, generalizing, expressing with a mathematical formula, calculating, testing hypotheses, and making analogies. People with this area of intelligence think like a scientist or mathematician. Recognizing logic patterns in a wide range of fields, effective reasoning, discovering principles and cause-effect relationships, prioritizing, classifying, predicting, developing hypotheses, understanding complex relationships, forming and questioning assumptions, and being sensitive to similar abstract processes are indicators of this intelligence. Individuals with strong logical mathematical intelligence learn best by categorizing objects into certain categories, establishing logical relationships between events, quantifying and calculating certain properties of objects, and thinking about certain abstract relationships between events (Açıkgöz, 2003; Bümen, 2002; Campell, 1996; Checkly, 1997; Demirel 2004; Gardner, 1999; Saban,

2002; Özden, 2003; Selçuk, 2002; Tan and Erdoğan, 2004; Ülgen, 1995; cited in Oral,

2004). At the core of logical-mathematical intelligence are thinking skills such as (1) recognizing abstract structures, (2) reasoning inductively, (3) reasoning deductively, (4) distinguishing connections and relationships, (5) making complex calculations and (6) using the scientific method (Bümen, 2002).

According to another definition, mathematical ability requires a combination of many mental operations such as comprehending information, establishing relationships and making these relationships functional (Spearman, 1927; cited in Sheffield, 1994). According to Werdelin (1958), mathematical ability is the ability to understand and learn the nature of mathematical problems, symbols, methods and proofs; to retain this information in memory, to relate it to different and related problems, symbols, methods and proofs, and to reproduce it (as cited in Sak, 2004b).

According to psychologist Krutetskii, mathematically gifted individuals have a unique organization of the mind called "mathematical thinking". Krutetskii reports that mathematically gifted students, whom he describes as "very good", have *a* mathematical cast of mind. According to Krutetskii, mathematical cast of mind is the tendency to see the world and many non-mathematical events and phenomena through a mathematical prism. The mathematical way of thinking is to see the world through a mathematical eye. The mathematical eye is an eye that considers the mathematical aspects of phenomena and brings them to the forefront. With this eye, students observe everything around them with their quantitative and spatial relationships (Krutetskii, 1976, as cited in Budak, 2008). Krutetskii (1976) defined mathematical ability or mathematical thinking as understanding (solving) the structure of mathematical problems, generalizing mathematical relationships and numerical structures, performing operations with numbers and symbols, transforming one cognitive process into another, understanding and mastering the concepts of mathematical space, and remembering mathematical structures and generalizations (Cited in Cai & Cifarelli, 2005). Polya (1945) described mathematical ability as the ability to make analogies and solve mathematical problems.

When mathematical thinking is mentioned, the first thing that may come to mind is the effective use of mathematical rules and systems to reach a certain result in a mathematical situation. However, as Henderson (2003) states, mathematical thinking is the application of mental processes, explicitly or not, in solving mathematical problems rather than doing mathematics. If the solution of a problem requires higher-order thinking skills such as specialization, generalization, prediction, hypothesis generation, and checking the accuracy of the hypothesis, this process is realized through mathematical thinking (as cited in Yeşildere & Türnüklü, 2007). Mathematical thinking also includes higher-order thinking skills. To be explained for a mathematical situation, mathematical thinking requires not only understanding how mathematicians prove theorems, but also how they make predictions in order to do so (Polya, 1945, 1957). Therefore, when a problem is encountered, it can be thought that it requires mathematical thinking processes and mathematical ability to examine the problem with its various dimensions, rather than calculating for the solution of that problem.

Based on the work of Polya (1945) and Krutetskii (1976), Kiesswetter (1985) defines giftedness in mathematics as "a set of identifiable abilities of an individual". According to Kiesswetter (1985), a mathematically gifted student achieves high scores on relevant tests and subtests by showing success in mathematics or mathematics-related fields. The SAT (*Scholastic Aptitude Test*) test mentions a number of sub-abilities related to these mathematical tasks and subtests. These are: organizing relevant information and materials, identifying rules and models, changing the presentation of the problem and identifying rules and models in this new problem, comprehending complex structures and working with these structures, managing the process, constructing related structures or problems (cited in Wagner & Zimmermann, 1986).

Mathematically gifted students are individuals with deep curiosity, analytical thinking, verbal ability and active imagination (House, 1987; as cited in Diezmann & Watters, 2000). House (1987) defines gifted mathematical ability as a combination of enthusiasm, natural mathematical ability and mathematical creativity. According to House, mathematical ability is the ability to recognize/perceive the desired structured structure within a mathematical problem and to operate within this structure, to make logical generalizations and inferences, to move easily from one knowledge or approach to another and to recognize unrelated knowledge, to operate with spatial concepts and symbols, to recognize relationships, differences and models easily and quickly, to transform relationships and facts into mathematical structure and to visualize them in the mind, and to provide clarity, clarity and rationality in arguments (Cited, Mingus & Grassl, 1999).

Mathematical ability is more than being able to perform arithmetic operations in mathematics or to score high on mathematics achievement tests; it is the ability to understand mathematical ideas and to draw mathematical conclusions. It is also numerical awareness and curiosity; the ability to learn, understand and apply mathematical ideas; the ability to think and work practically; the ability to recognize mathematical relationships and models; the ability to find flexible and creative ways of solving mathematical problems rather than using familiar ways; and the ability to transfer knowledge to new and unfamiliar situations (Miller, 1990).

In general, gifted students differ from other students in three areas that are very important for mathematics: *1) speed of learning, 2) depth of understanding, and 3) interest.* Students who are gifted in mathematics also differ from their peers in some skills. They can formulate mathematical problems much more easily than their peers and are more flexible in the use of data and more advanced in its organization. They have a high ability to transfer ideas and make generalizations. These students tend to "generate alternative solutions", "have a great interest in mathematics" and "look at the world from a mathematical perspective" (Johnson, 2000; as cited in Davaslıgil, 2004).

Cameron "s (1925) definition of mathematical ability differs from the above definitions in that it evaluates the process.

Cameron defines the most important aspects of mathematical ability as the ability to reconstruct mathematical elements, the combination of these structures and the analysis of their combinations, the comparison and classification of numerical and spatial data, concrete imagination and practicality in mechanical operations, the application of general principles and the ability to process abstract quantities. In this definition, Cameron emphasizes both mathematical processes and mathematical content knowledge (cited in Sak, 2004b).

2.1.2. Sub-dimensions of Mathematics Ability

Thinking is an action that is functional, active and has a specific goal (Rogoff, 1990; as cited in Yeşildere & Türnüklü, 2007). In the literature, mathematical thinking and mathematical mental processes are directly related to problem solving skills. Problems differ in themselves. These differences may vary in many aspects such as the scope of the problem, the discipline to which the problem belongs, the level of knowledge required for the solution and the benefit that the solution of the problem will provide (Sak, 2004b). These differences in the structure of problems naturally affect the solution process. Each problem encountered requires the formation of a new idea for the solution of that problem. From this perspective, it can be said that thinking takes place in every situation where problem solving is involved. Sternberg (2000) argues that in the problem solving process, analytical thinking, creative thinking and He argues that three different ways of thinking, namely practical thinking, can be used together or separately.

Therefore, mathematical thinking creates some processes while solving mathematical problems. According to Goldman (2002), higher order thinking skills such as creative thinking, analytical thinking, interpretive thinking, reasoning and logical thinking are more important in the mathematical process, while lower order thinking skills applied while performing simple mathematical operations are less valued (cited in Yeşildere & Türnüklü, 2007). According to Krulik and Rudnick (1999), mathematical thinking skills can range from simple to complex, such as recall, simple thinking, critical/critical thinking and creative thinking (as cited in Günhan & Başer, 2009).

2.1.2.1 Logical Thinking

Logical thinking skill, which is one of the cognitive skills that have an important place in the success of students, is one of the most emphasized topics in educational studies (Barr, 1994; as cited in Yaman, 2005). Logical thinking is known as one of the characteristics of Piaget "s cognitive developmental stages of concrete and abstract processing period. Students in the concrete operations period can use logical thinking skills in solving concrete problems. In the abstract operations period, they reach the level of adults in terms of logical thinking (Selçuk, 2001; as cited in Yaman, Karamustafaoğlu, & Karamustafaoğlu, 2005). This skill is the ability of an individual to solve a problem by performing various mental operations or to reach principles and laws by making some abstractions and generalizations (Korkmaz, 2002; as cited in Yaman et al., 2005). Lawson, who tried to explain Piaget "s logical thinking skill, put forward the multiconditional hypothesis theory to reveal this skill. According to this theory, in logical thinking, it is necessary to choose the most appropriate one among multiple answers to a proposition (Norman, 1997; Yaman, 2005; as cited in Koray & Azar, 2008). According to this theory, logical thinking is choosing the appropriate option. Logical knowledge includes concepts, knowledge and high-level ideas formed through trial, error and observation. This is a knowledge that can be created by the individual himself/herself in the human mind (Yaman, 2005).

2.1.2.2 Reasoning

All rules and operations in mathematics are based on reasoning (Umay, 2003). Reasoning is the process of thinking and reaching a rational conclusion by considering all factors. According to Umay, someone who can reason about a subject:

i. has sufficient level of knowledge,

ii. examines and explores the new situation in all its dimensions, makes logical predictions and assumptions,

iii. thoughts justifies it, some Conclusions reaches, reached can explain and defend the result.

Associating mathematics with its own operational priority with the help of reasoning, questioning its structure and knowing why it does what it does, ensures the formation of a mathematics that is both permanent and open to development. Mathematical reasoning both progresses and is structured on a mathematical network of knowledge. Seeing mathematics as a network of multi-related ideas is both a result of the emphasis on reasoning and a basis for further reasoning (Umay & Kaf, 2005). Studies show that students who are successful in school mathematics are not as successful in real life situations. A similar finding is that people who successfully use mathematics in daily life, on the street, in the market, are not successful when asked to express their ideas mathematically (Sternberg, 1996, 1999; Umay & Kaf, 2005).

2.1.2.3 Analytical and Creative Thinking

The use of analytical ability occurs in problem solving, in the process of thinking about the problem and trying to reach a conclusion. The process of using analytical ability in decision-making is the process of choosing the most appropriate one among different options or evaluating opportunities (Sternberg, 1997). According to Sternberg, there are many different ways of using analytical ability. These include comparison, deduction, induction, criticism, interpretation and evaluation.

Analytical ability involves using performances of intelligence such as analyzing, making comparisons, comparing, evaluating and judging. Analytical ability emerges in the dimension of abstract thinking (Sternberg, 1977). According to Sternberg, he analyzed analytical problems, such as making analogies, by breaking them down into their components to understand the foundations of each analytical ability in the knowledge process. Coding, inference and comparison are considered as important processes in solving analytical problems.

Poincare argued that there are two types of superior mathematical abilities: analytical and creative (as cited in Gould, 2001). Polya (1954) and Hadamard (1945) also support this distinction. In a similar definition, Usiskin (2000) defines mathematical ability gradually and combines it with mastery of mathematical knowledge. According to him, the highest level of mathematical ability is creativity in mathematics in a test in which mastery of mathematical knowledge is also emphasized (as cited in Sriraman, 2005).

A review of the literature shows that there is no consensus on the definition of mathematical creativity (Sriraman, 2005). In the definitions compiled by Sriraman, mathematical creativity is: seeing or sensing the forces in problems (Hadamard, 1945; Poincare, 1958); distinguishing between useful and useless structures in a problem (Birkhoff, 1969); and mastering the non-algorithmic decision-making process (Ervynck, 1991). However, at the secondary level, creative mathematical ability is the process of finding unusual solutions and/or ways of solving given problems or analogical problems and imaginatively discovering new/possible situations, formulas and relationships from an old problem (Einstein & Inheld, 1938; Kulh, 1962; cited in Sriraman, 2005). According to Lamon (2003), mathematical creativity is to come up with an unusual and original solution even for a problem that can be solved with a standard algorithm (as cited in Chamberlin & Moon, 2005). When given a problem, students who are creative in mathematics tend to reconstruct the mathematical problem or make analogies between problems (Polya, 1945). According to Ervynck (2002; 47), mathematical creativity is the ability to solve mathematical problems, to develop ideas within the mathematical structure, to make unusual logical-deductive inferences across disciplines or studies, that is, to reach important core structures of mathematics from general concepts. Zimmermann (1999) defines creativity as problem He defines creative problem solving in four stages: *finding* complementary *similarities, dual design* (visual-perceptual/formal-logical), multidimensional classification and complexity reduction (Meissner, 2006).

Sternberg (2000) also defined creativity as creating unusual, original but useful products. Based on all these definitions, mathematical creativity can be defined as solving mathematical problems in a different and unusual way, recognizing structures in problems and generalizing these structures to new situations, and reaching new formulas and generalizations from problems.

Martindale (1995) discusses analytical and creative thinking with a deductive explanation based on the premise that creative ability is not possible. Because creative productions in conclusions and propositions usually require divergent thinking. Analytical thinking, on the other hand, involves breaking down the problem and evaluating and interpreting these parts, and a good focus on the components of the problem is necessary for a solution (Dykes & McGhie, 1976).

Creative ability in mathematical thinking is the ability to perceive relationships and patterns in complex and non-algorithmic thinking and to think originally in mathematical symbols by proposing multiple solution strategies and/or solutions (Munro, 2000; Smith & Stain, 1998; Stain, Smith, Henningsen, & Silver, 2000; as cited in Livne & Milgram, 2006). Creativity is a rare talent and feeds on innovation. Analytical ability includes not only innovation but also analysis, comparison, contrast and evaluation. The consensus among researchers is that creativity is a higher cognitive ability (Martindale, 1999). Because creative ability discovers. It recreates. It creates new theorems out of theorems. It discovers new relationships and rules within rules.

On the other hand, according to Poincare (1952) and Hadamard (1945), cognitive levels are explained by divergent and convergent thinking. While the components that bring convergent thinking together are superficial, some of the components that bring divergent thinking together may be deeper and more obscure. According to Sak (2004b), the former describes an analytical type of thinking, while the latter characterizes a creative brain. Again, Poincare (1958) draws the distinction between analytical and creative thinking as follows: all creative people are also analytical people who are capable of analytical thinking may not have the necessary creativity. According to Poincare, analysts can perform analytical operations very well but are weak in creativity. Creators have the potential to analyze and create. According to him, analytical thinking in mathematics means being able to show different mathematical solutions or combinations. However, mathematical creativity is the ability to select and use the appropriate one among the solutions or combinations (as cited in Gould, 2001). As can be understood from this definition, analytical thinking in mathematics is an ability that involves high-level cognitive skills. It involves important processes such as analyzing and combining relationships. However, mathematical creativity involves higher level thinking skills including analytical thinking.

2.1.3. Domain Expertise in Mathematics

Mathematics is a science that progresses cumulatively due to its structure. Gaps between mathematical knowledge prevent the mathematician from progressing. Therefore, unlike other sciences, mathematics requires a field specialization.

According to Sak (2009), in order to understand and evaluate mathematics, it is important to have a master mind, that is, to develop domain expertise in mathematics. However, although domain expertise in mathematics depends on mathematical knowledge rather than cognitive processes, it is directly related to mathematical analytical ability and mathematical creative ability. Analysts and creators differentiate in their cognitive processes. However, they do so through their mathematical knowledge. It is accepted that the mathematical thinking structure of individuals with knowledge in mathematics, field experts, has different thinking processes than those who are not knowledgeable in mathematics (Chi, Glaser, & Farr; 1988, Ericsson, 2003). Those who work and conduct research on learning-teaching processes in mathematics emphasize the importance of domain knowledge in mathematics as well as cognitive processes such as deduction and induction (Martindale, 2003; as cited in Sak, 2009).

According to Sak (2004b, 2009), the state of having skills can be conceptualized through the interaction of three ideas. For example, the interaction of expertise and analytical ability creates an expert analyst. This person is proficient in both domain knowledge and analysis. The interaction of expertise and creativity creates a creative expert. This expert is strong is a free thinker with intuition and at the same time has considerable domain knowledge. For the same reason, the interaction of analysis and creativity is the source of the creative analyst, who is capable of both logical reasoning and possibly flexible thinking. As a result, the interaction of all components leads to the expert. This expert combines logical analytical ability, domain knowledge and creative efficiency.

2.2. Tests Used in the Identify of Mathematics Ability

The sooner a student with precocious mathematical development is helped to escape from academic boredom and frustration in the classroom, the more likely it is that his or her potential can be utilized for the benefit of society and youth (Stanley, 1997). From this point of view, it is possible to emphasize how important it is to recognize and identify the potential of a student gifted in mathematics. However, the process of identifying a student gifted in mathematics usually begins with teacher nomination, peer nomination, parent nomination and/or teacher observation. In the continuation of the process, students are directed to standardized or standardized tests and their potential is generally interpreted according to the results of these tests.

The tests that can be used to discover mathematical ability should be examined under different headings. These can be grouped as intelligence tests, creativity tests, mathematics achievement tests and mathematics aptitude tests. From here on, the identification of mathematics ability will be discussed under these headings.

2.2.1. Intelligence Tests Used in the Identify of Mathematics Ability

Intelligence tests are used to test potential and intelligence quotient scores are often used to predict later test scores. According to Miller (1990), intelligence tests can provide valuable data on the level of mathematical ability. However, when used alone, these intelligence tests are insufficient for the Identify of mathematics ability (Miller, 1990; Davaslıgil, 2004). In a similar sense, high intelligence quotient score alone is not sufficient to predict or determine an individual's future performance (Niederer & Irwin, 2001; Span et al., 1986; as cited in Budak, 2008). Because while intelligence scores are a summary of many different abilities, mathematics ability is an ability in itself. For example, suppose there are two students who have the same intelligence score in an intelligence test. One of these students scored high in mathematics and low in verbal, while the other student scored high in verbal and low in mathematics. Although they both have the same intelligence quotient score, it is clear that the first student is more talented in mathematics than the second student. This shows that students with high intelligence quotient scores cannot be assumed to be gifted in mathematics.

The Test of Basic Abilities (TKT) 5-7, which is widely used in Turkey for the Identify of giftedness, is a group test and was developed by T. G. Thurstone and L. L. Thurstone as three separate forms to be applied to 5-7, 7-11 and 11-17 age groups. The 5-7 form of this test is widely used by Guidance and Research Centers (GRCs) in Turkey for pre-selection purposes. The TKT 5-7 consists of four subsections and a total of 130 question items. These are: language concept, discrimination speed, number concept and place concept. The TKT 5-7 Group Intelligence Test, which is widely used in our country, was translated into Turkish in 1953 and partially adapted. In the Turkish standardization study of the TKT 5-7 test completed in late 1992, it was found that the test items were discriminative and reliable (except for three items) and that all items were at the desired level. When the test is considered as a whole, it is a test of medium difficulty. The results showed that TKT 5-7 is a reliable and homogeneous test in terms of the characteristics it is intended to measure (MEB, 1994; 58).

2.2.2. Creativity Tests Used in the Identify of Mathematics Ability

Just as creativity tests are used to diagnose giftedness, some of the tools used to diagnose giftedness in mathematics are mathematical creativity tests. The basic structure of creativity tests is to assess the fluency, flexibility and originality of an individual's responses/ideas to open-ended questions. How useful are the results of creativity tests in diagnosing mathematical ability? (Miller, 1990). For example, the test battery of the Torrence test developed in 1966 consists of "verbal" and "figural" parts. There are seven subtests in the verbal part and three subtests in the figural part, totaling 10 subtests. The subtests in the verbal part are respectively: "asking questions, predicting causes, predicting consequences, product development, unusual uses, unusual questions, hypotheticals". In the figural section, there are subtests named "picture creation, picture completion, parallel lines" respectively. Tests in the verbal and figural sections are answered in a timed manner (Arslan, 2001). Although different norms of the test were developed in later years, the general framework of the test is based on "verbal and formal" creativity. Research has shown that in all creativity tests, mathematically talented students who are engaged in mathematical tasks are able to behave creatively, although there does not seem to be a significant correlation. In addition, higher-order measures of creativity associated with mathematics can be seen as a clear marker of mathematical ability (Miller, 1990). The correlation between mathematical creativity tests and an individual's scores on achievement tests was surprisingly high. It can be said that the student's score on open-ended questions in mathematical creativity tests is directly related to the student's mathematical ability and knowledge (Haylock, 1987). From this point of view, mathematical creativity tests can be used as a valid tool for identifying mathematically gifted students. However, students in different educational regions may be disadvantaged in the mathematics education they receive. In this respect, they may not perform very well in tests based on mathematical knowledge. In order to identify such students, it would be more appropriate to use tests that require less mathematics content knowledge when measuring mathematical ability.

Different tests have been developed since the 1960s to measure mathematical creativity. The main features of the tests are to ask students for as many different solutions as possible by posing open-ended questions. The test designed by Evan (1965) aimed to measure the mathematical creativity of students in the second level of primary education. Consisting of 16 subtests, the test evaluated students' solutions on the basis of fluency, originality and flexibility. Similarly, the test developed by Spraker in 1960 to measure 8th graders' creativity in mathematics was based on finding different solutions to 31 problems. The points that could be obtained from the questions in the test ranged from 1 to 4, depending on the effectiveness of the solutions (Aiken, 1973).

The MACAM (Multiscale Academic and Creative Abilities in Mathematics) test is a diagnostic test of academic ability and creative mathematical ability. This test measures domain-specific academic and creative ability in mathematics in four stages. The test consists of 16 items in total, eight of which measure academic and eight of which measure creative ability. Each academic question requires standard logical thinking and a single solution to arrive at a correct answer. Each creative problem is based on non-standard creative thinking and more than one solution to reach a single correct answer. In this test, where a total of 16 open-ended questions were asked, the value of the correct solution of each question is between 0-7 points. The participant scores between 0-64 points (Livne, Livne, & Milgram 1999; Livne & Milgram, 2006). Different studies have been conducted with this test in Israel and reliability and validity studies of the test have been completed. The test has been used as a diagnostic tool in student identification processes in different educational programs.

2.2.3. Mathematics Achievement Tests Used to Measure Mathematics Ability

Students who score above 95% or 97% of the national norms in mathematics achievement tests may be highly gifted in mathematics (Dağlıoğlu, 2004). This is because being successful in mathematics, i.e. being knowledgeable, is an indicator of giftedness in mathematics, as emphasized earlier. Standardized achievement tests may not reveal superiority or giftedness in mathematics. One reason for this is that these tests concentrate on low-level cognitive tasks (Romberg & Wilson, 1992). In other words, mathematics achievement tests cannot be used as a diagnostic tool due to the level of the questions used in these tests and the inadequacy of these questions to measure high-level abilities. However, it is also possible that students in the top 3% or 5% of these achievement tests may be gifted in mathematics. In general, students who fall into these achievement brackets in mathematics achievement tests can be accurately diagnosed by applying mathematics aptitude tests.

The Study of Talent Search Programs developed by Stanley, Keating and Fox (1974) and widely used in Talent Search Programs One of the most well-known approaches, called Precoucious Youth (SMPY), is the search for apparent talent rather than unrealized potential. In this approach, the indicator of mathematical ability is doing well on the math section (SAT-M) of the Scholastic Aptitude Test (SAT) at a younger age. This test is administered at 11th and 12th graders' mathematical reasoning abilities. However, Stanley, Keating, and Fox used this approach, namely SAT scores, to test the abilities of 7th graders in the Talent Search Program at Johns Hopkins University. Thus, the use of the SAT to find gifted students in mathematics appears to be a successful strategy in primary education (Callahan, 2001; Robinson, Aboott, Berninger, Busse, & Mukhopadhypay, 1997; VanTassel-Baska, 1998; 2001; cited in Davaslıgil, 2004).

Another test, called Explore, is a four-choice test with questions drawn from four different domains. These areas are English, mathematics, reading and science. The test prepared at the eighth grade level is used as a diagnostic tool in some universities in the United States for the identification of elementary school students with above-level achievement tests (Rotigel & Lupkowski-Shoplik, 1999). Again, according to Davaslıgil (2004), in recent years, using measures called PLUS and EXPLORE, aptitude testing has been pushed back to *the 5th* grade (Robinson, Abbott, Berninger, & Busse, 1996; Robinson, Abbott, Berninger, Busse, & Mukhopadhyay, 1997). Assouline and Lupkowski (1992) suggest that the *Secondary School Admission* Test (*SSAT)* should be administered to *4th* and *5th* grade students who fall in the top 5% of the grade level tests. Davaslıgil used the Turkish versions of these tests in his research titled "Early Estimation of Mathematics Ability".

2.2.4. Mathematics Ability Tests Used in the Identify of Mathematics Ability

According to Bloom (1979), ability is a word with meanings such as inherent skills and potential. Aptitude tests usually provide an indication of the relevant learning that has taken place in the family, school and the wider social environment, some special qualities that are expected to facilitate further learning, and signs that are predictive of further learning. Generalized tests based on intelligence quotient The use of field-specific diagnostic tests to diagnose a specific ability in a particular field will facilitate accurate Identify. There are also some mathematics aptitude tests that have been developed and used regionally or universally in the Identify of mathematics ability. In short, it is possible to determine the degree of a student's learning or predisposition towards a certain subject and the student's background in terms of related learning through aptitude tests (Ergün, Özdemir, Çorlu, & Savran, 2004).

The Comprehensive Mathematical Abilities Test (CMAT) is a mathematics ability diagnostic test consisting of six main subtests (addition, subtraction, multiplication, division, problem solving, diagrams, tables and graphs) and six supplementary subtests (algebra, geometry, rational numbers, time, money and measurement). The main subtests are intended to provide an overall mathematics score, while the supplementary subtests are intended to provide information about higher-level mathematics ability. Approximately 1625 students participated in its administration in 17 states of the United States. As a result of this application, the reliability of all subtests of the test was found to be between .80 and .92. In the mixed results, the values were between .93 and .98. These values show that the test has a high level of reliability.

The Quantitative Aptitude Test is a subtest of the Differential Aptitude Tests battery developed in the United States of America to determine the different ability characteristics of individuals (Benett, Seashore, & Wesman, 1992; Savran, Sert, & Uzun, 1999). The linguistic equivalence, validity and reliability of the test suitable for Turkish conditions was carried out by Topsever (Yurdal, 1992; as cited in Savran et al., 1999). This test consists of 40 items designed to measure students' level of understanding of numerical relationships and is a special aptitude test lasting 30 minutes. All questions are based on knowledge of 4 basic operations and do not include verbal expressions. It can be administered to individuals as a group or individually. The half-test reliability coefficient calculated with the Spearman-Brown formula is .90, and the reliability coefficient between parallel forms is .68 for boys and .70 for girls.

Another test used to diagnose mathematics ability in Turkey is the School and College Ability Test (SCAT) by Mills, Ablard, and Stumpf (1993). This test was used to determine the mathematics ability of 2nd-6th grade students. Students were administered the version of the test that was 2 grades above the grade they were attending. Although the SCAT has been used since the second grade, its negative aspect is that it is based on little mathematical knowledge (Davaslıgil, 2004).

> Raven "s Standard Progressive Matrices (SPM) are among the tests used in the early identification of gifted students because they measure mathematical abilities but are not based on mathematical knowledge (Matthews, 1988; Robinson, Bradley, & Stanley, 1990). According to Kirby and Williams (2000), there are two types of processing: concurrent and sequential. The essence of sequential processing is the realization of order and sequence. On the other hand, the essence of simultaneous operation is based on the realization of relationships. Problem solving in arithmetic is a simultaneous process and the Raven SPM test is a commonly used test to test simultaneous processing. The solution of this matrix test requires the construction of a spatial pattern. Once such a pattern is constructed, the option that completes the pattern can be selected (Das, Kirby, & Jarman, 1979; Kirby & Williams, 2000; Robinson, Bradley, & Stanley, 1990). Standard Progressive Matrices (SPM) is not a test of general

intelligence. It is a test that measures the ability to understand relationships between meaningless shapes. It consists of 60 items in 5 sets of 12 problems each (as cited in Davaslıgil, 2004).

2.3. Mathematics Aptitude Test (TMT)

The Mathematics Aptitude Test (MATT) was created based on Sak "s (2004b) Triple Model of Mathematics Aptitude (M³). The Triple Model of Mathematical Ability was proposed by Sak based on the studies of Polya (1954;1957), Poincare (1958) and Krutetskii (1976) on mathematical ability, the theory of successful intelligence (Sternberg, 1997) and research on expertise (Ericsson, 2003). This model is also based on the teachings of mathematicians on types of giftedness, expertise, and mathematical ability as proposed by Sternberg (2000). In summary, the Triadic Model of Mathematical Ability is a model that proposes that mathematical ability is a combination of analytical, creative, and domain expertise model. According to this model, the combination of analytical and creative talent constitutes a creative analyst, the combination of creative talent and domain expertise constitutes a creative expert, the combination of analytical talent and domain expertise constitutes an analytical expert, and the combination of analytical talent, creative talent and domain expertise constitutes an expert. This model, the TMT, which is based on the M^3 model, is used to identify students who are gifted in mathematics. (Related questions can be seen in Appendix-3.)

TMT is a test consisting of 48 questions and includes a total of twelve subtests. There are four questions in each subtest, from simple to difficult. Each question in the subtest is evaluated on its own. Question scoring is based on the classical item difficulty method. The maximum score that can be obtained from a question is "1". Each participant receives points from the questions in inverse proportion to the item strength ratio. The scores obtained from each question are added to the base score to obtain the participant's score.

Since the TMT is a test prepared to diagnose only mathematics ability, it differs from other tests in some aspects in the diagnostic process. TMT is not a general intelligence test. It aims to diagnose students with a performance based on mathematics ability. In this sense, it differs from general intelligence tests.

The TMT is not just a test of knowledge or achievement. It aims to measure the subcomponents of mathematical ability with little or no need for mathematical knowledge. This makes it possible to diagnose the mathematical ability of gifted students who have been disadvantaged in mathematics education.

As Ericsson (2003) and other experts (Chi et al., 1988; Martindale, 1995) emphasize, domain knowledge in mathematics is an important criterion for giftedness. The TMT does not only consist of knowledge subtests. However, the knowledge subtests of the TMT are also intended to identify domain expertise in mathematics. In this respect, it differs from its counterparts, such as the Numerical Aptitude Test. In this respect, the TMT also differs from other aptitude tests.

The TMT does not have subtests that directly measure creative ability. Creativity tests are constructed by directing open-ended questions and each correct method applied by the student is evaluated as a correct answer. TMT is a test consisting only of multiple-choice questions. In this sense, it is different from creativity tests. This is the weakness of the test.

However, the use of multiple-choice questions instead of open-ended questions increases the reliability of the test. In this respect, TMT can be said to be stronger than creativity tests.

TMT is not an adaptation test. It was developed by field experts and mathematics teachers working in the Turkish education system. Therefore, it was created based on the cognitive characteristics and mathematical knowledge of the targeted student group. In this sense, the test is different from other adaptation tests.

TMT is an individually administered test based on individual performance. In this sense, it is different from group aptitude and intelligence tests. Equal time and equal conditions were provided to each participant during the administration of the test. Since it is not a group test, it is assumed that the degree to which individuals are affected by each other and the degree to which they are affected by the environment are almost equal since they are in the same conditions.

2.3.1. TMT Subtests

2.3.1.1. Subtest 1: Number Sequences

The questions in this subtest consist of sequences of numbers. These questions can be classified as ascending sequences of numbers, descending sequences of numbers, complex sequences of numbers, associative sequences of numbers, completing the missing term of a sequence, finding the wrong term of a sequence, and rules in sequences.

Questions involving numerical sequences are questions that measure students' skills such as seeing different relationships between numbers, carrying relationships, and establishing functional relationships between numbers. This subtest aims to measure students' analytical thinking skills. However, the solution of the questions may require some level of mathematical content knowledge.

2.3.1.2. Subtest 2: Numerical Analogy

In the numerical analogy subtest, like the other subtests, there are four questions ranked from easy to difficult. In the question types in which the relationship in the first number group is given from two number groups and the relationship in the second number group is asked, students are expected to analyze the linear or quadratic functional relationships between number groups. While solving the relationship structures, students are required to see these relationships, recall the relevant schematic information from memory and make associations. This subtest aims to measure the student's analytical thinking skills. The solution of the problems in the test may require some knowledge of mathematics, albeit at a low level.

2.3.1.3. Subtest 3: Figurative Rotation

In this subtest, students are expected to recognize the appearance of figures of different sizes with some features from different perspectives, projection or rotation from different degrees. Students should be able to imagine, visualize, elaborate and mentally rotate these figures or diagrams in three dimensions. In this way, students make comparison, elaboration, evaluation, mental visualization as sub-skills of analytical thinking skills with questions ranked from simple to difficult. This subtest is expected to measure students' analytical thinking skills and creative abilities.

2.3.1.4. Subtest 4: Figurative Sequences

With the questions in this subtest, students are expected to be able to discover the relationships between visual elements formed according to a certain rule. In figurative sequences, the shapes are formed as a sequence within a certain rule. While solving these questions, students are expected to find the numerical or visual relationship between the shapes and discover the function of the relationship. In this way, students establish numerical and visual relationships, make comparisons, look for contrasts, make associations and find solutions. This subtest is expected to measure students' analytical thinking skills. However It can be said that this subtest partially measures students' creative abilities, albeit indirectly.

2.3.1.5. Subtest 5: Figurative Analogy

In the figurative analogy sub-test, students are expected to perform tasks such as establishing similar relationships between two different shapes by giving the relationship between two shapes, finding the relationship and applying it to other shapes, discovering the relationship between the shapes and revealing the shape that will create integrity, and recognizing the shape that reveals the rule in questions ranked from easy to difficult. In this way, students' cognitive skills such as discovering relationships, creating new information and structures, and constructing existing structures are measured. With this subtest, analytical thinking and partially creative thinking are tried to be measured. Students do not need mathematical knowledge when solving the questions in this subtest.

2.3.1.6. Subtest 6: Categorical Logic

In the categorical logic subtest, students are expected to reach other information by giving data classified according to a certain logic and system. While solving the questions in this subtest, students are required to select relevant and necessary data, eliminate unnecessary data, establish relationships between information, reconstruct information, and diagram data. The questions in this subtest are expected to measure students' analytical thinking skills. Students do not need or need very little algorithmic mathematical knowledge when solving the questions in this subtest.

2.3.1.7. Subtest 7: Conditional Logic

This subtest consists of problems structured with data consisting of a set of conditional propositions. In this subtest, the student is expected to find the correct cognitive skills such as finding the proposition, discovering the structures and relationships within the problem, structuring the information within the problem, and analyzing the problem. It is thought that students' analytical thinking skills are measured in this subtest. Students are expected to know some basic quantities to solve the questions in this subtest. This subtest is not a test that directly measures knowledge, but it also requires students to use their existing mathematical knowledge.

2.3.1.8. Subtest 8: Linear Logic

In this subtest, which consists of four questions like the other subtests, students are given some true propositions. Students are expected to arrive at different true or false propositions based on the given true propositions. In this subtest, students construct relationships between data. They form new propositions in line with the propositions. In this process, students analyze, discover opposites and contradictory propositions and create new propositions. This subtest is expected to measure students' analytical ability. In this subtest, students need mathematical knowledge, even at a small level, in order to understand, interpret and reconstruct basic propositions.

2.3.1.9. Subtest 9: Measurement

In the measurement subtest, which is one of the knowledge subtests, different measurement problems are posed to the students in order to measure their knowledge in the field of measurement as well as their problem solving skills. In the subtest, students encounter problems that measure units such as speed, time and height. In verbal or visual problems, students need to know basic information, associate them and solve the problem by analyzing them.

2.3.1.10. Subtest 10: Algebra

In the algebra subtest, some systems of equations and mathematical problems that are expected to be solved using algebraic concepts and equations at the elementary level are given.

The student is expected to use his/her mathematical knowledge and experience in solving these questions and to solve the given problems by making analogies. This subtest also measures whether students can use the knowledge they have learned so far.

2.3.1.11. Subtest 11: Geometry

Geometry is one of the learning areas of the elementary mathematics course. In the geometry subtest, problems based on geometry and mathematics knowledge covering geometry topics at primary school level are posed. With these problems, students' geometry knowledge is measured. Students are expected to extract the information they need to use, to reach the correct information, to obtain new and meaningful geometric shapes or information from the shape or shapes in the given problem, and to establish analogies in the process. This subtest is a knowledge subtest.

2.3.1.12. Subtest 12: Statistics and Probability

In this subtest, questions on probability calculation and inferring other information from probability calculation are asked. The questions on transforming statistical information into graphs and making sense of the information in the graphs are also used to measure students' knowledge of statistics. The problems in the subtest are intended to measure students' mathematical knowledge. However, it can be said that the subtest also measures students' analytical and creative abilities, albeit indirectly.

2.3.2. Research on TMT

Research has been conducted on different features of TMT. In this context, it would be useful to consider the development process of the TMT in three stages. In the first stage, the theoretical substructure of the test was developed by a team with expertise in mathematics education and psychometrics.

The question samples were developed gradually and in accordance with the structure. The difficulty levels of the sample questions were tried to be adjusted systematically. The questions in the pool were discussed and some questions were revised or removed from the question pool. The first version of the test was created by selecting 4 questions for each subtest deemed appropriate by the experts and 48 questions in total. Then, teachers with at least two years of experience teaching in primary schools were asked to rank the item difficulties of these questions and to express their opinions about the subtests. The question items were revised again in line with the feedback from the teachers. In the second stage, the test was piloted. After the pilot application, the test items were analyzed. In line with the results obtained from the analysis, the items and difficulty levels of the test were revised again. In the third stage, the TMT was administered to a total of 368 students, 236 boys and 132 girls, who were studying in the 6th and 7th grades. The test was administered simultaneously to all participants for 90 minutes (Sak et al., 2008, 2009).

2.3.2.1. Reliability of the TMT

As a result of the data obtained from the application mentioned in the previous section, the KR-20 reliability coefficient for the overall test was found to be .80. This shows that the test is moderately reliable. The reliability coefficient (Cronbach Alpha value) for the whole test was .76. This shows that the test is moderately reliable. The correlation values between the subtests of the test ranged from .26 to .66. When the correlation values of the subtests with the total test are examined, it is seen that the correlations of the categorical logic and figurative analogy subtests with the total test are low. The correlation values of the other subtests are higher than .45 and are acceptable (Sak et al., 2008, 2009).

2.3.2.2. Validity of the TMT

The criterion validity of the TMT was investigated by examining the relationship between the TMT and students' performance in the placement test (SBS). The correlation values between the two tests were .62 for 6th graders and .69 for 7th graders was found. These values indicate that the criterion validity of the FMT is at a good level (Sak et al., 2008, 2009).

On the other hand, the correlation value between the TMT and students' mathematics grades in school was calculated as .50 for 6th graders and .57 for 7th graders. These statistically significant values can be considered as additional evidence for the criterion validity of the TMT. However, these studies investigating the relationship between the TMT and both SBS and mathematics course grades were conducted on a group of students who applied to an education program for gifted students. The fact that most of the students who applied to the program had high levels of mathematics ability may be thought to be the reason why the ranges of both TMT and SBS and mathematics grades were low. It should be taken into consideration that the narrow score ranges of the variables may cause low correlation values. Therefore, when the same studies are conducted with different student populations, it is possible to obtain slightly higher values than the correlation values given above (Sak et al., 2008, 2009).

In order to determine the discriminant validity of the TMT, the performances of 6th and 7th grade students in the TMT were compared. The findings revealed that the mean scores of the 7th graders were significantly higher than the mean scores of the 6th graders (F (2, 288) = 14.66, $p < .001$). Effect size analysis (Cohen "s d) was used to test the magnitude of the difference between the means. The calculated effect size is also a medium-sized effect (Eta squared=,04). This indicates that the 7th graders performed better than the 6th graders ($p < .01$). These findings can be considered as scientific evidence on the discriminant validity of the FMT (Sak et al., 2008, 2009).

3. METHOD

In this section, explanations about the research model, the population and sample of the study, the data collection tool and the statistical techniques used in the analysis of the collected data are given.

3.1. Research Model

The research is a descriptive study. In the study, the single survey model, one of the general survey models, was used.

3.2. Working Group

The study group consisted of academicians working in the field of mathematics education and/or mathematical science at the faculties of education of state universities in three provinces of Turkey (Ankara, Eskişehir and İzmir) and elementary mathematics teachers working in Eskişehir province, each of whom had at least two years of work experience.

The study included 20 faculty members and 20 mathematics teachers. The 40 experts selected for the study group were identified using the "convenience sampling" method. In this method, the researcher defines the study group starting from the most accessible respondents until he reaches a group of the size he needs (Büyüköztürk, Çakmak, Akgün, Karadeniz, Demirel; 2008).

The determination of the study group was based on the volunteerism of the participants. The participants were recruited from the faculties of education of seven different universities in Ankara, Izmir and Eskisehir.

faculty members working in the field and elementary mathematics teachers working in elementary schools in Eskişehir province, each of whom had at least two years of work experience.

Table 1: Educational background of experts

	Education Area	License		Master's Degree		PhD	
		f	%	f	%	f	%
Teacher	Mathematics	5	25	1	5	-	-
	Mathematics Education	15	75	3	15	-	-
	Other	-	-	2	10	-	-
Academician	Mathematics	14	70	10	50	7	35
	Mathematics Education	5	25	8	40	12	60
	Other	1	5	2	10	1	5

As seen in Table 1, 15 (75%) of the participants who were teachers did their undergraduate education in mathematics teaching and 5 (25%) in mathematics science. Six of the teacher participants (30%) continued their postgraduate education with a master's degree. Among the participants who were teachers, 1 (5%) of them received graduate education in mathematics, 3 (15%) in mathematics education, and 2 (10%) in various branches of educational sciences. Among the participants who were academicians, 14 (70%) received their undergraduate education in mathematics, 5 (25%) in mathematics education, and one (5%) in other fields (machine teaching). Two (10%) of the participants who were academicians completed their master's degree in other fields

(Department of Statistics, Department of Measurement and Evaluation in Education), while one (5%) of the participants completed his/her doctorate in other fields (Department of Measurement and Evaluation in Education). Among the participants who were academicians, 18 of them, i.e. 90%, completed their master's degree in mathematics science or mathematics education, and 19 of them, i.e. 95%, completed their doctorate degree in mathematics science or mathematics education.

Table 2: Experts' teaching experience in primary schools

	Experience(years)											
	Nothing.		1-2		3-5		5-10		10-20		20- >20	
Profession	f	%	f	%	f	%	f	%	f	%	f	%
Teacher	-	-	-	-	7	35	7	35	3	15	3	15
Academician	13	60	4	20	2	10	1	5	-	-	-	-

As seen in Table 2 , teachers with at least two years of teaching experience 35% have 3 to 5 years of teaching experience, 35% have 5 to 10 years of teaching experience, 15% have 10 to 20 years of teaching experience, and 15%, i.e. 3 people, have 20 years or more of teaching experience. While 60% of the academics participating in the sample had no teaching experience at all; 20% had 1-2 years of teaching experience, 10% had 3-5 years of teaching experience and 5% had 1 year of teaching experience.

3.3. Data and Data Collection

3.3.1. Data Collection Tool

In order to measure the content validity of the FMT, the questions in each subtest and their possible solutions were given to the participants. After the fourth question of each subtest, the participant was asked an evaluation scale consisting of four questions. In this rating scale, the experts were asked to evaluate the extent to which the subtest measured mathematical analytical ability, mathematical creative ability, domain knowledge in mathematics, and general mathematical ability. Participants were asked to answer these four questions using a five-point Likert-type scale. The same four questions (Appendix 1) were then posed to the participants to evaluate the whole test.

In addition, enough space was left for the participants to make different revision and evaluation studies on each question and it was stated that the participants could make different evaluations required for each question or subtest in this space. At the end of the test, a space was left for the participants to make the relevant evaluations and they were asked to indicate their other opinions about the test in this space.

As a result of analyzing the data obtained from the participants, the reliability coefficient (Cronbach alpha) of the whole scale was found to be .96. The reliability coefficients for each subtest of the data collection scale used after each subtest ranged between .72 and .85. The average reliability coefficient of these subtests was .76.

3.3.2. Data Collection

The research scales were delivered to the academics and teachers who volunteered to participate in the study by the researcher and then collected back by the researcher. The number of academicians and teachers reached by the researcher was 27 and 31, respectively. However, a total of 21 scales were returned from academics who had completed their doctoral education and 22 scales were returned from teachers. Since one of the scales sent by the academics was incomplete, this scale was excluded from the research sample. Among the scales returned from the teachers, 20 of the participants with less than 2 years of teaching experience were randomly selected.

3.4. Data Analysis and Interpretation

The expert opinions collected on the content validity of the test were analyzed with both percentage and frequency distribution. Percentage values indicating the level at which each subtest measured the targeted mathematics skill were calculated according to the scores given by the participants to the subtests. Then, the ratios of the participants who rated the subtest as good and very good on the evaluation scale of the subtest and the ratios of all participants were taken. The values obtained from these ratios were compared with the value of .80 (Lynn, 1986) and comments were made about the content validity of the subtest. This value, which Lynn used as a basis for the participants in his studies, is frequently used as a comparison value in scale development studies today.

The corrections and relevant information added by the participants in the relevant blanks at the end of each subtest and the section where the participants wrote their comments about the test at the end of the test were analyzed by qualitative analysis method and the relevant discussions in the discussion section were supported by the data obtained from this analysis.

4. RESULTS AND INTERPRETATIONS

In this section, the findings that emerged as a result of the statistical analysis of the data collected for the research are explained.

The opinions of the experts who evaluated the test were compared with independent samples t-test in terms of the professions of the experts and no significant difference was found in the opinions of the experts in terms of their professions ($p > .05$). Based on this finding, the opinions of academicians and teachers were evaluated together.

4.1. Content Validity of the TMT

Validity is the ability of a measurement tool to accurately measure the characteristic it aims to measure. Content validity of a test refers to the relationship between the scope of the test and the scope of the construct it is intended to measure. In other words, content validity is the ability of the content of the measurement tool to sample the set of behaviors or characteristics measured. The main problem in content validity is whether the scale represents all observable markers of the attitude to be measured with the items in its scope. (Tezbaşaran, 2008;51)

In order to test the inclusiveness of the scale, the opinions of experts in the field related to the subject of the scale and the theoretical and practical studies conducted on this subject are generally utilized (Tezbaşaran, 2008; 51). Expert evaluation is aimed at revealing the basic factors related to the conceptual structure or determining whether the items developed are suitable for a certain conceptual or factorial structure. One of the methods used in content validity research by taking expert opinions is the Hambleton approach. The Hambleton approach was used in this study.

There are four stages in the approach called the Hambleton method. In the first stage, experts who are familiar with the content of the scale or test or who know the subject well are identified. In the second stage, a letter is sent to the experts with the definitions of the research area and the conceptual structure under investigation and a questionnaire form developed within this framework is sent. In the third stage, each expert independently evaluates the questionnaire on a graded scale. In the fourth stage, the scales given by the experts are evaluated for content validity (Şencan, 2005; 751).

In this section, the data collected to comment on the content validity of the test are tabulated. For each subtest, the content validity ratio value of the items in the evaluation scale was calculated. This section also includes the comments and opinions of the experts about the subtests of the test. Subtests whose primary purpose was to measure analytical ability in mathematics and subtests whose primary purpose was to measure content knowledge in mathematics were grouped under the same headings.

4.1.1. Analytical Ability Subtests

The primary purpose of the subtests discussed in this section is to measure analytical ability. These subtests are: number sequences, numerical analogy, conditional logic, linear logic, categorical logic, figurative rotation, figurative sequences and figurative analogy.

4.1.1.1. Number Sequences Subtest

The primary purpose of this subtest is to measure analytical ability and the secondary purpose is to measure creative ability. Expert opinions on the inclusiveness and adequacy of the subtest are given in Table 3 as frequency and percentage values.

Table 3: Percentage and frequency distributions of expert opinion on number sequences subtest

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	f	%	f	%	f	%
Measures at a very good level	9	22.5	8	20	5	12.5	9	22.5
Measures at a good level	22	55	16	40	11	27.5	17	42.5
Measures moderately	9	22.5	9	22.5	18	45	14	35
Measures at a low level	-	-	7	17.5	6	15	-	-
Never measures	-	-	-	-	-	-	-	-
Total	40	100	40	100	40	100	40	100

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As seen in Table 3, 31 participants (77.5%) stated that this subtest measures analytical ability at a very good or good level. This subtest also measured creative ability at a good level by 24 participants (60%) and general mathematical ability at a good level by 26 participants (65%). The majority of the participants reported that this subtest was not closely related to content knowledge. According to these findings, it can be said that the subtest measures analytical ability at a good level in accordance with its theoretical structure and measurement objective.

In order to find the content validity ratio of the subtest for measuring analytical ability and to compare it with Lynn "s (1986) threshold value for content validity (.80), .77 is reached when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is very close to .80, which is accepted as the threshold score for content validity of analytical ability. The creativity content validity of this subtest is .65. This value was well below Lynn "s threshold value. The analytical ability content validity of this subtest can be considered adequate and the creative ability content validity can be considered moderately adequate.

4.1.1.2. Numerical Analogy Subtest

The primary purpose of this subtest is to measure analytical ability and the secondary purpose is to measure creative ability. Expert opinions on the inclusiveness and adequacy of the subtest are given in Table 4 as frequency and percentage values.

Table 4: Percentage and frequency distributions of numerical analogy subtest expert opinion

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	f	%	f	%	f	%
Measures at a very good level	9	22.5	9	22.5	4	10	7	17.5
Measures at a good level	25	62.5	15	37.5	16	40	16	40
Measures moderately	5	12.5	10	25	14	35	15	37.5
Measures at a low level	-	-	5	12.5	5	12.5	1	2.5
Never measures	-	-	-	-	-	-	-	-
Total	39	97.5	39	97.5	39	97.5	39	97.5

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As seen in Table 4, 34 participants (85%), the majority of the participants, stated that this subtest measured analytical ability at a very good or good level. At the same time, 24 (60%) of the participants stated that this subtest can measure creative ability at a good level. As can be seen from the percentage and frequency values in the table, the participants reported that this subtest was not closely related to content knowledge. According to these findings, it can be said that the subtest measures analytical ability at a good level in accordance with its theoretical structure and measurement objective.

In order to find the content validity ratio of the subtest for measuring analytical ability and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .85 is obtained when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is above .80, which is accepted as the threshold score for content validity of analytical ability. The creativity content validity of this subtest is .60. This value was well below Lynn "s threshold value. The content validity of this subtest is adequate in terms of measuring analytical ability, and its content validity is moderate in terms of measuring creative ability.

4.1.1.3. Conditional Logic Subtest

The purpose of this subtest is to measure analytical ability. Expert opinions on the inclusiveness and adequacy of the subtest are given in Table 5 as frequency and percentage values.

Table 5: Percentage and frequency distributions of expert opinion on conditional logic subtest

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	f	%	f	%	f	%
Measures at a very good level	16	40	6	15	7	17.5	9	22.5
Measures at a good level	21	52.5	16	40	22	55	22	55
Measures moderately	2	5	13	32.5	10	25	8	20
Measures at a low level	1	2.5	5	12.5	1	2.5	1	2.5
Never measures	-	-	-	-	-	-	-	-
Total	40	100	40	100	40	100	40	100

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As seen in Table 5, 37 participants (92.5%), the majority of the participants, stated that this subtest measured analytical ability at a very good or good level. The frequency in the table shows that this subtest can also measure content knowledge.

(29) and percentage (72.5%) values. According to these findings, it can be said that the subtest measures analytical ability at a good level in accordance with its theoretical structure and measurement objective.

In order to find the content validity ratio of the subtest for measuring analytical ability and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .92 was found when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is above .80, which is accepted as the threshold score for content validity of analytical ability. Content validity of this subtest is sufficient in terms of measuring analytical ability.

4.1.1.4. Linear Logic Subtest

The purpose of this subtest is to measure analytical ability. Expert opinions on the inclusiveness and adequacy of the subtest are given in Table 6 as frequency and percentage values.

Table 6: Percentage and frequency distributions of expert opinion on linear logic subtest

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	f	%	f	%	f	%
Measures at a very good level	13	32.5	4	10	14	35	7	17.5
Measures at a good level	22	55	17	42.5	17	42.5	20	50
Measures moderately	4	10	13	32.5	9	22.5	12	30
Measures at a low level	1	2.5	6	15	-	-	1	2.5
Never measures	-	-	-	-	-	-	-	-
Total	40	100	40	100	40	100	40	100

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As seen in Table 6, 35 participants (87.5%), the majority of the participants, stated that this subtest measured analytical ability at a very good or good level. This subtest also measured content knowledge at a good or very good level.

31 participants (77.5%) stated this. According to these findings, it can be said that the subtest measures analytical

ability at a good level in accordance with its theoretical structure and measurement objective. Based on these findings, it can be said that this subtest also measures content knowledge in mathematics.

In order to find the content validity ratio of the subtest for measuring analytical ability and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .87 was found when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is above .80, which is accepted as the threshold score for content validity of analytical ability. It can be said that the content validity of this subtest is sufficient in terms of measuring analytical ability.

4.1.1.5. Categorical Logic Subtest

The purpose of this subtest is to measure analytical ability. The frequency distribution based on expert opinions on the comprehensiveness and adequacy of the subtest is given in Table 7 with percentages.

Table 7: Percentage and frequency distributions of categorical logic subtest expert opinion

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	F	%	f	%	f	%
Measures at a very good level	8	20	5	12.5	6	15	3	7.5
Measures at a good level	25	62.5	15	37.5	24	60	19	47.5
Measures moderately	6	15	13	32.5	9	22.5	17	42.5
Measures at a low level	1	2.5	7	17.5	1	2.5	1	2.5
Never measures	-	-	-	-	-	-	-	-
Total	40	100	40	100	40	100	40	100

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As seen in Table 7, 33 participants (82.5%), the majority of the participants, stated that this subtest measured analytical ability at a very good or good level. It can be understood from the frequency (30) and percentage (75%) values in the table that this subtest can also measure domain knowledge at a good level. According to these findings, it can be said that the subtest measures analytical ability at a good level in accordance with its theoretical structure and measurement objective.

In order to find the content validity ratio of the subtest for measuring analytical ability and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .82 was found when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is above .80, which is accepted as the threshold score for content validity of analytical ability. It can be said that the content validity of this subtest is sufficient in terms of measuring analytical ability.

4.1.1.6. Figurative Rotation Subtest

The primary purpose of this subtest is to measure analytical ability and the secondary purpose is to measure creative ability. Expert opinions on the inclusiveness and adequacy of the subtest are shown in Table 8 as frequency and percentage values.

Table 8: Percentage and frequency distributions of expert opinion on figurative rotation subtest

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	f	%	f	%	f	%
Measures at a very good level	16	40	20	50	6	15	11	27.5
Measures at a good level	13	32.5	11	27.5	14	35	14	35
Measures moderately	5	12.5	6	15	13	32.5	12	30
Measures at a low level	3	7.5	2	5	5	12	2	5
Never measures	2	5	-	-	1	2.5	-	-
Total	39	97.5	39	97.5	39	97.5	39	97.5

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As seen in Table 8, 29 participants (72.5%) stated that this subtest measured analytical ability at a very good or good level. It can be understood from the frequency (31) and percentage (77.5%) values in the table that this subtest can also measure creative ability at a good level. According to these findings, it can be said that the subtest measures analytical ability in accordance with its theoretical structure and measurement objective.

In order to find the content validity ratio of the subtest for measuring analytical ability and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .72 was found when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is below .80, which is accepted as the threshold score for content validity of analytical ability. The creativity content validity of this subtest is .77. This value is quite close to Lynn "s threshold value. It can be said that the content validity of this subtest in terms of measuring analytical ability is moderately adequate and the content validity in terms of measuring creative ability is adequate.

4.1.1.7. Figurative Sequences Subtest

The primary purpose of this subtest is to measure analytical ability and the secondary purpose is to measure creative ability in mathematics. Expert opinions on the inclusiveness and adequacy of this subtest are given in Table 9 as frequency and percentage values.

Table 9: Percentage and frequency distributions of expert opinion on figurative sequences subtest

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	f	%	f	%	f	%
Measures at a very good level	18	45	19	47.5	7	17.5	12	30
Measures at a good level	20	50	16	40	21	52.5	22	55
Measures moderately	2	5	4	10	11	27.5	5	12.5
Measures at a low level	-	-	1	2.5	1	2.5	1	2.5
Never measures	-	-	-	-	-	-	-	-
Total	40	100	40	100	40	100	40	100

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As seen in Table 9, 38 participants (95%), who constitute the majority of the participants, stated that this subtest measures analytical ability at a very good or good level. It can be understood from the percentage and frequency values in the table that this subtest can also measure creative ability (35; 87.5%), content knowledge (28; 70%) and general mathematical ability (34; 85%) at a good level. According to these findings, it can be said that the subtest measures analytical ability at a good level in accordance with its theoretical structure and measurement objective.

In order to find the content validity ratio of the subtest for measuring analytical ability and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .95 was found when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is well above .80, which is accepted as the threshold score for content validity of analytical ability. The creativity content validity of this subtest is .87. This value is above Lynn "s threshold value. The content validity of this subtest is sufficient in terms of measuring analytical ability and creative ability.

4.1.1.8. Figurative Analogy Subtest

The primary purpose of this subtest is to measure analytical ability and the secondary purpose is to measure creative ability in mathematics. Expert opinions on the inclusiveness and adequacy of this subtest are given in Table 10 as frequency and percentage values.

Table 10: Percentage and frequency distribution of expert opinion on figurative analogy subtest

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	f	%	f	%	F	%
Measures at a very good level	19	47.5	17	42.5	6	15	12	30
Measures at a good level	15	37.5	20	50	19	47.5	16	40
Measures moderately	6	15	2	5	10	25	11	27.5
Measures at a low level	-	-	1	2.5	5	12.5	1	2.5
Never measures	-	-	-		-	-	-	-
Total	40	100	40	100	40	100	40	100

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As seen in Table 10, 34 participants (85%), the vast majority of the participants, reported that this subtest measured analytical ability at a very good or good level. The majority of the participants (37; 92.5%) reported that this subtest also measured creative ability at a good or very good level. It can be seen from the frequency and percentage values in the table that this subtest can also measure general math ability (28; 70%). According to these findings, it can be said that the subtest measures analytical ability and creative ability at a good level in accordance with its theoretical structure and measurement objective.

In order to find the content validity ratio of the subtest for measuring analytical ability and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .85 was found when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is above .80, which is accepted as the threshold score for content validity of analytical ability. The creativity content validity rate of this subtest is .92. This value is well above Lynn "s threshold value. The content validity of this subtest is sufficient in terms of measuring analytical ability and creative ability.

4.1.2. Field Knowledge Subtests

The primary purpose of the subtests discussed in this section is to measure content knowledge. These subtests are: algebra, geometry, statistics-probability and measurement.

4.1.2.1. Algebra Subtest

The purpose of this subtest is to measure content knowledge. Expert opinions on the inclusiveness and adequacy of the subtest are given in Table 11 as frequency and percentage values.

Table 11: Percentage and frequency distributions of expert opinion on algebra subtest

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	f	%	f	%	F	%
Measures at a very good level	13	32.5	7	17.5	11	27.5	13	32.5
Measures at a good level	17	42.5	15	37.5	23	57.5	22	55
Measures moderately	8	20	10	25	6	15	5	12.5
Measures at a low level	2	5	8	20	-	-	-	-
Never measures	-	-	-	-	-	-	-	-
Total	40	100	40	100	40	100	40	100

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As can be seen in Table 11, 34 participants (85%), who constitute the majority of the participants, stated that this subtest measures content knowledge at a very good or good level. It can be understood from the percentage and frequency values in the table that this subtest can also measure analytical ability (30; 75%) and general mathematical ability (35; 87.5%). According to these findings, it can be said that the subtest measures domain knowledge at a good level in accordance with its theoretical structure and measurement objective.

In order to find the content validity value of the subtest for measuring content knowledge and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .85 was found when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is above .80, which is accepted as the threshold score for content validity. Content validity of this subtest is sufficient in terms of measuring content knowledge.

4.1.2.2. Geometry Subtest

The purpose of this subtest is to measure content knowledge. Expert opinions on the inclusiveness and adequacy of the subtest are given in Table 12 as frequency and percentage values.

Table 12: Percentage and frequency distributions of expert opinion on the Geometry subtest

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	F	%	f	%	f	%
Measures at a very good level	12	30	10	25	13	32.5	9	22.5
Measures at a good level	19	47.5	14	35	19	47.5	23	57.5
Measures moderately	8	20	9	22.5	8	20	8	20
Measures at a low level	1	2.5	6	15	-	-	-	-
Never measures	-	-	1	2.5	-	-	-	-
Total	40	100	40	100	40	100	40	100

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As can be seen in Table 12, 32 participants (80%), who constitute the majority of the participants, stated that this subtest measures content knowledge at a very good or good level. It can be understood from the frequency and percentage values in the table that this subtest can also measure analytical ability (31; 77.5%) and general mathematical ability (32; 80%) at a good level. According to these findings, it can be said that the subtest measures domain knowledge at a good level in accordance with its theoretical structure and measurement objective.

In order to find the content validity value of the subtest for measuring content knowledge and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .85 was found when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is above .80, which is accepted as the threshold score for content validity. Content validity of this subtest is sufficient in terms of measuring content knowledge.

4.1.2.3. Statistics-Probability Subtest

The purpose of this subtest is to measure content knowledge in mathematics. Expert opinions on the inclusiveness and validity of this subtest are given in Table 13 as frequency and percentage values.

Table 13: Percentage and frequency distributions of expert opinion on statistics-probability subtest

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	f	%	f	%	f	%
Measures at a very good level	13	32.5	9	22.5	11	27.5	9	22
Measures at a good level	22	55	17	42.5	22	55	22	55
Measures moderately	4	10	8	20	6	15	8	20
Measures at a low level	1	2.5	5	12.5	1	2.5	1	2.5
Never measures	-	-	1	2.5	-	-	-	-
Total	40	100	40	100	40	100	40	100

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As can be seen in Table 13, 33 participants (82.5%), who constitute the majority of the participants, stated that this subtest measures content knowledge at a very good or good level. It can be understood from the percentage values in the table that this subtest can also measure analytical ability (35; 87.5%) at a good level. According to these findings, it can be said that the subtest measures content knowledge at a good level in accordance with its theoretical structure and measurement objective.

In order to find the content validity value of the subtest for measuring content knowledge and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .82 was found when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is above .80, which is accepted as the threshold score for content validity. Content validity of this subtest is sufficient in terms of measuring content knowledge.

4.1.2.4. Measurement Subtest

The objective of this subtest is to measure content knowledge in mathematics. Expert opinions on the inclusiveness and adequacy of the subtest are given in Table 14 as frequency and percentage values.

Table 14: Percentage and frequency distributions of expert opinion on the measurement subtest

	Assessed Area							
	AY*		YY**		AB***		GMY****	
Degrees of evaluation	f	%	f	%	f	%	f	%
Measures at a very good level	8	20	5	12.5	9	22.5	9	22.5
Measures at a good level	18	45	12	30	19	47.5	17	42.5
Measures moderately	12	30	16	40	12	30	12	30
Measures at a low level	2	5	6	15	-	-	2	5
Never measures	-	-	1	2.5	-	-	-	-
Total	40	100	40	100	40	100	40	100

*AY: Analytical Ability, **A: Creative Ability, ***AB: Field Knowledge, ****GMY: General Mathematical Aptitude

As can be seen in Table 14, 28 participants (70%) stated that this subtest measured content knowledge at a very good or good level. It can be understood from the percentage values in the table that this subtest can also measure analytical ability (f=26; 65%). According to these findings, it can be said that the subtest measures content knowledge in accordance with its theoretical structure and measurement objective.

In order to find the content validity value of the subtest for measuring content knowledge and to compare it with Lynn "s (1986) threshold value for content validity (.80), a value of .70 was found when the ratio of those who expressed a positive opinion to all those who expressed an opinion. This value is below .80, which is accepted as the threshold score for content validity. Content validity of this subtest is moderately sufficient in terms of measuring content knowledge.

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Discussion

This section discusses the findings and presents conclusions and recommendations.

5.1.1. General Mathematical Aptitude

In this study, the content validity of the FMT was investigated. In the study, the opinions of 40 experts, 20 faculty members and 20 teachers, were consulted. The content validity ratios of the opinions received from the experts were calculated and the values found were compared with the minimum value of .80. When the findings are interpreted, it can be said that the test generally measures the mathematics ability to be measured. The data obtained from the opinions of the participants can be interpreted as the TMT measures general mathematics ability at a moderate level.

Those who evaluated the test in general stated that it was a well-structured test. According to the experts, the test is generally an appropriate tool for the Identify of mathematics ability. When the answers of the experts who evaluated the test to the open-ended question were evaluated, it was seen that the experts criticized the problem types in some of the subtests in the test (in subtests that measure domain knowledge such as measurement and algebra) as "problems that can be encountered in many places, ordinary knowledge problems". From this point of view, it may be considered to change some question types. One of the experts who evaluated the test suggested, "Problem types in the test can be differentiated by using interdisciplinary questions." According to the same expert, different question types can be used in probability, combination, permutation and especially in problems that are among the basic subjects of geometry.

Another point emphasized by the experts is that some of the questions (in subtests such as categorical logic, conditional logic) produced at the knowing/remembering level disrupts the general structure of the test. In order to improve the test, such questions can be removed from the test and problems requiring higher level thinking skills can be produced. Another issue emphasized by the experts who evaluated the test is the systematic generation of questions, which was not achieved in some subtests. Experts suggest that the patterns and relationships used in the problems can be used gradually to determine mathematical abilities at different levels.

When the measurement of general ability in all subtests was questioned and the content validity ratios of the items (ranging from .52 to .85) were examined, it was observed that the numerical analogy, categorical logic, and figurative rotation subtests did not measure general ability at a good level. It was observed that the participants who evaluated these subtests evaluated these subtests as measuring general mathematical ability at a moderate level. This decreased the content validity rate of the test. Participants may have thought that the problems in the numerical analogy subtest, which included problems with similar relationships, would not be sufficient to measure general mathematical ability. In addition, participants specifically stated that the figurative rotation subtest was not directly related to general mathematical ability, but to visuospatial ability. Therefore, according to the participants, this subtest is not directly related to math ability. Most of the participants rated the categorical logic subtest as a very difficult subtest. Participants may have thought that this subtest, which they found difficult, would not measure or predict general mathematical ability.

On the other hand, the participants' evaluations indicated that the number sequences, linear logic, algebra, geometry, conditional logic, statistics, measurement, figurative sequences, figurative analogy subtests measured general mathematical ability at a good level (content validity ratio values ranged between .60 and .82). All these subtests included problems directly related to the structure of mathematics. These subtests, which also included mathematical symbols and numerically related functions, were accepted by the experts as measuring mathematical ability. For these subtests, it can be interpreted *that "Content validity is sufficient in terms of measuring mathematical ability."*

5.1.2. Analytical Ability

The general judgment of the participants who evaluated the test was that analytical ability was measured at a good level in all subtests and in the overall test. Except for the knowledge subtests, all subtests directly measure the analytical ability of the student. In this sense, the test consists of problems that can be solved with little or no need for mathematical knowledge in some subtests to measure analytical ability and creative ability. The problems in these subtests were generally evaluated by the experts as "*measuring analytical ability at a good level*".

The knowledge subtests also included mathematical problems related to learning areas at the level of elementary mathematics. The ability to solve mathematical problems was seen by the experts as directly related to analytical ability. Therefore, according to the experts, the subtests that include problems related to content knowledge measure both mathematical content knowledge and analytical ability in mathematics. However, the content validity ratios of the measurement (content validity ratio .65) and algebra (content validity ratio .74) subtests of the test for measuring analytical ability were lower compared to the other subtests. Experts stated that some of the problems, especially in the knowledge subtests, were ordinary questions that students might encounter frequently. As an educator, John Dewey defines a problem as an ambiguous situation that confuses the human mind. From a similar point of view, Türnüklü and Yeşildere (2005) define a problem as a problem that arouses the desire to solve because it confuses the mind when encountered, and that has no standard solution because it is encountered for the first time, and that can only be solved by using the knowledge of the person trying to solve it correctly. Therefore, in order for students to be able to see a question as a problem and to use their different cognitive abilities in solving this problem, they must have encountered the problem for the first time. From this point of view, the low content validity rate values obtained from the frequency of the opinions of the experts who gave opinions about the subtests should be considered as a striking finding. It would be appropriate to interpret what the experts emphasized with this value with the necessity of differentiating the questions and transforming them into problems.

Again, according to the experts, the content validity of the figurative rotation test (content validity ratio .72), whose primary purpose is to measure analytical ability, was found to be low when compared with the other subtests and the threshold value. In fact, according to the experts, this subtest measures creative ability better than analytical ability. Although this subtest does not directly measure creative ability, the experts' opinion is partially correct. According to the experts, the figurative rotation subtest is evaluated as a subtest that measures more visual-spatial ability. Experts also stated that the difficulty levels of the problems of the subtest should be revised. Experts also stated that this subtest needs systematic structuring. According to the experts, this subtest can be revised by including different types of problems such as translation, view from different faces.

Another point emphasized by the experts is that some questions produced at the knowing/remembering level disrupt the general structure of the test. In order to improve the test, such questions should be removed from the test and problems requiring higher level thinking skills should be produced. This is an important problem especially in the knowledge subtests. Therefore, it reduces the content validity of the subtests in terms of measuring analytical and creative skills.

As an interesting finding, the content validity ratio values of the conditional logic (.92) and figurative sequences (.95) subtests are noteworthy. According to the experts, finding the correct proposition or answer with conditional propositions and problems in the conditional logic subtest is directly related to analytical ability in mathematics. However, solving the network of relationships and reaching generalizations in the figurative sequences subtest is directly related to mathematical analytical ability according to the experts. The content validity of the numerical analogy, linear logic, figurative analogy, categorical logic, number sequences, conditional logic, statistics, geometry subtests is sufficient in terms of measuring analytical ability.

In conclusion, when the content validity of the test in terms of measuring the analytical ability of the primary purpose of the test is examined; the content validity of the test is sufficient on the basis of subtests. It can be said that the opinions of the test evaluators and the purpose of the test and the subtests of the test coincide.

5.1.3. Creative Talent

The general judgment of the participants who evaluated the test was that the subtests of the test measured creative ability in mathematics at a low or moderate level. Therefore, the content validity of the test is not sufficient in terms of measuring creative ability.

The categorical logic, conditional logic, linear logic, algebra, measurement subtests developed in accordance with the theoretical substructure of the test do not have problem types that directly measure creative ability in mathematics. The content validity ratios of these subtests of the test vary between .40 and .60. According to expert opinions, these subtests cannot measure creative ability. The fact that these subtests are knowledge subtests or subtests that contain problems solved by requiring mathematical knowledge may have caused the experts to use their opinions in this direction. Some of the experts emphasized that the problems related to these subtests turned into frequently encountered questions. This decreases the content validity of these subtests in terms of measuring creative ability.

The content validity ratios of the number sequences, numerical analogy, geometry, and statistics subtests in terms of measuring creative ability were around .60. This may mean that the experts agreed that the problems in these subtests measured mathematical creativity, albeit partially. This is in line with the theoretical background of the test. For example, the primary purpose of the number sequences subtest is to measure analytical ability. In this subtest, missing numbers in number sequences are tried to be discovered. In this part of the test, the cognitive process includes creative ability because students have to discover the rules that make up the number sequence. Similarly, some of the suggestions given by the experts for the number sequences subtest were to give the number of steps along with the number patterns. One of the experts who evaluated in the same direction emphasized that it would be more productive for students to use their creative abilities if functional relationships were given and/or required. According to mathematicians, discovering rules is an important part of mathematical creativity (Sak, 2004a, 2004b). However, in the related literature, the boundaries of analytical ability and creative ability in mathematics are not clearly defined.

As an interesting finding, the content validity ratio values of the figurative sequences and figurative analogy subtests were .95 and .85, which are values above the threshold value. These subtests are considered by field experts as "good or very good measures of creative ability". While defining mathematical ability in the previous sections of the study, it was stated that mathematical creativity and analytical ability are directly related; students may use different methods when solving different types of problems in these subtests. Therefore, although the test's sole aim is not to directly measure mathematical creativity, it is possible that students may use their mathematical creative abilities in addition to using their cognitive skills.

5.1.4. Field Knowledge

The theoretical background of the test also emphasizes the importance of content knowledge in mathematics. Therefore, the test has subtests that directly measure content knowledge in mathematics. These subtests are measurement, statistics and probability, geometry and algebra subtests which are related to learning areas at the primary level. The content validity of these subtests ranged between .70 and .82.

The content validity of these subtests in terms of measuring content knowledge in mathematics is moderate or sufficient.

The content validity ratio value of the algebra subtest was found to be lower than the other subtests measuring content knowledge. This subtest was criticized by the field experts especially in terms of question structuring, difficulty level and lack of variety in the questions. The fact that this measurement area was evaluated as adequate but not high enough by the field experts may be due to the fact that the problems in the test are routine, the kind of problems that students frequently encounter.

Some subtests such as number sequences, numerical analogy, figurative rotation, figurative analogy contain problems that can be solved without the need for deep mathematical knowledge. The content validity ratios of these subtests vary between .40 and .60. These values indicate that the experts were of the opinion that the problems in this part of the test can be solved with little or no need for mathematical knowledge.

This finding suggests that these subtests are not directly related to content validity in terms of content validity. This finding shows that these subtests are not directly related to content knowledge in mathematics in terms of content validity.

Experts commented that the solutions of problems in subtests such as conditional logic, linear logic, categorical logic, and figurative sequences may require mathematical knowledge. The content validity of these subtests ranged between .70 and .77. These subtests included mathematical symbols and relationships. In this sense, these subtests also measure domain knowledge in mathematics. Among these subtests, especially the linear logic subtest stands out with a higher content validity ratio value than the others. The reason for this may be that different mathematical numbers and symbols are included in the problems and it is not possible to solve these mathematical problems without domain knowledge.

5.2. Conclusion

The data obtained from the participants' opinions can be interpreted as the TMT measures general mathematical ability. When the content validity of the subtests, whose primary purpose is to measure analytical ability, is examined in this respect, the content validity of the test in general and on the basis of subtests is sufficient. Although there are subtests that do not have the expected value in the findings, it can be said that the opinions of the test evaluators and the purpose of the test and subtests coincide.

The general judgment of the participants who evaluated the test was that the subtests of the test measured creative ability in mathematics at a low or moderate level. Therefore, the content validity of the test is not sufficient in terms of measuring creative ability. The theoretical background of the test also emphasizes the importance of content knowledge in mathematics. Therefore, the test has subtests that directly measure content knowledge in mathematics. These subtests are measurement, statistics and probability, geometry and algebra subtests, which are related to learning areas at the primary school level. The content validity of these subtests ranged between .70 and .82. The content validity of these subtests in terms of measuring content knowledge in mathematics is moderate or sufficient.

5.3. Recommendations

As a result of the opinions received from the experts in the research, the following suggestions can be taken into consideration:

- The content validity of the subtests of the test for content knowledge was found to be moderate. When the corrections and expressions added by the experts on the subtest were examined, it was seen that the items in these subtests were mostly questions at the familiar/ordinary, knowing/remembering level. Reconsidering or revising the problems in these subtests may increase the content validity of the subtests for content knowledge.

- The test does not include a subtest whose primary purpose is to measure mathematical creativity. This reduces the content validity of the test for creative ability. As suggested by some field experts, the content validity of the test can be strengthened by adding open-ended questions.
- The content validity of the test for measuring analytical ability in mathematics is generally sufficient. However, revising the problems in some of the subtests, some of which have low content validity ratio values compared to others and which are intended to measure analytical ability, may increase the content validity of the test for measuring analytical ability.
- According to the experts' statements, similar question structures and patterns are observed in different subtests within the test. If the patterns in the

subtests are differentiated, the content validity of the test for analytical and creative ability may be higher.

- The experts emphasized that the level difference between the questions was not evident in subtests such as number sequences, numerical analogy, conditional logic, geometry, measurement, categorical logic, and figurative rotation. The experts' evaluations were very There are also question items emphasized as simple and very difficult. The difficulty levels of the test questions could be revised.
- Mathematical symbols and expressions should be used in order to make some of the statements in the test more understandable and sufficient in terms of content validity. Some expressions should also be explained so that the question stem in the test is more descriptive.
- In the opinions received from the experts, it was stated that some questions in the overall test have become quite stereotypical questions. These questions should be revised or replaced.
- Experts stated that some subtests in the test, such as categorical logic, were quite difficult. Item difficulty analysis can be made in the relevant

subtests and the difficulties of the problems can be changed.

- In the future, evaluating the test on a question basis rather than on a subtest basis may be valuable for the development of the test.

ANNEX

Sample Problems for Subtests of TMT*

Number Sequences	Which of the following numbers should replace the question mark in the number sequence above? **A)** **B)** **C)** **D)** **E)**
Numerical Analogy	3, x, x → x, x, x, x m, k, l → **?** Which of the following sets of numbers should replace the question mark above? **A)** **B)** **C)** **D)** **E)**
Conditional Logic	In a group of ...... people, since Ali is ....."................, the group .... Who is it? **A)** **B)** **C)** **D)** **E)**

Linear Logic	Since the number C is one, which of the following is true? **A)** **B)** **C)** **D)** **E)**
Algebra	Since ...., which of the ....following is x? **A)** **B)** **C)** **D)** **E)**
Geometry	In the figure long edges .... piece by piecedivided one of a rectangle There is a triangle placed inside . ..... Since .... is ...., is ....? **A)** **B)** **C)** **D)** **E)**

Statistics-probability	Ali "s .... is .... as a reward. According to this situation, what is the probability of .....? **A)** **B)** **C)** **D)** **E)**
Measurement	An automobile race ...... is organized on a circular track .... with a circumference ...... of about 100 meters. According to .... one of the drivers .... is it? **A)** **B)** **C)** **D)** **E)**
Categorical Logic	In a school, ... is organized for .... students. From a class with .... Since the number of students in .... is x, only ...., the number of .... How many? **A)** **B)** **C)** **D)** **E)**

<table>
<tr><td>Figurative Rotation</td><td>What is the image that can be obtained from the above figure......?

A)
B)
C)
D)
E)</td></tr>
<tr><td>Figurative Sequences</td><td>The intersections of the shapes above......, which are created according to a certain rule, are shown with dots. If these shapes continue to increase as above,
..... way................would it be?

A)
B)
C)
D)
E)</td></tr>
<tr><td>Figurative Analogy</td><td><table><tr><td></td><td></td></tr><tr><td></td><td></td></tr></table>
1 2

There is a certain relationship between the two figures in group 1 above. In order for a relationship similar to this relationship to exist in figure 2, which of the following should replace ....?</td></tr>
</table>

*Contact the researcher to obtain the full test.

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CONTENT VALIDITY OF THE TEST OF MATHEMATICAL TALENT

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